BEFORE THE
STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

---

In the Matter Of

Keyspan Gas East Corporation d/b/a National Grid and
The Brooklyn Union Gas Company d/b/a National Grid NY

Cases 16-G-0058 and 16-G-0059

May 2016

---

Prepared Exhibits of:

Gas Policy and Supply Panel

John P. Sano
Utility Supervisor

James Lyons
Utility Consumer Program
Specialist 4

Davide Maioriello
Utility Engineer 3

Claude Semexant
Utility Engineer 1

Office of Electric, Gas and
Water

State of New York
Department of Public Service
Three Empire State Plaza
Albany, New York 12223-1350

List of Exhibits


| Exhibit | Description | PDF Page |
|---|---|---|
| Exhibit___(GPSP-1) | IR Responses | 3 |
| Exhibit___(GPSP-2) | FMI’s Labor Skills Shortage Report | 513 |
| Exhibit___(GPSP-3) | National Grid’s Long Term Capacity Plan for KEDNY and KEDLI | 531 |

# Exhibit GPSP-1

## Table of Contents


| Information Request Response | | Page |
|---|---|---|
| DPS-305 | Gas Supply Planning | 2 |
| DPS-329 | Cap Ex Non-Infrastructure | 7 |
| DPS-332 | Renewable Gas Interconnections | 51 |
| DPS-418 | Automated Meter Reading - KEDLI | 81 |
| DPS-419 | Automated Meter Reading – KEDNY | 84 |
| DPS-420 | Research and Development Costs – KEDLI | 87 |
| DPS-421 | Research and Development Costs – KEDNY | 237 |
| DPS-426 | Sales Promotion Expense – KEDLI | 385 |
| DPS-427 | Sales Promotion Expense – KEDNY | 389 |
| DPS-435 | Natural Gas Vehicles – KEDNY | 392 |
| DPS-443 | Geothermal/Solar Technologies | 467 |
| DPS-460 | Chromatographs – KEDNY and KEDLI | 469 |
| DPS-476 | Sales Promotion Expense – KEDNY | 479 |
| DPS-482 | Information Systems Issues – Gas Transportation Information System (GTIS) | 481 |
| DPS-487 | Research and Development Costs for KEDNY | 502 |
| LIPA-7 | Generator Transportation Rates | 509 |

Date of Request: March 17, 2016
Due Date: March 28, 2016

DPS Request No. DPS-305 JPS-1
KEDNY/ KEDLI Req. No. BULI-241

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, John P. Sano

TO: National Grid, Elizabeth Arangio

SUBJECT: Gas Supply Planning

Request:

Provide the following information for both KEDNY and KEDLI:

On p. 36 of Mr. Daley's testimony, he discusses the capital improvements to both Liquefied Natural Gas (LNG) facilities and he identify several important transmission projects needed for both reinforcement and growth purposes.

1. Identify the changes required in the gas supply plan required to maintain design day, as well as, colder than normal weather service during the time any portion of the LNG facilities are out of service. Include or explain the following:

    a. What is the schedule for work on LNG facilities requiring attention and what effect do these facilities have on the gas supply plan?

    b. Will more than one LNG tank be taken out of service at any given time?

    c. What will the reduction in design day deliverability when the Holtsville, Long Island tank is unavailable? Describe how the gas supply plan will accommodate or replace this supply loss?

    d. What will be the reduction in design day deliverability when either of the Greenpoint, Brooklyn tanks are unavailable? Describe how the gas supply plan will accommodate or replace this supply loss?

e. What will be the reduction in design day deliverability for any of the other LNG site work identified by the Companies in their rate filing? Describe how the gas supply plan will accommodate or replace this supply loss?

f. What contingencies are required for any schedule delays to any of the work identified above? Describe how will the gas supply plan will accommodate or replace this supply loss.

g. Describe the extent to which the Companies or other National Grid operations have previously performed similar work on its LNG facilities, for example, in New England. Describe in detail lessons learned regarding the need to modify the gas supply plan or project schedules to maintain reliability when LNG service is restricted.

2. Identify the changes required in the gas supply plan to maintain design day, as well as, colder than normal weather service during the time any portion of the transmission system is out of service due to any or the following transmission projects discussed on pp. 37-38 of Mr. Daley's testimony:

   a. Metropolitan Reliability Infrastructure Project (MRI);

   b. Northern Queens Project;

   c. Northwest Nassau Transmission Project; and

   d. Any other transmission project included in the Companies' Capital Expenditure plan.

3. How does the agreement with Transco, referenced on p. 14 of your testimony, for 115,000 dekatherms/day of incremental capacity in 2017 and a possible additional 400,000 dths/day in 2019, split between the Staten Island and Rockaway Lateral delivery points, impact the capital work for gas supply planning discussed in questions #1 and #2 above?

   a. Can this additional capacity be modified to alter the gas flows between the two delivery points, if needed, due to any concerns for reliability?

   b. Do the Companies' currently have the flexibility to alter flows between the Rockaway Lateral and Long Beach to meet fluctuating demand requirements between KEDNY and KEDLI? If there are restrictions on this flexibility describe and explain them?

   c. Explain why the Companies propose to proceed with all the capital work mentioned in your testimony instead of delaying at least a portion of the work until the additional 400,000 dekatherms a day may be available in 2019.

<u>Response</u>:

1.

a. Greenpoint Tank 2 is scheduled to be out of service for the 2020/21 winter season. Vaporization capability at Greenpoint totals 290,000 Dth/day. When Tank 2 is out of service for the 2020/21 winter season, total vaporization capability will be reduced from 290,000 Dth/day to 115,000 Dth/day, as Tank 1 will still be in operation. The Holtsville tank is scheduled to be out of service for the 2021/22 winter season. Vaporization capability at Holtsville totals 103,000 Dth/day. When the tank is out of service for the 2021/22 winter season, total vaporization capability will be reduced from 103,000 Dth/day to 0 Dth/day.

b. No. Only one tank will be taken out of service at a time.

c. The reduction in design day deliverability when the Holtsville tank is unavailable totals 103,000 Dth/day. To replace this reduction in deliverability, replacement supplies would have to flow primarily from South Commack and Transco (Floyd Bennett Field ("FBF")/Long Beach) to offset the supply loss of LNG. Prior to the 2021/22 winter season, the Company will: (1) review the latest customer requirements forecast; (2) determine whether customer requirements exceed the deliverability of existing gas supply assets; and (3) procure additional capacity and/or peaking supplies at the respective pipeline interconnects as needed.

d. The reduction in design day deliverability when Greenpoint Tank 2 is unavailable totals 175,000 Dth/day. To replace this reduction in deliverability, replacement supplies would have to flow primarily from Transco (FBF/Narrows) to offset the supply loss of LNG. Prior to the 2020/21 winter season, the Company will: (1) review the latest customer requirements forecast; (2) determine whether customer requirements exceed the deliverability of existing gas supply assets; and (3) procure additional capacity and/or peaking supplies at the respective pipeline interconnects as needed.

e. There are no additional reductions in design day deliverability for any of the other LNG site work identified by the Companies in their rate filings other than those identified in (a) and (b) above.

f. For either of the tanks to be taken out of service, Transco's New York Reliability Enhancement Project ("NYRE Project") must be in service. The NYRE Project has an expected in service date of November 2019. Additionally, the Company's on-system Metropolitan Reliability Infrastructure Project ("MRI Project") is required to be in service to allow Tank 2 at Greenpoint to come out of service for one heating season. The MRI Project has an expected in-service date of November 2020. Additionally, the Holtsville tank must be back in service before Tank 2 at Greenpoint is taken out of service. As discussed in responses (c) and (d) above, additional capacity and/or peaking supplies will be secured at the respective pipeline interconnects as needed.

   To allow these tanks to come out of service for one heating season, Gas Supply Planning will secure additional incremental pipeline supplies to support system reliability in the absence of vaporization availability. The LNG facilities will continue to operate until such time as the above referenced projects are completed and gas supply is secured to replace the vaporization capacity with the tanks out of service.

g. National Grid personnel have on a number of occasions successfully removed LNG tanks from active service, performed tank entry, conducted inspections, testing, redesign and rebuild of the tanks and associated components and re-commissioned the LNG tanks back into service. In the US, National Grid LNG Operations have engaged in these activities on five occasions, most recently in 2011 and 2012 when the Tewksbury, MA LNG tank was project was completed. The supply plan was adjusted to support the execution of the Tewksbury LNG project, which included the need for securing incremental pipeline supplies to ensure reliability of the system during peak periods of demand during the winter heating season. The project schedule was closely monitored by key stakeholders, including Gas Control and Gas Supply Planning, to ensure safe system operations and supply reliability. The magnitude of these projects, including the impact to system operations, requires close coordination and planning several years in advance of the project start to ensure the basic objectives of providing safe and reliable service to customers is achieved.

2. a. – d.
Planned outages on any portion of the transmission system to accommodate transmission work, including work associated with the Metropolitan Reliability Infrastructure Project (MRI), Northern Queens, and the Northwest Nassau Transmission Project, are not permitted during design day or colder than normal weather conditions. Any transmission projects that would cause an outage on a portion of the transmission system would be scheduled between the Spring and Fall to minimize system impacts.

3. a. and b.
After submitting direct testimony, the Companies executed precedent agreements on February 29, 2016 with Transco for up to 400,000 Dth/day of incremental capacity to Rockaway. The volumes will be split between KEDNY and KEDLI. The total volume, and the exact split between KEDNY and KEDLI, is not determined at this time as this project is subject to an Open Season by Transco, expected to occur in April 2016.

The Companies currently have the flexibility to alter flows between the Rockaway Lateral and Long Beach to meet fluctuating demand requirements between KEDNY and KEDLI. The existing gate station at FBF in Rockaway has 647,000 Dth/day of takeaway capacity. With the existing Northeast Connector capacity, up to 100,000 Dth/day can flow to FBF. Transco currently provides flexibility to re-nominate gas from Long Beach and Narrows to FBF. Gas can also be re-nominated from FBF to the other Transco gates, if needed. The new upstream capacity projects in 2017 and 2019 will provide the same flexibility.

There are currently two limitations on flexibility to alter flows between Long Beach, Narrows and Rockaway:

1. Re-nominating gas from Narrows and/or Long Beach is subject to restrictions that would affect Transco's balancing pools. In some instances, the supplier would need to re-nominate gas at the receipt point before the Company would be able to process a port-cycle or retroactive nomination; and
2. The Companies must observe the New York Facility Group's Delivery Point Entitlements.

c. The MRI Project will allow the system to take additional capacity from Transco at the Rockaway Lateral delivery point and provides the flexibility to move volumes throughout the system, as well as facilitates taking an LNG outage for work at the Greenpoint LNG plant. Construction of the MRI Project is over a four year period and is currently scheduled to be in service for winter 2020/2021. Construction of the Northern Queens project is completed and awaiting a final inspection before it is placed into service to address an existing distribution system need in the northern portion of Queens. The Northwest West Nassau project addresses both integrity concerns with Gas Mains 1, 8, and 16 and existing transmission pressure issues in the line that goes through Lake Success. The capital work planned by the Companies each year is intended to match the internal forecast by the AMF group to maintain above minimum pressures.

<u>Name of Respondent</u>: Elizabeth Arangio

<u>Date of Reply</u>: March 28, 2016

Date of Request: March 22, 2016 DPS Request No. DPS-329 MT-3
Due Date: April 1, 2016 KEDNY/ KEDLI Req. No. BULI-286

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, Michael Tushaj

TO: National Grid, GIOP

SUBJECT: Cap Ex Non-Infrastructure

Request:

The Following questions refer to the Companies' forecasts for categories in the Non-Infrastructure Classification, as listed in the Companies' Exhibit__(GIOP-1):

1) Provide Companies' sanction papers for the following Non-Infrastructure line item accounts:
    a. AMR Installation/Replacements (KEDLI)
    b. AMR Installation (KEDNY)
    c. AMR Replacement (KEDNY)
    d. Tools & Equipment (KEDNY and KEDLI)
    e. Telecomm (KEDNY and KEDLI)

To the extent that the following information is not included in the sanction papers provided in response to the question above:

2) Provide, in Excel, a detailed breakdown of the forecasts for the "Non-Infrastructure" line item accounts "AMR Installation/Replacements" for KEDLI. Similarly, provide, in Excel, a detailed breakdown of the forecasts for "AMR Installation" and "AMR Replacement" for KEDNY.

3) Provide the experienced cost per meter and the number of meters installed over the past 3 calendar years for KEDNY and KEDLI, respectively.

4) Provide the average service life of a typical AMR meter.

5) Provide, in Excel, a breakdown for the forecasted costs in RY 1, 2 and 3 for the "Non-Infrastructure**"** line item account "Tools & Equipment – All" for KEDNY and KEDLI, respectively.

Response:

1.

a There is no sanction paper for this program because it less than the $1M threshold required for sanctioning.

b. Attachment 1 is the requested sanction paper.

c. Attachment 2 is the requested sanction paper.

d. Attachment 3 is the sanction paper for KEDNY. Attachment 4 is the sanction paper for KEDLI.

e. There is no sanction paper for this program because it less than the $1M threshold required for sanctioning.

2. Attachment 5 provides the requested information.

3. The table below shows the experienced cost per meter (exclusive of installation cost) and the number of meters installed over the past three calendar years for KEDNY and KEDLI. The experienced cost per meter is an average cost for all meters, both industrial and commercial. A common residential meter costs approximately $60, whereas an industrial meter could range from several hundred to over $20,000. In CY14, the Companies purchased a higher proportion of commercial rotary meters than in CY13 or CY15, which is reflected in the higher average price in that year.

| | **CY13** | **CY14** | **CY15** |
|---|---|---|---|
| **KEDNY** | | | |
| Meters Installed | 37,388 | 18,986 | 21,023 |
| Experienced Cost/Meter | $205 | $305 | $205 |
| | | | |
| **KEDLI** | | | |
| Meters Installed | 34,626 | 32,292 | 25,759 |
| Experienced Cost/Meter | $192 | $186 | $117 |

4. The average service life of a typical AMR meter is 20 years.

5. The "Tools & Equipment – All" line item is a blanket program. Costs are forecast based on historic levels and not at the individual unit level. The sanction papers provided in response to part 1 above provide greater detail on this program. Most tools and equipment purchases are on an as-needed basis, and these items are generally replacements for tools and equipment that are beyond repair. Some purchases are for improved or obsolete tools and equipment. The program is also used for new technology tools and equipment that will provide enhanced (employee, public and environmental) safety and improved operations. The table below provides examples of some common tools and equipment purchased through this program.

| | KEDNY and KEDLI |
|---|---|
| | **20 Common tools & equipment purchased within the Capital Tools & Equipment budget** |
| 1 | Safety equipment (PPE, fresh air bottles, etc.) |
| 2 | Road traffic protection & public safety equipment |
| 3 | Fusing equipment |
| 4 | Electro fuse equipment |
| 5 | Water pumps |
| 6 | Welding equipment |
| 7 | Inspection tools |
| 8 | Locating devices |
| 9 | Pipe tapping equipment |
| 10 | Generators |
| 11 | Pipe cutting tools (plastic, cast iron, steel) |
| 12 | Saw cutters and pavement breakers |
| 13 | Backfilling compaction equipment |
| 14 | Pneumatic tools |
| 15 | Coring equipment |
| 16 | Lighting |
| 17 | Exterior pipe cleaning tools |
| 18 | Underground drilling tools & equipment |
| 19 | Shell cutters for tapping equipment |
| 20 | New technology tools |

Name of Respondent:
James Thompson
Marina Perrone
Philip Di Giglio

Date of Reply:
March 31, 2016

nationalgrid

***Short Form Sanction Paper***

| | | | |
|---|---|---|---|
| **Title:** | FY17 AMR Purchase and Installation Blanket - KEDNY | **Sanction Paper #:** | USSC-16-048 |
| **Project #:** | C048384 | **Sanction Type:** | Sanction |
| **Operating Company:** | The Brooklyn Union Gas Co. | **Date of Request:** | February 9, 2016 |
| **Author:** | Marina Perrone | **Sponsor:** | John Stavrakas – VP Gas Asset Management |
| **Utility Service:** | Gas | **Project Manager:** | Marina Perrone |

## 1 Executive Summary

### 1.1 Sanctioning Summary

This paper requests sanction of project C048384 in the amount $4.842M and a tolerance of +/- 10% for the purposes of full implementation.

This sanction amount is $4.842M broken down into:

$4.842M Capex
$0.000M Opex
$0.000M Removal

### 1.2 Project Summary

This project provides funding for the purchase and installation of Automatic Meter Reading Equipment for replacement of failed units, end of life units, and to support meter replacement and growth programs.

## 2 Project Detail

### 2.1 Background

The Brooklyn Union Gas Company currently has an installed AMR population of approximately 790K units. Each year a quantity of AMR units are replaced in the field by Customer Meter Service Technicians as they either fail, or have reached the end of their useful life. Recently we matched the AMR population against a battery life model supplied by the vendor to more accurately predict the number of AMR replacements which must be performed on an annual basis. Using this model, we have calculated that 35,000 AMR units will require replacement each year for the next 4 year period.

*Short Form Sanction Paper*

nationalgrid

## 2.2 *Drivers*

The primary driver for this project is the continuation of customer meter read rate and our ability to provide timely, accurate bills.

## 2.3 *Project Description*

This project, and sanction request, covers material and installation costs associated with the purchase of installation of 68,500 AMR equipment units which will be used to replace failed units, to accommodate growth, and proactively replace units that are approaching their battery end of life. The FY17 budget is in line with last year's budget.

This project supports regulatory requirements for accurate meter reading and billing.

## 2.4 *Benefits*

This project enables the company to provide accurate, actual billing information to customers by maintaining the health and integrity of our automatic meter reading system.

## 2.5 *Business & Customer Issues*

There are no significant business issues beyond what has been described elsewhere.

## 2.6 *Alternatives*

**Alternative 1:** Base Case – Leave as is

This alternative is rejected as the quantity of projected AMR equipment failures resulting from age without a proactive replacement policy is expected to reach 50K units within 2 years. This failure rate will adversely impact meter read rates, customer satisfaction, and results in a less efficient use of field labor by not leveraging "tag along" process to include Proactive AMR equipment replacements

In addition, these options are rejected since AMR equipment will fail without replacement. Failures will result in the addition of over 25,000 meters to the manual meter reading routes requiring additional manpower and opex spend. In addition, this policy would adversely impact meter read rates and customer satisfaction.

***Short Form Sanction Paper***

**Alternative 2:** Revise Project Size and Scope – Partial Deferral

This alternative is rejected for the same reasons as Alternative 1

### 2.7 *Investment Recovery*

Investment recovery will be through standard rate recovery mechanisms

### *2.7.1 Customer Impact*

This project results in an indicative first full year revenue requirement when the asset is placed in service equal to approximately $0.995M. This is indicative only. The actual revenue requirement will differ, depending upon the timing of the next rate case and/or the timing of the next filing in which the project is included in rate base.

## *3 Related Projects, Scoring, Budgets*

### 3.1 *Summary of Projects*

| Project Number | Project Type (Elec only) | Project Title | Estimate Amount ($M) |
|---|---|---|---|
| C048384 | | AMR Purchase | 4.842 |
| | | **Total** | 4.842 |

### 3.2 *Associated Projects*

None

### 3.3 *Prior Sanctioning History*

N/A

nationalgrid

***Short Form Sanction Paper***

### 3.4 *Category*

| Category | Reference to Mandate, Policy, NPV, or Other |
|---|---|
| O Mandatory<br>⦿ Policy- Driven<br>O Justified NPV<br>O Other | Support Operations thru maintaining Meter Reading Rates and delivering accurate billing to customers |

### 3.5 *Asset Management Risk Score*

Asset Management Risk Score: _49____

**Primary Risk Score Driver:** (Policy Driven Projects Only)

⦿ Reliability O Environment O Health & Safety O Not Policy Driven

### 3.6 *Complexity Level*

O High Complexity O Medium Complexity ⦿ Low Complexity O N/A

Complexity Score: _15____

### 3.7 *Next Planned Sanction Review*

| Date (Month/Year) | Purpose of Sanction Review |
|---|---|
| June 2017 | Sanction Paper Closeout |

*Short Form Sanction Paper*

nationalgrid

## 4 Financial

### 4.1 Business Plan

| Business Plan Name & Period | Project included in approved Business Plan? | Over / Under Business Plan | Project Cost relative to approved Business Plan ($) |
|---|---|---|---|
| FY17-FY21 Gas Capital Plan | ⦿ Yes ○ No | ○ Over ○ Under ⦿ NA | $0.000M |

#### 4.1.1 If cost > approved Business Plan how will this be funded?

N/A

### 4.2 CIAC / Reimbursement

N/A

### 4.3 Cost Summary Table

| Project Number | Project Title | Project Estimate Level (%) | Spend | Prior Yrs | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| C048384 | AMR Purchase | Est Lvl (e.g. +/- 10%) | CapEx | - | 4.842 | - | - | - | - | - | 4.842 |
| | | | OpEx | - | - | - | - | - | - | - | - |
| | | | Removal | - | - | - | - | - | - | - | - |
| | | | Total | - | 4.842 | - | - | - | - | - | 4.842 |
| Total Project Sanction | | | CapEx | - | 4.842 | - | - | - | - | - | 4.842 |
| | | | OpEx | - | - | - | - | - | - | - | - |
| | | | Removal | - | - | - | - | - | - | - | - |
| | | | Total | - | 4.842 | - | - | - | - | - | 4.842 |

nationalgrid

*Short Form Sanction Paper*

4.4 ***Project Budget Summary Table***

**Project Costs per Business Plan**

| $M | Prior Yrs (Actual) | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|
| CapEx | 0.000 | 4.842 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 4.842 |
| OpEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Cost in Bus. Plan | 0.000 | 4.842 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 4.842 |

**Variance** **(Business Plan-Project Estimate)**

| $M | Prior Yrs (Actual) | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|
| CapEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| OpEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Cost in Bus. Plan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## 5 ***Key Milestones***

| Milestone | Target Date: (Month/Year) |
|---|---|
| Provide vendors with annual requirements and product delivery schedule for first half of FY16 | February 2016 |
| Provide vendors with delivery schedule for second half of FY16 | July 2016 |
| Project Closeout | June 2017 |

## 6 ***Statements of Support***

### *6.1.1 Supporters*

The supporters listed have aligned their part of the business to support the project.

| Role | Individual | Responsibilities |
|---|---|---|
| *Investment Planner* | Roden, Thomas | Endorses relative to 5-year business plan or emergent work |
| *Resource Planning* | Buckleman, Brian | Endorses Resources, cost estimate, schedule, and Portfolio Alignment |
| Project Management | Fortier, Joseph Jr | Endorses Resources, cost estimate, schedule |

### *6.1.2 Reviewers*

The reviewers have provided feedback on the content/language of the paper.

| Reviewer List | Individual |
|---|---|
| Finance | Fowler, Keith<br>Horowitz, Philip |
| Regulatory | Zschokke, Peter<br>Gavilondo, Carlos |
| Jurisdictional Delegate | Brown, Laurie |
| Procurement | Curran, Art |
| Control Center | Metzdorff, Peter |

### *6.1.3 List References*

N/A

*Short Form Sanction Paper*

nationalgrid

## 7 Decisions

I:

(a) APPROVE this paper and the investment of $4.842M and a tolerance of +/- 10%

(b) NOTE that Marina Perrone is the Project Manager and has the approved financial delegation.

(c) NOTE: In the event that any Blanket/Program projects are not approved prior to the start of the FY2018 fiscal year, the FY2017 approval limits will remain in effect until such time as the FY2018 blanket/program projects are approved by USSC and/or other appropriate authority for approval.

Signature................................................................Date 3/1/2016

Ross Turrini – SVP & Gas Process & Engineering

## 8 Other Appendices

### 8.1 Sanction Request Breakdown by Project

N/A

*US Sanction Paper*

nationalgrid

| | | | |
|---|---|---|---|
| **Title:** | KEDNY AMR Deployment | **Sanction Paper #:** | USSC-15-263 |
| **Project #:** | C067854 | **Sanction Type:** | Sanction |
| **Operating Company:** | The Brooklyn Union Gas Co. | **Date of Request:** | 11/19/2015 |
| **Author:** | Philip Di Giglio | **Sponsor:** | Johnny Johnston – VP CMS |
| **Utility Service:** | Gas | **Project Manager:** | Philip Di Giglio |

## 1 Executive Summary

### 1.1 Sanctioning Summary

This paper requests sanction of C067854 in the amount $33.112 with a tolerance of +/- 10% for the purpose of completing the installation of Automatic Meter Reading (AMR) equipment in the KEDNY territory.

*This sanction amount is $33.112 broken down into:*
*$32.062 Capex*
*$1.050 Opex*
*$0.000 Removal*

### 1.2 Project Summary

There are currently approximately 1.3 million gas meters in the KEDNY territory of which 780K are equipped with automatic meter reading (AMR) equipment. The remainder (520K) is read bi-monthly by pedestrian meter readers.

This project provides funding for the purchase and installation of AMR equipment on the remaining 520K customers.

Installation of AMR on these sites will increase billing accuracy, reduce estimated bills by over 250K per month, and deliver an annual opex savings of over $5.8 Million when fully deployed.

Initial funding for this project was included in our recent KEDNY Deferral which was approved by the NYS PSC on 10/19/15. This funding covers the project thru the end of CY16 (3rd quarter of FY17).

CY15 - $3.75M
CY16- $12.75M
Total - $16.5M

*US Sanction Paper*

nationalgrid

### *1.3 Summary of Projects*

| Project Number | Project Type (Elec only) | Project Title | Estimate Amount ($M) |
|---|---|---|---|
| C067854 | N/A | KEDNY AMR Deployment | 33.112 |
| | | Total | 33.112 |

### *1.4 Associated Projects*

N/A

### *1.5 Prior Sanctioning History*

N/A

### *1.6 Next Planned Sanction Review*

| Date (Month/Year) | Purpose of Sanction Review |
|---|---|
| June 2018 | Project Closure |

### *1.7 Category*

| Category | Reference to Mandate, Policy, NPV, or Other |
|---|---|
| ○ Mandatory<br>⦿ Policy- Driven<br>○ Justified NPV<br>○ Other | Installation of Automatic Meter Reading equipment is policy to collect monthly accurate reads for billing, reduce issuance of estimated bills, and reduce Opex costs |

*US Sanction Paper*

nationalgrid

### *1.8 Asset Management Risk Score*

Asset Management Risk Score: ____49_

**Primary Risk Score Driver:** (Policy Driven Projects Only)

◉ Reliability ○ Environment ○ Health & Safety ○ Not Policy Driven

### *1.9 Complexity Level*

○ High Complexity ○ Medium Complexity ◉ Low Complexity ○ N/A

Complexity Score: __15___

### *1.10 Process Hazard Assessment*

A Process Hazard Assessment (PHA) is required for this project:

○ Yes ◉ No

### *1.11 Business Plan*

| Business Plan Name & Period | Project included in approved Business Plan? | Over / Under Business Plan | Project Cost relative to approved Business Plan (M$) |
|---|---|---|---|
| FY16-FY20 Gas Capital Plan | ◉ Yes ○ No | ◉ Over ○ Under ○ NA | 0.914 |

### *1.12 If cost > approved Business Plan how will this be funded?*

*US Sanction Paper*

Re-allocation of funds within the portfolio will be managed by Resource Planning to meet jurisdictional budgetary, statutory, and regulatory requirements. Funding for FY16 as provided in the recent KEDNY Deferral has been incorporated in current estimates.

### 1.13 Current Planning Horizon

| | | Current Planning Horizon | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Yr. 1 | Yr. 2 | Yr. 3 | Yr. 4 | Yr. 5 | Yr. 6 + | |
| $M | Prior Yrs | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | Total |
| CapEx | 0.000 | 6.832 | 16.033 | 9.197 | 0.000 | 0.000 | 0.000 | 32.062 |
| OpEx | 0.000 | 0.230 | 0.410 | 0.410 | 0.000 | 0.000 | 0.000 | 1.050 |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| CIAC/Reimbursement | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total | 0.000 | 7.062 | 16.443 | 9.607 | 0.000 | 0.000 | 0.000 | 33.112 |

### 1.14 Key Milestones

| Milestone | Target Date: (Month/Year) |
|---|---|
| Sanction Approval | Nov 2015 |
| Order Equipment | Nov 2015 |
| Receive AMR Equipment (initial order) | Dec 2015 |
| Begin Deployment | Jan 2016 |
| Project Completion | Mar 2018 |
| Project Closure | June 2018 |

### 1.15 Resources, Operations and Procurement

| Resource Sourcing | | | |
|---|---|---|---|
| Engineering & Design Resources to be provided | ☑ Internal | ☐ Contractor | |
| Construction/Implementation Resources to be provided | ☑ Internal | ☐ Contractor | |
| **Resource Delivery** | | | |
| Availability of internal resources to deliver project: | ○ Red | ⦿ Amber | ○ Green |
| Availability of external resources to deliver project: | ○ Red | ○ Amber | ⦿ Green |
| **Operational Impact** | | | |
| Outage impact on network system: | ○ Red | ○ Amber | ⦿ Green |

*US Sanction Paper*

nationalgrid

| Procurement Impact | | | |
|---|---|---|---|
| **Procurement impact on network system:** | ○ Red | ○ Amber | ⦿ Green |

### *1.16 Key Issues (include mitigation of Red or Amber Resources)*

| | |
|---|---|
| 1 | CMS to begin Hiring Process Immediately upon Funding Project Approval |
| 2 | IS to complete FDM interface to KEDNY Customer System |
| 3 | |

### *1.17 Climate Change*

| | | | |
|---|---|---|---|
| Contribution to National Grid's 2050 80% emissions reduction target: | ⦿ Neutral | ○ Positive | ○ Negative |
| Impact on adaptability of network for future climate change: | ⦿ Neutral | ○ Positive | ○ Negative |

### *1.18 List References*

N/A

*US Sanction Paper*

nationalgrid

## 2 Decisions

The US Sanctioning Committee (USSC) at a meeting held on 11/19/2015

(a) APPROVED this paper and the investment of $33.112M and a tolerance of +/- 10

(b) NOTED that Philip Di Giglio has the approved financial delegation.

Signature Margaret M Smyth Date 11/30/15

Margaret Smyth
US Chief Financial Officer
Chair, US Sanctioning Committee

*US Sanction Paper*

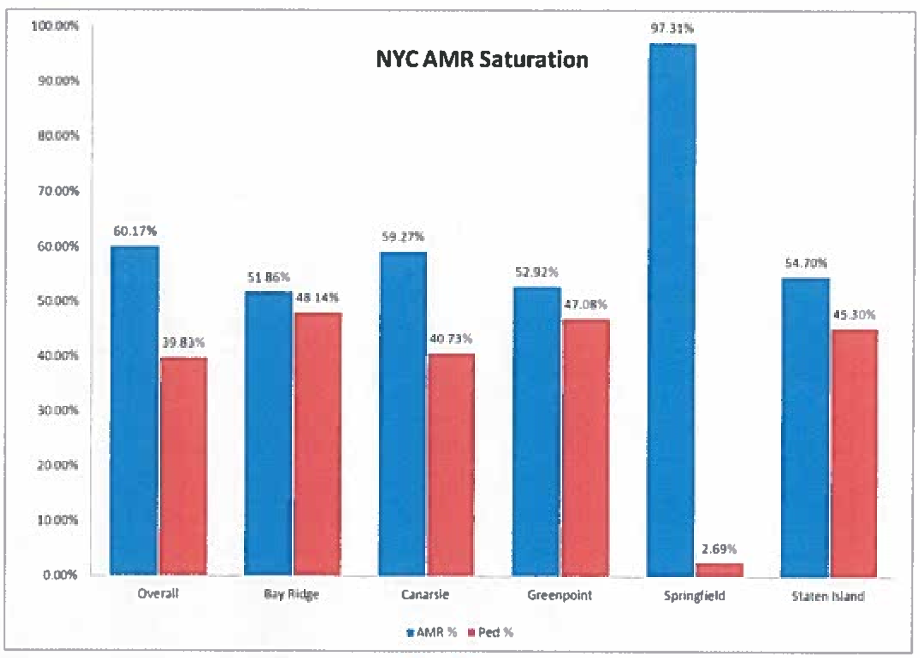
## 3 Sanction Paper Detail

| | | | |
|---|---|---|---|
| **Title:** | KEDNY AMR Deployment | **Sanction Paper #:** | USSC-15-263 |
| **Project #:** | C067854 | **Sanction Type:** | Sanction |
| **Operating Company:** | The Brooklyn Union Gas Co. | **Date of Request:** | 11/19/2015 |
| **Author:** | Philip Di Giglio | **Sponsor:** | Johnny Johnston – VP CMS |
| **Utility Service:** | Gas | **Project Manager:** | Philip Di Giglio |

### 3.1 Background

The Brooklyn Union Gas Company has approximately 1.3M gas customers of which approximately 780K are equipped with Automatic Meter Reading (AMR) equipment. The remaining meter population is read using pedestrian meter readers.

While the overall saturation of AMR equipment is just over 60%, the saturation of AMR varies by individual yard within the territory



***US Sanction Paper*** nationalgrid

Originally, AMR equipment was deployed primarily in the "Springfield" area over 25 years ago as a mass installation project. Over the past 25 years, AMR deployment has expanded as a result of targeted "hard to access" areas, or as part of our meter exchange program resulting in a slow expansion of the technology.

Over the past year, AMR expansion has been positive but slow. While this expansion has been positive for customer satisfaction and increasing the accuracy of customer bills, the scattered expansion approach has an adverse impact on the pedestrian meter reading process whereby we have noted increasing distances between pedestrian read customers, and reduced meter counts on pedestrian route.

NYC AMR Meter Saturation FY2016 nationalgrid HERE WITH YOU. HERE FOR YOU.

Choose Month: September 2015

| | Pedestrian | Ped Variance vs April | Pedestrian % | AMR | AMR Variance vs April | AMR % | Total |
|---|---|---|---|---|---|---|---|
| Bay Ridge | 171,274 | -2,516 | 48.14% | 184,520 | 2,206 | 51.86% | 355,794 |
| Canarsie | 96,884 | -1,524 | 40.73% | 140,976 | 1,453 | 59.27% | 237,860 |
| Greenpoint | 175,753 | -4,358 | 47.08% | 197,592 | 4,340 | 52.92% | 373,345 |
| Springfield | 4,870 | -384 | 2.69% | 176,387 | 304 | 97.31% | 181,257 |
| Staten Island | 71,116 | -1,845 | 45.30% | 85,863 | 1,888 | 54.70% | 156,979 |
| Grand Total | 519,897 | -10,627 | 39.83% | 785,338 | 10,191 | 60.17% | 1,305,235 |

This project allows for the addition of AMR equipment on the remaining 520K accounts over a 24 month period.

### *3.2 Drivers*

Mobile AMR is currently near 100% deployed throughout all other National Grid regions. Once completed in KEDNY, AMR technology will improve the gas actual read rate from the current overall level of 93.75% to above 98% and provide monthly, rather than bi-monthly actual reads for billing for the 520K customers without AMR. As a result, we anticipate a monthly reduction over 250K estimated bills being issued to customers.

This transformational improvement in customer service coupled with a projected annual reduction in opex costs of over $5.8M is the primary driver.

### *3.3 Project Description*

This project provides funding for the completion of the installation of a Mobile (Drive By) AMR System for all gas meters on the KEDNY Gas Distribution System. The AMR endpoint which will be installed is planned to be the ITRON 100G device which is the latest version of the ITRON Gas AMR endpoint already in use in all other National Grid US Gas Distribution service territories.

This endpoint has increased range over the prior version (40G) and is planned to be compatible with the ITRON IPV6 Smart Grid Fixed Network System in the coming year.

The project includes the purchase of 2 additional mobile collectors, AMR Endpoints, installation labor, supervision, and clerical support. We have also included IS costs of $.5M, to support the creation of an interface between the KEDNY customer system and the ITRON Field Deployment System (FDM) currently in use in the KEDLI AMR Project.

### *3.4 Benefits Summary*

- Improved meter reading actual read from an overall rate of 93.75% to 98%
- Decrease in FTE resources required to perform off cycle "Special Read" requests due to a higher actual read rate and monthly versus bi-monthly read schedule.
- Overall reduction in FTE resources required to perform meter reading function
- Projected Annual Opex savings of > $5.8M when fully Deployed
- Overall reduction in chronic long term estimate (LTE) accounts
- Increased ability to track advance consumption on inactive accounts
- Improved customer satisfaction due to a reduction in read to bill errors.
- Avoidance & reduction of OSHA recordables, LTIs and RTCs and associated workers compensation costs.
- Provides ability to capture hourly consumption data with 100G AMR device to support Load Research etc. programs with little or no added cost.

### *3.5 Business and Customer Issues*

There are no significant business issues beyond what has been described elsewhere.

### *3.6 Alternatives*

**Alternative 1:**

Continue Pedestrian Meter Reading

- Continued opex spend of over $5.8M per year for pedestrian meter reading
- Continued 250K estimated bills generated per month
- Continued overall read rate of 83% for pedestrian read meters (vs projected 99%)
- Continued, non-targeted AMR expansion reduces pedestrian route efficiency

This alternative is rejected as it increases Opex spend indefinitely, and provides no operational or customer benefits

**Alternative 2:**

Defer project

- Deferring project delays realization of potential opex savings and customer benefits detailed above

### *3.7 Safety, Environmental and Project Planning Issues*

Project planning issues are mostly centered on deployment strategy. Deployment strategy is currently being developed with the goal of having the IS work to interface our Field Deployment Manager (FDM) system with the KEDNY customer system in place to begin deployment in the fourth quarter of FY16.

In addition, we are developing a staffing plan which will support the installation project within the specified timeline (24 months) while beginning to achieve our opex reduction targets.
For the purposes of the development of this strategy, we have considered the current budgeted Gas resources will remain and are currently developing a roll out strategy which will allow that workforce to continue manual reads for all meters not fitted with

*US Sanction Paper*

nationalgrid

AMR technology during deployment. We believe this is achievable if the project is approved within the time frame indicated in Section 1.6 (Key Milestones) of this paper.

## *3.8 Execution Risk Appraisal*

| Number | Detailed Description of Risk / Opportunity | Probability | Impact | | Score | | Strategy | Pre-Trigger Mitigation Plan | Residual Risk | Post Trigger Mitigation Plan |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Cost | Schedule | Cost | Schedule | | | | |
| 1 | Purchase Orders for project not issued in accordance with project timeline | 1 | 1 | 1 | 1 | 1 | Accept | | | |
| 2 | Qty of installed AMR equipment falls short of 2018 Target | 2 | 3 | 2 | 6 | [illegible] | Mitigate | Develop Strategy to minimize/optimize installation plan | Monitor Installation progress during project | Adjust In-house resources as needed to meet targeted installation |
| 3 | Customer rejection of AMR Technology | 3 | 3 | 5 | 9 | 15 | Mitigate | Develop Customer Outreach Program to socialize benefits of AMR Program | Develop communications plan for Call Center to communicate positives of the project with concerned customers | Work with Regulatory to develop "Opt Out" option for next KEDNY Rate Case |
| 4 | | | | | | | | | | |
| 5 | | | | | | | | | | |
| 6 | | | | | | | | | | |
| 7 | | | | | | | | | | |
| 8 | | | | | | | | | | |
| 9 | | | | | | | | | | |
| 10 | | | | | | | | | | |

## *3.9 Permitting*

N/A

## *3.10 Investment Recovery*

### *3.10.1 Investment Recovery and Regulatory Implications*

Investment recovery will be through standard rate recovery mechanisms approved by appropriate regulatory agencies.

### *3.10.2 Customer Impact*

AMR technology will improve the gas actual read rate for the 520K pedestrian read meters from the current level of 83% to above 99% and provide monthly, rather than bi-monthly actual reads for billing.

***US Sanction Paper***

nationalgrid

The 100G ERT technology will position KEDNY to deploy advanced fixed network technologies thus enabling the creation of beneficial rate structures.

This project results in an indicative first full year revenue requirement when the asset is placed in service equal to approximately $6.59M. This is indicative only. The actual revenue requirement will differ depending upon the timing of the next rate case and/or the timing of the next filing in which the project is included in rate base.

### *3.10.3 CIAC / Reimbursement*

| $M | Prior Yrs | Yr. 1 2014/15 | Yr. 2 2015/16 | Yr. 3 2016/17 | Yr. 4 2017/18 | Yr. 5 2018/19 | Yr. 6 + 2019/20 | Total |
|---|---|---|---|---|---|---|---|---|
| CIAC/Reimbursement | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## *3.11 Financial Impact to National Grid*

### *3.11.1 Cost Summary Table*

| | | | | | Current Planning Horizon | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Project Number | Project Title | Project Estimate Level (%) | Spend ($M) | Prior Yrs | Yr. 1 2015/16 | Yr. 2 2016/17 | Yr. 3 2017/18 | Yr. 4 2018/19 | Yr. 5 2019/20 | Yr. 6 + 2020/21 | Total |
| C067854 | KEDNY AMR Deployment | Est Lvl (e.g. +/- 10%) | CapEx | 0.000 | 6.832 | 16.033 | 9.197 | 0.000 | 0.000 | 0.000 | 32.062 |
| | | | OpEx | 0.000 | 0.230 | 0.410 | 0.410 | 0.000 | 0.000 | 0.000 | 1.050 |
| | | | Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | | Total | 0.000 | 7.062 | 16.443 | 9.607 | 0.000 | 0.000 | 0.000 | 33.112 |
| Total Project Sanction | | | CapEx | 0.000 | 6.832 | 16.033 | 9.197 | 0.000 | 0.000 | 0.000 | 32.062 |
| | | | OpEx | 0.000 | 0.230 | 0.410 | 0.410 | 0.000 | 0.000 | 0.000 | 1.050 |
| | | | Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| | | | Total | 0.000 | 7.062 | 16.443 | 9.607 | 0.000 | 0.000 | 0.000 | 33.112 |

US Sanction Paper

nationalgrid

### 3.11.2 Project Budget Summary Table

**Project Costs per Business Plan**

| | | Current Planning Horizon | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Prior Yrs | Yr. 1 | Yr. 2 | Yr. 3 | Yr. 4 | Yr. 5 | Yr. 6 + | |
| $M | (Actual) | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | Total |
| CapEx | 0.000 | 0.000 | 0.000 | 10.245 | 17.563 | 4.390 | 0.000 | 32.198 |
| OpEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Cost in Bus. Plan | 0.000 | 0.000 | 0.000 | 10.245 | 17.563 | 4.390 | 0.000 | 32.198 |

**Variance** (Business Plan-Project Estimate)

| | | Current Planning Horizon | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Prior Yrs | Yr. 1 | Yr. 2 | Yr. 3 | Yr. 4 | Yr. 5 | Yr. 6 + | |
| $M | (Actual) | 2015/16 | 2016/17 | 2017/18 | 2018/19 | 2019/20 | 2020/21 | Total |
| CapEx | 0.000 | (6.832) | (16.033) | 1.048 | 17.563 | 4.390 | 0.000 | 0.136 |
| OpEx | 0.000 | (0.230) | (0.410) | (0.410) | 0.000 | 0.000 | 0.000 | (1.050) |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Cost in Bus. Plan | 0.000 | (7.062) | (16.443) | 0.638 | 17.563 | 4.390 | 0.000 | (0.914) |

### 3.11.3 Cost Assumptions

- AMR Equipment costs per current contracts
- FTE Labor Costs per FY16 Actuals including loadings
- Future FTE Costs include inflation for current GWI (2.5%)
- Additional requirements are estimated using historical manual meter reading data
- Incremental back office costs to support project have been projected based on similar historical values

### 3.11.4 Net Present Value / Cost Benefit Analysis

#### 3.11.4.1 NPV Summary Table

This is not an NPV Project

#### 3.11.4.2 NPV Assumptions and Calculations

This is not an NPV Project

### *3.11.5 Additional Impacts*

None

## *3.12 Statements of Support*

### *3.12.1 Supporters*

The supporters listed have aligned their part of the business to support the project.

| Department | Individual | Responsibilities |
|---|---|---|
| Investment Planner | Roden, Thomas | Endorses relative to 5-year business plan or emergent work |
| Resource Planning | Buckleman, Brian | Endorses Resources, cost estimate, schedule, and Portfolio Alignment |
| Project Management | Fortier, Joseph Jr. | Endorses Resources, cost estimate, schedule |

### *3.12.2 Reviewers*

The reviewers have provided feedback on the content/language of the paper.

| Function | Individual |
|---|---|
| Finance | Fowler, Keith<br>Horowitz, Philip |
| Regulatory | Zschokke, Peter<br>Gavilondo, Carlos |
| Jurisdictional Delegate | Brown, Laurie |
| Procurement | Curran, Art |
| Control Center | Metzdorff, Peter |

# *4 Appendices*

## *4.1 Sanction Request Breakdown by Project*

N/A

## *4.2 Other Appendices*

None

### *4.3 NPV Summary*

N/A

### *4.4 Customer Outreach Plan*

Appropriate plans will be developed to communicate how NGRID services will be changing and what KEDNY customers can expect from the transition to AMR. Benefits of AMR will include the elimination of estimated bills and the need to provide premise access every cycle in order to obtain an actual read. Communications also will include information on the proven safety and reliability of AMR.

Initially communication channels will include bill messages and inserts, website updates, and news media articles and possibly first class mailings. As deployment begins, more targeted proactive communications will be delivered to customers selected for conversion in specific neighborhoods. Roll out plans and progress updates will be shared with the call center so telephone agents are kept informed in order to respond to customer questions.

It is recommended that at the conclusion of deployment, the Company place news briefings in popular media outlets to recap the ongoing benefits of AMR to customers

The communication plan will be developed in coordination with CMS, Customer Relations, Public Affairs and the NYS Jurisdictional team.

*Short Form Sanction Paper*

nationalgrid

| | | | |
|---|---|---|---|
| **Title:** | FY17 Purchase Misc Capital Tools & Equipment - KEDNY | **Sanction Paper #:** | USSC-16-042 |
| **Project #:** | CNCC501, CNSC501, CNNC501, CNFC501 | **Sanction Type:** | Sanction |
| **Operating Company:** | The Brooklyn Union Gas Co. | **Date of Request:** | February 9, 2016 |
| **Author:** | James Thompson | **Sponsor:** | Robert De Marinis – VP Maintenance & Construction NY |
| **Utility Service:** | Gas | **Project Manager:** | James Thompson |

## 1 Executive Summary

### 1.1 Sanctioning Summary

This paper requests sanction of project numbers CNCC501, CNSC501, CNNC501 and CNFC501 in the amount $ 3.168M and a tolerance of +/- 10% for the purposes of full implementation.

This sanction amount of $3.168M is broken down as follows:
$3.168M Capex
$0.000M Opex
$0.000M Removal

### 1.2 Project Summary

Purchase Miscellaneous Capital Tools and Equipment in FY17 that are not used for specific projects. These items support the safe, efficient and on-going day-to-day operations of the gas business unit.

## 2 Project Detail

### 2.1 Background

Current Company policy capitalizes general tool and/or equipment purchases subject to predetermined minimum dollar thresholds ($500 for The Brooklyn Union Gas Company). Such general equipment includes tooling (hand, power, pneumatic, hydraulic, etc.), specialty equipment, PPE, office machines, electronic data processing equipment and software applications, shop and garage equipment and communications. The Purchase Miscellaneous Capital Tools and Equipment line item captures the above mentioned items that are not used for specific projects but rather support the safe, efficient and on-going day-to-day operations of the gas business unit.

*Short Form Sanction Paper*

Purchase of miscellaneous Capital Tools and Equipment are blanket project numbers that are budgeted based on historical funding due to the inability to associate this equipment with any one specific project.

### *2.2 Drivers*

Maintenance of on-going operations to ensure safety, compliance and commitments to customer needs and expectations are the primary drivers. This budget item is typically used to assure that process related initiatives and subsequent goals are achieved. Funds from this budget line item support significant tasks that support the entire Gas organization. These items relate to safety (e.g. mechanized maintenance of traffic devices, worker safety enhancements etc.), climate change (e.g. apparatus to minimize emissions through natural gas drawdown operations), support of new, emerging and on-going technologies (e.g. capital spares and parts for trenchless and keyhole technologies) and initiation of innovative applications of core technologies that will lead to improved operations.

### *2.3 Project Description*

Purchase Miscellaneous Capital Tools and Equipment that are not used for specific projects but rather support the safe, efficient and on-going day-to-day operations of the gas business unit.

### *2.4 Benefits*

The budget line items support our on-going ability to provide timely service to Customers.

### *2.5 Business & Customer Issues*

There are no significant business and customers issues beyond what has been described elsewhere

### *2.6 Alternatives*

**Alternative 1: Reduce Request – not recommended**
Reducing the budget line item is not recommended because funds allocated here drive process changes that support new initiatives and productivity improvements throughout Gas distribution organization.

*Short Form Sanction Paper*

nationalgrid

### 2.7 Investment Recovery

Investment recovery will be through standard rate recovery mechanisms.

#### 2.7.1 Customer Impact

This project results in an indicative first full year revenue requirement when the asset is placed in service equal to approximately $0.651M. This is indicative only. The actual revenue requirement will differ, depending upon the timing of the next rate case and/or the timing of the next filing in which the project is included in rate base.

## 3 Related Projects, Scoring, Budgets

### 3.1 Summary of Projects

| Project Number | Project Type (Elec only) | Project Title | Estimate Amount ($M) |
|---|---|---|---|
| CNCC501, CNSC501, CNNC501, CNFC501 | | Purchase Misc. Capital Tools & Equipment | 3.168 |
| | | Total | 3.168 |

### 3.2 Associated Projects

N/A

### 3.3 Prior Sanctioning History

N/A

### 3.4 Category

| Category | Reference to Mandate, Policy, NPV, or Other |
|---|---|
| ○ Mandatory<br>◉ Policy- Driven<br>○ Justified NPV<br>○ Other | |

*Short Form Sanction Paper*

nationalgrid

### 3.5 Asset Management Risk Score

Asset Management Risk Score: 36

**Primary Risk Score Driver:** (Policy Driven Projects Only)

◉ Reliability ○ Environment ○ Health & Safety ○ Not Policy Driven

### 3.6 Complexity Level

○ High Complexity ○ Medium Complexity ◉ Low Complexity ○ N/A

Complexity Score: 15

### 3.7 Next Planned Sanction Review

| Date (Month/Year) | Purpose of Sanction Review |
|---|---|
| June 2017 | Project closure |

## 4 Financial

### 4.1 Business Plan

| Business Plan Name & Period | Project included in approved Business Plan? | Over / Under Business Plan | Project Cost relative to approved Business Plan ($) |
|---|---|---|---|
| FY17 – FY21 Capital Plan - Gas | ◉ Yes ○ No | ○ Over ○ Under ◉ NA | $0.000 M |

### 4.1.1 If cost > approved Business Plan how will this be funded?

N/A

### 4.2 CIAC / Reimbursement

*Short Form Sanction Paper*

N/A

## *4.3 Cost Summary Table*

| Project Number | Project Title | Project Estimate Level (%) | Spend | Prior Yrs | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLCC501 | Purchase Misc Capital Tools & Equipment | +/- 10% | CapEx | - | 3.168 | - | - | - | - | - | 3.168 |
| CLSC501 | | | OpEx | - | - | - | - | - | - | - | - |
| CLNC501 | | | Removal | - | - | - | - | - | - | - | - |
| CLFC501 | | | Total | - | 3.168 | - | - | - | - | - | 3.168 |

## *4.4 Project Budget Summary Table*

### Project Costs Per Business Plan

| $M | Prior Yrs (Actual) | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|
| CapEx | 0.000 | 3.168 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.168 |
| OpEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Cost in Bus. Plan | 0.000 | 3.168 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 3.168 |

### Variance (Business Plan-Project Estimate)

| $M | Prior Yrs (Actual) | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|
| CapEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| OpEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Cost in Bus. Plan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## *5 Key Milestones*

| Milestone | Target Date: (Month/Year) |
|---|---|
| Project Sanction | February 2016 |
| Project Close | June 2017 |

*Short Form Sanction Paper*

nationalgrid

## 6 Statements of Support

### 6.1.1 Supporters

The supporters listed have aligned their part of the business to support the project.

| Role | Individual | Responsibilities |
|---|---|---|
| Investment Planner | Roden, Thomas | Endorse relative to 5 yr business plan or emergent work |
| Resource Planning | Buckleman, Brian | Endorses Resources, cost estimate, schedule, and Portfolio Alignment |
| Project Management | Fortier, Joseph Jr | Endorses Resources, cost estimate, schedule |

### 6.1.2 Reviewers

The reviewers have provided feedback on the content/language of the paper.

| Reviewer List | Individual |
|---|---|
| Finance | Keith Fowler, Philip Horowitz |
| Regulatory | Peter Zschokke, Carlos Gavilondo |
| Jurisdictional Delegate Gas - NY | Laurie Brown |
| Procurement | Arthur Curran |
| Control Center | Peter Metzdorff |

### 6.1.3 List References

N/A

*Short Form Sanction Paper*

nationalgrid

## *7 Decisions*

| | |
|---|---|
| (a) | APPROVE this paper and the investment of \$3.168M and a tolerance of +/-10% |
| (b) | NOTE that James Thompson is the Project Manager and has the approved financial delegation. |
| (c) | NOTE: In the event that any Blanket projects are not approved prior to the start of the FY2018 fiscal year, the FY2017 approval limits will remain in effect until such time as the FY2018 blanket projects are approved by USSC and/or other appropriate authority for approval. |

Signature........................................................Date. 3/16/2016

Executive Sponsor – Ross Turrini, SVP, Gas Process & Engineering

7

## *8 Other Appendices*

N/A

### *8.1 Sanction Request Breakdown by Project*

N/A

***Short Form Sanction Paper***

| | | | |
|---|---|---|---|
| **Title:** | FY17 Purchase Misc Capital Tools & Equipment - KEDLI | **Sanction Paper #:** | USSC-16-041 |
| **Project #:** | CLCC501, CLSC501, CLNC501, CLFC501 | **Sanction Type:** | Sanction |
| **Operating Company:** | KeySpan Gas East Corp. | **Date of Request:** | February 9, 2016 |
| **Author:** | James Thompson | **Sponsor:** | Robert De Marinis – VP Maintenance & Construction NY |
| **Utility Service:** | Gas | **Project Manager:** | James Thompson |

# *1 Executive Summary*

## *1.1 Sanctioning Summary*

This paper requests sanction of project numbers CLCC501, CLSC501, CLNC501 and CLFC501 in the amount $1.7M and a tolerance of +/- 10% for the purposes of full implementation.

This sanction amount of $1.700M is broken down as follows:
- $1.700M Capex
- $0.000M Opex
- $0.000M Removal

## *1.2 Project Summary*

Purchase Miscellaneous Capital Tools and Equipment in FY17 that are not used for specific projects. These items support the safe, efficient and on-going day-to-day operations of the gas business unit.

# *2 Project Detail*

## *2.1 Background*

Current Company policy capitalizes general tool and/or equipment purchases subject to predetermined minimum dollar thresholds ($500 for Keyspan Energy East Corp). Such general equipment includes tooling (hand, power, pneumatic, hydraulic, etc.), specialty equipment, PPE, office machines, electronic data processing equipment and software applications, shop and garage equipment and communications. The Purchase Miscellaneous Capital Tools and Equipment line item captures the above mentioned items that are not used for specific projects but rather support the safe, efficient and on-going day-to-day operations of the gas business unit. Purchase of miscellaneous

*Short Form Sanction Paper*

nationalgrid

Capital Tools and Equipment are blanket project numbers that are budgeted based on historical funding due to the inability to associate this equipment with any one specific project.

### *2.2 Drivers*

Maintenance of on-going operations to ensure safety, compliance and commitments to customer needs and expectations are the primary drivers. This budget item is typically used to assure that process related initiatives and subsequent goals are achieved. Funds from this budget line item support significant tasks that support the entire Gas organization. These items relate to safety (e.g. mechanized maintenance of traffic devices, worker safety enhancements etc.), climate change (e.g. apparatus to minimize emissions through natural gas drawdown operations), support of new, emerging and on-going technologies (e.g. capital spares and parts for trenchless and keyhole technologies) and initiation of innovative applications of core technologies that will lead to improved operations.

### *2.3 Project Description*

Purchase Miscellaneous Capital Tools and Equipment that are not used for specific projects but rather support the safe, efficient and on-going day-to-day operations of the gas business unit.

### *2.4 Benefits*

The budget line items support our on-going ability to provide timely service to Customers.

### *2.5 Business & Customer Issues*

There are no significant business and customers issues beyond what has been described elsewhere

### *2.6 Alternatives*

**Alternative 1: Reduce Request – not recommended**
Reducing the budget line item is not recommended because funds allocated here drive process changes that support new initiatives and productivity improvements throughout Gas distribution organization.

*Short Form Sanction Paper*

nationalgrid

### 2.7 Investment Recovery

Investment recovery will be through standard rate recovery mechanisms.

#### 2.7.1 Customer Impact

This project results in an indicative first full year revenue requirement when the asset is placed in service equal to approximately $0.349M. This is indicative only. The actual revenue requirement will differ, depending upon the timing of the next rate case and/or the timing of the next filing in which the project is included in rate base.

## 3 Related Projects, Scoring, Budgets

### 3.1 Summary of Projects

| Project Number | Project Type (Elec only) | Project Title | Estimate Amount ($M) |
|---|---|---|---|
| CLCC501, CLSC501, CLNC501, CLFC501 | | Purchase Misc Capital Tools & Equipment | 1.700 |
| | | $ | 1.700 |

### 3.2 Associated Projects

N/A

### 3.3 Prior Sanctioning History

N/A

### 3.4 Category

| Category | Reference to Mandate, Policy, NPV, or Other |
|---|---|
| ○ Mandatory<br>⊙ Policy- Driven<br>○ Justified NPV<br>○ Other | |

*Short Form Sanction Paper*

nationalgrid

### *3.5 Asset Management Risk Score*

Asset Management Risk Score: 36

**Primary Risk Score Driver:** (Policy Driven Projects Only)

⦿ Reliability ○ Environment ○ Health & Safety ○ Not Policy Driven

### *3.6 Complexity Level*

○ High Complexity ○ Medium Complexity ⦿ Low Complexity ○ N/A

Complexity Score: 15

### *3.7 Next Planned Sanction Review*

| Date (Month/Year) | Purpose of Sanction Review |
|---|---|
| June 2017 | Project closure |

## *4 Financial*

### *4.1 Business Plan*

| Business Plan Name & Period | Project included in approved Business Plan? | Over / Under Business Plan | Project Cost relative to approved Business Plan ($) |
|---|---|---|---|
| FY17 – FY21 Capital Plan - Gas | ⦿ Yes ○ No | ○ Over ○ Under ⦿ NA | $0.000 M |

#### *4.1.1 If cost > approved Business Plan how will this be funded?*

N/A

### *4.2 CIAC / Reimbursement*

*Short Form Sanction Paper*

nationalgrid

N/A

### 4.3 Cost Summary Table

| Project Number | Project Title | Project Estimate Level (%) | Spend | Prior Yrs | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CLCC501 | Purchase Misc Capital Tools & Equipment | +/- 10% | CapEx | - | 1.700 | - | - | - | - | - | 1.700 |
| CLSC501 | | | OpEx | - | - | - | - | - | - | - | - |
| CLNC501 | | | Removal | - | - | - | - | - | - | - | - |
| CLFC501 | | | Total | - | 1.700 | - | - | - | - | - | 1.700 |

### 4.4 Project Budget Summary Table

**Project Costs Per Business Plan**

| $M | Prior Yrs (Actual) | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|
| CapEx | 0.000 | 1.700 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.700 |
| OpEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Cost in Bus. Plan | 0.000 | 1.700 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 1.700 |

**Variance (Business Plan-Project Estimate)**

| $M | Prior Yrs (Actual) | Current Planning Horizon ($M) Yr. 1 2016/17 | Yr. 2 2017/18 | Yr. 3 2018/19 | Yr. 4 2019/20 | Yr. 5 2020/21 | Yr. 6 + 2021/22 | Total |
|---|---|---|---|---|---|---|---|---|
| CapEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| OpEx | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Removal | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Total Cost in Bus. Plan | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

## 5 Key Milestones

| Milestone | Target Date: (Month/Year) |
|---|---|
| Project Sanction | February 2016 |
| Project Close | June 2017 |

*Short Form Sanction Paper*

## 6 *Statements of Support*

### 6.1.1 *Supporters*

The supporters listed have aligned their part of the business to support the project.

| Role | Individual | Responsibilities |
|---|---|---|
| Investment Planner | Roden, Thomas | Endorse relative to 5 yr business plan or emergent work |
| Resource Planning | Buckleman, Brian | Endorses Resources, cost estimate, schedule, and Portfolio Alignment |
| Project Management | Fortier, Joseph Jr | Endorses Resources, cost estimate, schedule |

### 6.1.2 *Reviewers*

The reviewers have provided feedback on the content/language of the paper.

| Reviewer List | Individual |
|---|---|
| Finance | Keith Fowler,<br>Philip Horowitz |
| Regulatory | Peter Zschokke,<br>Carlos Gavilondo |
| Jurisdictional Delegate Gas - NY | Laurie Brown |
| Procurement | Arthur Curran |
| Control Center | Keith Rooney |

### 6.1.3 *List References*

N/A

***Short Form Sanction Paper***

nationalgrid

## *7 Decisions*

(a) APPROVE this paper and the investment of $1.700M and a tolerance of +/-10%

(b) NOTE that James Thompson is the Project Manager and has the approved financial delegation.

(c) NOTE: In the event that any Blanket projects are not approved prior to the start of the FY2018 fiscal year, the FY2017 approval limits will remain in effect until such time as the FY2018 blanket projects are approved by USSC and/or other appropriate authority for approval.

Signature................................................................Date.. 3/15/2016 ........

Executive Sponsor – Ross Turrini, SVP, Gas Process & Engineering

*Short Form Sanction Paper*

## 8 Other Appendices

N/A

### 8.1 Sanction Request Breakdown by Project

N/A

KeySpan Gas East Corporation
d/b/a National Grid
The Brooklyn Union Gas Company
d/b/a/ National Grid NY
16-G-0058 16-G-0059
Attachment 5 to DPS-329 MT-3 BULI-286
Page 1 of 1

| KEDNY AMR INSTALLATION (NON-INFRASTRUCTURE) | | | |
|---|---|---|---|
| Category | CY'17 Capital Plan | CY'18 Capital Plan | CY'19 Capital Plan |
| AMR Installation | $ 15,821 | $ 7,065 | $ 600 |
| Number of Units | 259,000 | 115000 | 9800 |
| Material | $ 10,360,000 | $ 4,600,000 | $ 392,000 |
| Labor | $ 5,459,720 | $ 2,424,200 | $ 206,584 |
| Total | $ 15,819,720 | $ 7,024,200 | $ 598,584 |

| KEDNY AMR REPLACEMENT | | | |
|---|---|---|---|
| Category | CY'17 Capital Plan | CY'18 Capital Plan | CY'19 Capital Plan |
| AMR Installation | $ 5,078 | $ 5,225 | $ 5,330 |
| Material | $ 3,234,000 | $ 3,314,850 | $ 3,397,721 |
| Labor | $ 1,844,000 | $ 1,890,100 | $ 1,937,353 |
| Total | $ 5,078,000 | $ 5,204,950 | $ 5,335,074 |

| KEDLI AMR INSTALLATION / REPLACEMENT (NON-INFRASTRUCTURE) | | | |
|---|---|---|---|
| Category | CY'17 Capital Plan | CY'18 Capital Plan | CY'19 Capital Plan |
| AMR Installation/Replacements | $ 835 | $ 855 | $ 873 |
| Material (12000 units) | $ 475,000 | $ 486,875 | $ 496,613 |
| Labor (field replacments of new or damaged units included above) | $ 360,000 | $ 369,000 | $ 376,380 |
| Total | $ 835,000 | $ 855,875 | $ 872,993 |

Date of Request: March 22, 2016 DPS Request No. DPS-332 JS-1
Due Date: April 1, 2016 KEDNY/ KEDLI Req. No. BULI-289

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, John Sano

TO: National Grid, GIOP

SUBJECT: Renewable Gas Interconnections

Request:

1. Do the Companies have gas quality standards that the Companies provide to local producers of natural gas like anaerobic digester projects, landfills or other in territory gas sources? If so, provide a copy of the gas quality standards that are required.

2. Do the Companies have a standard interconnection process in place for local gas producers? If so, provide a copy of the interconnection process or agreement used.

3. What type of equipment is installed at the interconnection with local gas producers to measure gas quality?

4. What capability does such equipment have to deter gas of inferior quality from entering the distribution system?

5. Describe the process for filtering in place at an interconnection with a typical landfill gas producer.

6. How do the Companies measure heat content of gas entering its distribution system from a local gas producer?

7. Are there operational limits to how much gas can be accepted from local gas producers? If so, provide a list of and detailed explanation of the operational limits.

Response:

1. Yes, National Grid maintains gas quality guidelines for renewable natural gas ("RNG") projects (see Attachment 1). These guidelines provide developers of RNG projects with a framework in which to consider design options based on the nature of the biomass feedstock and resulting digester gas. National Grid is currently leading a collaborative in New York through the Northeast Gas Association to develop a standardized approach for LDCs to consider introduction of RNG into gas distribution systems. The collaborative will work with developer representatives to address technical gas quality and interchangeability issues.

2. The Companies have two standard agreements that cover the interconnection process. Pursuant to an Engineering Services Agreement, National Grid will perform a technical evaluation for the RNG connection requests (see Attachment 2). A separate Gas Sales Agreement defines the commercial/operational arrangement for accepting gas into the distribution system (see Attachment 3). Together, these agreements provide criteria for RNG interconnection.

3. The equipment that is required for continuous quality monitoring of biomethane derived from raw biogas includes:

   - Moisture measurement equipment
   - A gas chromatograph to measure and analyze hydrocarbon and non-hydrocarbon gases, based on constituent measurement, calculated parameters such as heating value, interchangeability indices, specific gravity, hydrocarbon dew point
   - Automated sampling devices to capture samples of gas for measurement and analysis of trace constituents and other components identified in the site specific sampling/monitoring plan
   - Gas temperature, pressure monitoring equipment

4. Critical gas quality variables are monitored in real-time and process control measures (as specified in the Engineering Service Agreement and corresponding Gas Supply Agreement) are in place to facilitate remote isolation of the RNG facility from the gas distribution system. The Companies monitor these critical variables through the SCADA System and reserve the right to isolate the facility from the system upon discovery of unacceptable gas quality conditions. Site specific procedures are developed collaboratively with the RNG project developers to ensure optimized production, acceptance of the gas into the distribution system and to address safety concerns.

5. A variety of biogas clean-up technologies exist; however, these technologies must be evaluated for appropriate application at each RNG project based on a number of site specific variables, including raw gas treatment constituents and facility interconnection physical limitations (pressure and acceptable flow rates into the distribution system). These treatment systems include:

a. Solid phase absorption (raw gas is passed over the solid material to absorb constituents of concern).
b. Membrane systems utilizing selective constituent semi-permeable membrane materials that filter constituents of concern from the raw gas stream followed by regeneration once the membrane become saturated.
c. Solvent based absorption processes, which include contacting raw gas with an appropriate solvent that is capable of absorbing constituents of concern.

Most treatment systems incorporate a combination of technologies depending on the constituents of concern to be removed to meet the gas quality specifications of the LDC and are designed based of detailed raw gas analysis.

6. The Companies monitor the heating value of gas entering its system through gas chromatographs. Hydrocarbon and non-hydrocarbon constituents are identified, and a software program is used to calculate heating value consistent with ASTM standards.

7. The Companies evaluate site specific interconnection variables to ensure the anticipated production volumes can be accommodated within the distribution system. It is the Companies' policy not to offer pairing services (commercial blending services) for these facilities as dilution of non-conforming gases cannot be relied on to ensure system safety. Gas entering the distribution system is expected to be pre-treated such that processed gas is similar in composition and characteristics of pipeline gas at the specified connection point within the distribution system. National Grid's gas quality guidelines are included in Attachment 1.

| | |
|---|---|
| Name of Respondent:<br>Robert Wilson | Date of Reply:<br>March 31, 2016 |

# RNG DEVELOPMENT & ACCEPTANCE GUIDELINES FOR PIPELINE QUALITY GAS

Raw biogas shall be appropriately treated utilizing industry acceptable practices and treatment systems acceptable to National Grid to ensure reliability in meeting the following gas quality guidelines:

(1) Gas shall be of composition and quality to ensure safe, reliable operation of the distribution system and be capable of direct utilization by distribution system customers without further treatment or blending/aggregation by National Grid, and,

(2) Commercially free of objectionable matter as defined in latest edition of **AGA Report 4A - Natural Gas Contract Measurement and Quality Clauses** including, but not limited to, trace constituents such as bacteria and other particulate matter, liquids, dust, gums, tars, volatile metals, siloxanes, VOC's, SVOC's, PCB's and other hazardous constituents that interfere with merchantability of pipeline natural gas, and

(3) Completely interchangeable with flowing pipeline gas common to the National Grid distribution system.

In addition, it shall meet the specifications set forth below.

| **Value** | **Minimum Acceptable** | **Preferred (Normal Operations)** |
|---|---|---|
| HHV (dry @ 14.73 psia) | 975 Btu/Scf | 980 Btu/Scf |
| Wobbe Number | 1280 | 1290 |
| | | |
| **Constituent** | **Maximum** | **Preferred** |
| $CO_2$ | 2% | As low as practical |
| $N_2$ | 2.50% | As low as practical |
| Total Inerts ($N_2 + CO_2$) | 4% | As low as practical |
| Total Sulfur (Incl. contributions from naturally occurring mercaptans) | < 1 ppm | As low as practical |
| $H_2S$ | < 0.25 grains/100cf (4 ppm) | As low as practical |
| $O_2$ | < 0.2% | As low as practical |
| Moisture Content | < 7 lbs/mmcf | As low as practical |
| Temperature | 100 $^{O}$F | - |

Draft 6/18/15

**SAMPLE**
**ENGINEERING SERVICES REIMBURSEMENT AGREEMENT**

**THIS ENGINEERING SERVICES REIMBURSEMENT AGREEMENT** ("*Agreement*"), effective as of this [____] day of [_________] ("*Effective Date*"), is by and between [_____________] ("*Customer*"), a [_____________] organized and existing under the laws of [____________], and KeySpan Gas East Corporation d/b/a National Grid ("*Company*"), a corporation organized and existing under the laws of the State of New York.

**WHEREAS,** Customer is proposing to build an anaerobic digester within a landfill located in [____], New York that will recover methane gas from organic food waste to be burned on site to generate electricity, with excess gas to be sent to Company's natural gas distribution system (the "*Project*"); and

**WHEREAS,** Customer desires to have Company perform certain engineering services (as specified below) in connection with the Project, and Company has agreed to perform such services upon the terms and conditions set forth below;

**NOW, THEREFORE,** in consideration of the mutual promises and covenants contained herein, and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, the parties entering into this Agreement (each a "*Party*", and collectively, the "*Parties*"), with the intent to be bound, agree as follows:

**ARTICLE I – SERVICES**

**Section 1 - Scope of Services**

Company will perform those services specified in Exhibit A attached hereto and hereby incorporated herein ("*Services*"). No goods, equipment, or materials will be provided under this Agreement.

This Agreement does not provide for generation interconnection service, procurement of equipment, installation or construction, or transmission service.

**Section 2 - Customer's Responsibilities**

Customer shall provide:

1. Complete and accurate information regarding requirements for Services, including, without limitation, constraints, space requirements and relationships, special equipment, systems, site requirements, underground or hidden facilities and structures, and all applicable drawings and specifications;

2. If and to the extent applicable, Company access to the site where Services will be performed;

Draft 6/18/15

3. A project manager who will be given the authority to coordinate all aspects of the Project between Customer and Company;

4. If and to the extent applicable, adequate parking for the vehicles of Company personnel performing the Services; and

5. Other responsibilities and access deemed necessary by, and in the sole discretion of, Company to facilitate performance of the Services.

Customer shall reasonably cooperate with Company as required to facilitate Company's performance of the Services. Other express Customer responsibilities, if any, shall be as specified in Exhibit A attached hereto.

Anything in this Agreement to the contrary notwithstanding, Company shall have no responsibility or liability under this Agreement for any defective performance or nonperformance to the extent such defective performance or nonperformance is caused by the inability or failure of (i) Customer to cooperate or to perform any of the tasks or responsibilities contemplated to be performed or undertaken by Customer in Exhibit A or elsewhere in this Agreement, or (ii) Customer and Company to reach agreement on any matter requiring their mutual agreement as contemplated in Exhibit A or elsewhere in this Agreement.

**Section 3 - Unknown Conditions**

Customer represents, warrants and covenants that all information provided by Customer is accurate and complete and acknowledges and agrees that Company may and will rely on this representation, warranty and covenant in performing under this Agreement. If, as a result of additional, different, or previously unknown information, any changes in Services are required that will result in an increase or decrease in the cost or time of performance under the Agreement, the Price, schedule and other affected provisions of this Agreement shall be equitably adjusted and this Agreement shall be amended in writing to memorialize such changes.

**Section 4 - Changes and Extras**

Customer may request changes in Services in writing. If any such changes will result in an increase or decrease in the cost or time of performance under this Agreement, the Price, schedule and other affected provisions of the Agreement shall be equitably adjusted and this Agreement shall be amended in writing to memorialize such changes. Company may make changes in Services with the prior written approval of Customer (which approval shall not be unreasonably withheld, conditioned, or delayed).

**Section 5 - Governmental Requirements**

Changes in Services may be necessary in order to meet the requirements of governmental authorities, laws, regulations, ordinances, Good Utility Practice (as such term is defined in

Article V, Section 1, below) and/or codes. After Customer's approval (which shall not be unreasonably withheld, conditioned, or delayed), Company will make changes in Services as it deems necessary, in its sole discretion, to conform to such requirements. If any such changes will result in an increase or decrease in the cost or time of performance under this Agreement, the Price, schedule and other affected provisions of this Agreement shall be equitably adjusted and this Agreement shall be amended in writing to memorialize such changes. If Customer withholds its approval, and in Company's sole and exclusive judgment the withholding of approval by Customer is not reasonable, then, at Company's election, this Agreement may be immediately terminated upon written notice to Customer. Nothing in this Agreement shall relieve Customer of the responsibility to comply with requirements of ISO-NE or other utilities with regard to the Project and the Services.

**ARTICLE II – PRICE, TAXES, AND PAYMENT**

**Section 1 - Price**

The price for the Services to be paid by Customer shall be the actual costs and expenses incurred by the Company and its affiliates in connection with performance of the Services or otherwise incurred by Company in connection with this Agreement, and shall include, without limitation, any such costs that may have been incurred by Company prior to the Effective Date (the "*Price*").

The Price shall include, without limitation, the actual costs and expenses for the following to the extent incurred in connection with performance of the Services: labor (including, without limitation, internal labor); materials; subcontracts; equipment; travel, lodging, and per diem paid in accordance with Company policy; copying and reproduction of materials, overnight delivery charges, certified mailing charges, first class mailing charges and similar types of incidental charges; transportation; carrying charges and surcharges; all applicable overheads including an Administrative and General (A&G) expense charge at Company's current rate at the time of invoicing; all federal, state and local taxes incurred; all costs and fees of outside experts, consultants, counsel and contractors; all other third-party fees and costs; and all costs of obtaining any required consents, releases, approvals, or authorizations. All invoiced sums will include applicable expenses, surcharges, and federal, state and local taxes.

If Customer claims exemption from sales tax, Customer agrees to provide Company with an appropriate, current and valid tax exemption certificate, in form and substance satisfactory to Company, relieving Company from any obligation to collect sales taxes from Customer ("*Sales Tax Exemption Certificate*"). During the term of this Agreement, Customer shall promptly provide Company with any modifications, revisions or updates to the Sales Tax Exemption Certificate or to Customer's exemption status. If Customer fails to provide an acceptable Sales Tax Exemption Certificate for a particular transaction, Company shall add the sales tax to the applicable invoice to be paid by Customer.

Draft 6/18/15

**Section 2 – Payment**

Customer shall provide Company with an initial prepayment in the amount of twenty thousand US dollars ($20,000.00) ("*Initial Prepayment*"). Company shall not be obligated to commence performance of Services until it has received the Initial Prepayment. If, during the performance of the Services, Company determines that one or more additional prepayments are required before completing the Services, Company may, but is not required to, request additional prepayment from Customer; any such requests will be in writing. If an additional prepayment is requested and is not received from Customer on or before the date specified in each such request, or if no date is specified, within 30 days of receipt of the written request, Company may cease work upon the depletion of the Initial Prepayment and any other prepayments made by Customer to date, as applicable. Upon Company's receipt of the additional requested prepayment from Customer (such prepayment to be additional to the Initial Prepayment and any other prepayments made by Customer to date), Company will continue to perform the Services. The Initial Prepayment and the additional prepayments (if any) represent estimates only.

Company is not required to request additional prepayments from Customer and may elect, in its sole discretion, to continue performing Services hereunder after the depletion of the Initial Prepayment, or any other prepayments made by Customer to date, as applicable, without additional prepayments and invoice Customer for such Services at a later date. Customer shall be responsible to pay Company the total Price for completing the Services actually performed by Company whether or not any additional prepayments were made at Company's request. Any election by Company to seek or defer additional prepayments in one instance shall not obligate the Company to seek or defer additional prepayments in any other instance.

Company will invoice Customer for all sums owed under this Agreement. With the exception of additional prepayments required under the first paragraph of this Section 2 of Article II, in which case the due date provided in such paragraph shall apply, payment shall be due in full within thirty (30) days of Company's submittal of an invoice, without regard to claims or off-sets. Payment shall be made in immediately available funds transmitted by the method specified in the invoice. A continuing late payment charge of 1.5% per month will be applied on any late payments.

If Company's Price for completing the Services is less than the Initial Prepayment plus any such additional prepayments paid by Customer under this Article ("*Total Prepayment*"), Company will refund the remaining unused portion of the Total Prepayment to Customer.

**ARTICLE III - SCHEDULE, DELAYS, AND FORCE MAJEURE**

Company will use reasonable efforts to commence the Services promptly following its receipt of all of the following: a fully executed Agreement, the Initial Prepayment, and all information required by this Agreement to be supplied by Customer prior to commencement of the Services.

If Company's performance of the Agreement is delayed by Customer, an equitable adjustment shall be made for any increase in the cost and/or time of performance caused by the delay.

Any delays in, or failure of, performance by Customer or Company, other than payment of monies, shall not constitute default and shall be excused hereunder, if and to the extent such delays or failures of performance are caused by occurrences beyond the reasonable control of Customer or Company, as applicable, including, but not limited to, acts of God, Federal and/or state law or regulation, sabotage, explosions, acts of terrorism, unavailability of personnel, equipment, supplies, or other resources for utility-related duties, delays by governmental authorities in granting licenses, permits or other approvals necessary in connection with Services, compliance with any order or request of any governmental or judicial authority, compliance with Company's public service obligations, storms, fires, inclement or adverse weather, floods, riots or strikes or other concerted acts of workers, and accidents.

## ARTICLE IV – INTELLECTUAL PROPERTY

Any drawings, specifications or other documents (i) prepared or used by Company, or (ii) prepared by Customer for Company in connection with this Agreement, shall be the proprietary, confidential information and sole property of Company at no cost to Company (collectively "*Materials*").

Excluding third-party owned documents and software, Customer is granted an irrevocable, nontransferable, and non-assignable license to use such Materials solely in connection with the Project. No commercialization of such Materials by Customer is authorized. Customer shall not disclose any of the Materials to any third party, in whole or in part, without the prior written consent of Company.

The obligations imposed by this Article IV shall survive the completion, cancellation, or termination of this Agreement.

## ARTICLE V – PERFORMANCE

### Section 1 -- Performance.

Company shall perform the Services in a manner consistent with "Good Utility Practice" (as such term is defined below); provided, however, that Company shall have no responsibility or liability in connection with (i) any items or services provided by Customer or its third party contractors or representatives whether or not such items or services are incorporated in the Services, (ii) any items or services provided, manufactured or licensed by third parties whether or not such items or services are incorporated in the Services, or (iii) any defects in Services that result from the acts or omissions of persons other than Company or accidents not caused by Company.

Draft 6/18/15

"*Good Utility Practice*" shall mean the practices, methods and acts engaged in or approved by a significant portion of the electric utility industry during the relevant time period, or any practices, methods and acts which, in the exercise of good judgment in light of the facts known at the time the decision was made**,** would have been reasonably expected to accomplish the desired result consistent with good business practices, safety, and law. Good Utility Practice is not intended to require or contemplate the optimum practice, method or act, to the exclusion of all others, but rather to be reasonably acceptable practices, methods, or acts generally accepted in the region in which the Services are to be performed.

Prior to the expiration of one (1) year following the date of completion of a Service, Customer shall have the right to give Company written notice that some or all of such Service was not performed in compliance with the first paragraph of this Section 1, and the Company shall, at the option of Company, either (i) re-perform or repair the defective portion of such Service, or (ii) refund the amount of money paid by the Customer to Company attributable to the defective portion of such Service. The remedy set forth in this Section 1 of Article V is the sole and exclusive remedy granted to Customer for any failure of Company to meet the performance standards or requirements set forth in this Agreement.

## ARTICLE VI – INSURANCE

From the commencement of the Agreement through its expiration, each Party shall provide and maintain, at its own expense, insurance policies issued by reputable insurance companies with an A. M. Best rating of at least B+ (collectively, the "*Required Insurance Policies*"). The Required Insurance Policies shall, at a minimum, include the following coverages and limitations:

**Workers' Compensation and Employers Liability Insurance**, as required by the State in which the work activities under this Agreement will be performed. If applicable, coverage will include the U.S. Longshoremen's & Harbor Workers' Compensation Act, and the Jones Act. If a Party is a qualified self-insurer by the State, Excess Workers' Compensation coverage shall be maintained in lieu of the Workers' Compensation coverage.

**Public Liability**, including Contractual Liability and Products/Completed Operations coverage, covering all operations to be performed under this Agreement, with minimum limits of:

| | | |
|---|---|---|
| Bodily Injury | - | $1,000,000 per occurrence |
| Property Damage | - | $1,000,000 per occurrence |

**Automobile Liability**, covering all owned, non-owned and hired vehicles used under or in connection with this Agreement, with minimum limits of:

| | |
|---|---|
| Bodily Injury | - $500,000 per occurrence |
| Property Damage | - $500,000 per occurrence |
| OR | |
| Combined Single Limit | - $1,000,000 per occurrence |

Draft 6/18/15

If requested, each Party will provide evidence to the other Party that it maintains the Required Insurance Policies required under this Article.

Either Party may elect to self-insure to the extent authorized or licensed to do so under the applicable laws of the State of New York, provided, that, the electing Party provides written notice of any such election to the other Party. Company hereby notifies Customer that it is a qualified self-insurer under the applicable laws of the State of New York and that it elects to self-insure to satisfy its obligations under this Article.

**ARTICLE VII – TERM AND TERMINATION**

The term of this Agreement shall expire one (1) year from the Effective Date. As of the expiration of this Agreement or, if earlier, its termination, the Parties shall no longer be bound by the terms and provisions hereof, except (a) to the extent necessary to enforce the rights and obligations of the Parties arising under this Agreement before such expiration or termination (including, without limitation, with respect to payment of all amounts due and payable hereunder), and (b) such terms and provisions that expressly or by their operation survive the termination or expiration of this Agreement.

Either Party may terminate this Agreement for convenience by delivery of written notice to the other Party, such termination to be effective on the tenth (10th) day following delivery of such written notice, or upon payment in full of all amounts due and payable hereunder, whichever is later. On or before the effective termination date of this Agreement, Customer shall pay Company all amounts due and payable as the Price for that portion of the Services performed to the effective date of termination ("*Amount Outstanding*"), including, without limitation, all costs and expenses incurred, less the Total Prepayment. In the event that the Total Prepayment exceeds the Amount Outstanding, Company shall remit the balance to Customer.

**ARTICLE VIII – MISCELLANEOUS PROVISIONS**

**Section 1 - Assignment and Subcontracting**

Customer agrees that Company has the right, but not the obligation, to (i) use the services of its affiliated companies in connection with the performance of Services, and (ii) issue contracts to third parties for, or in connection with, the performance of Services hereunder, without the prior consent of Customer, and that the costs and expenses of such affiliated companies or third parties charged or chargeable to Company shall be paid by Customer as part of the Price.

**Section 2 – No Third-Party Beneficiary**

Nothing in this Agreement is intended to confer on any person, other than the Parties, any rights or remedies under or by reason of this Agreement.

Draft 6/18/15

**Section 3 – Amendment; Equitable Adjustments**

This Agreement shall not be amended, superseded or modified, except in a writing signed by both Parties. In any circumstance in which this Agreement contemplates an equitable adjustment to Price, schedule or any other term of this Agreement, Company shall have no obligation to continue performance hereunder until and unless such equitable adjustment has been mutually agreed to by both Parties in writing.

**Section 4 – Notices**

Any notice given under this Agreement shall be in writing and shall be hand delivered, sent by registered or certified mail, delivered by a reputable overnight courier, or sent by facsimile with electronic confirmation of receipt, to the party's representatives as follows:

Customer:

[___________________]
Attn: [ ]
[________________]
[________________]
Phone: [_____________]
Facsimile: [_________]

Company:

KeySpan Gas East Corporation d/b/a National Grid
Attn: [ ]
[__________________]
[__________________]
Phone: [_______________]
Email: [___________________]

**Section 5 - Waiver**

No term of this Agreement may be waived except in a writing signed by an authorized representative of the Party against whom the amendment, modification, or waiver is sought to be enforced. Waiver of any provision herein shall not be deemed a waiver of any other provision herein, nor shall waiver of any breach of this Agreement be construed as a continuing waiver of other breaches of the same or other provisions of this Agreement.

**Section 6 - Approvals**

It is understood that Company may be required to obtain, regulatory, and other third-party approvals and releases in connection with the provision of the Services. If so, this

Agreement shall be effective subject to the receipt of any such approvals and releases, in form and substance satisfactory to Company in its sole discretion, and to the terms thereof.

**Section 7 - Laws**

This Agreement shall be interpreted and enforced according to the laws of the State of New York and not those laws determined by application of the State of New York's conflicts of law principles. Venue in any action with respect to this Agreement shall be in the State of New York; each Party agrees to submit to the personal jurisdiction of courts in the State of New York with respect to any such actions.

**Section 8 - Severability**

To the extent that any provision of this Agreement shall be held to be invalid, illegal or unenforceable, it shall be modified so as to give as much effect to the original intent of such provision as is consistent with applicable law and without affecting the validity, legality or enforceability of the remaining provisions of the Agreement.

**Section 9 - Integration and Merger; Entire Agreement**

Customer and Company each agree that there are no understandings, agreements, or representations, expressed or implied, with respect to the subject matter hereof other than those expressed herein. This Agreement supersedes and merges all prior discussions and understandings with respect to the subject matter hereof, and constitutes the entire agreement between the Parties with respect to such subject matter.

**Section 10 – Authority**

Each Party represents to the other that the signatory identified beneath its name below has full authority to execute this Agreement on its behalf.

**Section 11 – Information and Coordination Contact**

[__name, contact information________________________________], or such other representative as Company may designate, will be the point of contact for Customer to submit the information required for Company to perform the Services stated in this Agreement. [____________] or such other representative as Customer may designate, will be the point of contact for Company to request additional information from Customer, if required.

**Section 12 – Counterparts**

This Agreement may be executed in multiple counterparts, each of which shall be considered an original, and all of which together shall constitute one and the same agreement. The exchange of copies of this Agreement and of signature pages by facsimile or other electronic transmission (including, without limitation, by e-mailed PDF) shall constitute effective execution and delivery of this Agreement as to the Parties and may be used in lieu of the original

Agreement for all purposes. Signatures of the Parties transmitted by facsimile or other electronic means (including, without limitation, by e-mailed PDF) shall be deemed to be their original signatures for all purposes.

*[Signatures are on following page.]*

Draft 6/18/15

**IN WITNESS WHEREOF,** the Parties hereto have caused this Agreement to be executed by their duly authorized representatives as of the Effective Date.

**KeySpan Gas East Corporation d/b/a National Grid**

By: ____________________________________
Name:
Title:

**Company Name**

By: ____________________________________
Name:
Title:

Draft 6/18/15

# EXHIBIT A

**Scope of Services**

Company's scope of Services shall be:

- Assign a Project Engineer and Project Manager to provide technical support for the Project;
- Arrange and schedule periodic Project meetings;
- Provide standards for Customer to follow in order to design metering equipment in accordance with Company specifications;
- Provide the specifications for the meters to be installed and determine the size and quantity of meters required;
- Provide technical assistance as needed by Customer in reviewing the design and layout for analytical equipment to be installed by Customer in accordance with manufacturer's recommendations;
- Provide technical assistance as needed by Customer in reviewing the design and layout for odorant equipment to be installed by Customer in accordance with applicable health and safety codes for the storage of odorant, including DEC, DEP, and Suffolk County Department of Health;
- Review drawings and specifications created by Customer for the equipment set forth below. Company reserves the right to make changes to the design in order to meet National Grid standards; and
- Provide engineering services to assist Customer in design and development of specifications for the work to purchase and install the equipment and facilities set forth below.

Equipment and Facilities Required for Project (to be provided by Customer):

- Gas service and associated metering equipment for back up supply from Company
- Gas outlet system tie-in and associated metering equipment for gas produced on site
- Remote Terminal Unit (RTU) to transmit gas quality and flow data to Company's Gas Control Room
- Gas Chromatograph (10 component) to measure BTU, inerts ($CO2$, $N2$), Oxygen of digester gas
- Odorant Chromatograph to measure mercaptans, total sulfur, and $H2S$ in the digester gas
- Moisture Meter to measure amount of $H2O$ in the digester gas
- Remote control valve to enable remote shut-in of Customer's outlet in cases where gas from the plant is out of specification as listed in Table below.
- Odorant injection system with sight glass diffusion probe, storage tank(s) with dike
- Gas filters with differential gages on plant outlet line

- Analyzer Building – prefab concrete building to house RTU and all analytical equipment with electric service and Power Conditioning, and Battery Back Up system, gas detector(s)
- Odorant Building – negative pressure concreted building to house odorant equipment with electric service and gas detector(s), charcoal filter, blower, fire suppression and monitoring equipment (as required by Town of Brookhaven Fire Marshall).

*Assumptions and Conditions:*

Any dates, schedules or cost estimates resulting from the Services are preliminary projections/estimates only and shall not become or give rise to any binding commitment.

The Services contemplated by this Exhibit and this Agreement do not include any construction, relocations, alterations, modifications, or upgrades with respect to any facilities ("Construction"), nor does Company make any commitment to undertake such Construction. If the Parties elect, in their respective sole discretion, to proceed with any Construction: (i) such Construction would be performed pursuant to a separate, detailed, written, and mutually acceptable Cost Reimbursement Agreement to be entered into by the Parties prior to the commencement of any such Construction, and (ii) payment of all actual costs incurred by Company or its Affiliates in connection with or related to such Construction shall be the responsibility of Customer and Customer shall reimburse Company for all such costs.

For the avoidance of doubt: This Agreement does not provide for generation interconnection service, procurement of equipment, installation or construction. The Company shall not have any responsibility for seeking or acquiring any real property rights in connection with the Services or the Project including, without limitation, licenses, consents, permissions, certificates, approvals, or authorizations, or fee, easement or right of way interests. Neither this Agreement nor the Services include securing or arranging for Customer or any third party to have access rights in, through, over or under any real property owned or controlled by the Company.

Draft 7/15/15

**Sample**
**DIGESTER GAS SALES AGREEMENT**

This Digester Gas Sales Agreement ("Agreement"), dated as of the __ day of _____, 201_ by and between KeySpan Gas East Corporation d/b/a National Grid (hereinafter referred to as "Buyer" or "Company"), a New York corporation with offices at 100 East Old Country Road, Hicksville, NY 11801 and Company Name (hereinafter referred to as "Seller"), a ____________[state] [corporation] with offices at [address] and each hereinafter referred to as a "Party" or collectively as the "Parties".

**WHEREAS**, Seller owns an anaerobic digester situated within a landfill located in [ ], New York that recovers digester methane gas from organic food waste exclusive of other gases from Landfill operations; and

**WHEREAS**, Buyer is a regulated natural gas distribution company which owns and operates a natural gas distribution system in Nassau and Suffolk counties; and

**WHEREAS**, Seller desires to sell and deliver Pipeline Quality Processed Digester Gas to Buyer, and Buyer desires to purchase and accept such Processed Digester Gas from Seller; and

**WHEREAS**, Buyer has agreed to operate and maintain certain of the facilities required in connection with the delivery of Processed Digester Gas, and Seller has agreed to reimburse Buyer for performing such operation and maintenance services; and

**NOW THEREFORE**, in consideration of the foregoing premises and of the mutual covenants and agreements contained herein, the Parties hereby agree as follows:

**ARTICLE 1**
**DEFINITIONS**

1.1 The term "Btu" means British Thermal unit, and shall be the quantity of heat required to raise the temperature of one (1) pound of water one degree Fahrenheit at sixty (60) degrees Fahrenheit at a pressure of 14.73 psia.

1 .2 The term "Day" means a period of twenty-four (24) consecutive hours beginning and ending at 9:00 AM Central Standard Time.

1 .3 The term "Delivery Point" shall mean the point of interconnection between the facilities of Seller and Buyer at or near the Landfill where Processed Digester Gas will be sold and delivered by Seller to Buyer under this Agreement, as shown on Exhibit "A" hereto. [Schematic drawing]

1.4 "Facilities'" means those facilities that will be maintained by the Company pursuant to this Agreement and other facilities utilized in connection with the delivery of Processed Digester Gas.

Draft 7/15/15

1.5 “Landfill” means the existing Customer Address.

1.6 The term "Maximum Daily Quantity" (or "MDQ')is the maximum amount of Processed Digester Gas that Buyer is obligated to purchase on any Day during the term of this Agreement.

1.7 The term "MMbtu" means one million Btu.

1.8 The term "Month" means a period beginning at 9:00 AM Central Standard Time on the first Day of any calendar month and ending at 9:00 AM Central Time on the first Day of the next succeeding calendar month.

1.9 The term Plant" means the digester and processing facilities operated by Seller located at the Landfill.

1.10 The term "Processed Digester Gas" means natural gas produced by Seller at the Plant.

1.11 "Services" has the meaning set forth in Article 8 of this Agreement.

1.12 “Pipeline Quality” has the meaning defined in latest version of AGA Report 4a.

**ARTICLE 2**
**EFFECTIVE DATE AND TERM**

2.1 The term of the Agreement shall commence as of the date first written above and shall remain in effect through _____________, 20__, and from month to month thereafter unless terminated by either Party on no less than thirty (30) days prior written notice to the other.

2.2 Upon the termination of this Agreement for any reason, any monies due and owing Seller or Buyer shall be paid pursuant to the terms hereof, and any corrections or adjustments to payments previously made shall be determined and made at the earliest possible time. The provisions of this Agreement shall remain in effect until the obligations under this paragraph have been fulfilled.

**ARTICLE 3**
**SALE AND PURCHASE OBLIGATIONS**

3.1 Subject to the terms and conditions of this Agreement, Seller agrees to sell and deliver, and Buyer agrees to purchase and receive, each Day during the term of this Agreement, at the Delivery Point, a quantity of Pipeline Quality Processed Digester Gas equal to the lesser of (a) the quantity of Processed Digester Gas produced by the Plant on such Day or (b) the MDQ for such Day.

3.2 As of the effective date of this Agreement, the MDQ shall be __________MMBtu.

Draft 7/15/15

3.3 Seller shall tender Pipeline Quality Processed Digester Gas for delivery at a substantially uniform rate of flow throughout each Day, at a minimum of 0 mdth/day and a maximum of ___ mdth/day, except that if Seller becomes aware that the rate of delivery or the total quantity of Pipeline Quality Processed Digester Gas, Seller will deliver for any Day will differ by more than twenty-five percent (25%) (positive or negative) from that achieved the previous Day, Seller shall so notify Buyer's Gas Control Center at the contact set forth in Section 13.10 below. Seller also shall notify Buyer's Gas Control Center at least twenty-four (24) hours in advance of any suspension of Processed Digester Gas deliveries under this Agreement necessitated by Seller's maintenance of its Plant.

**ARTICLE 4**
**PRICE OF GAS**

4.1 The price paid for each MMBtu of Processed Digester Gas sold and purchased under this Agreement in any Month shall be equal to the New York Mercantile Exchange (NYMEX) natural gas futures contract last day settle price for such Month.

**ARTICLE 5**
**TITLE TO GAS**

5.1 Seller hereby warrants good and merchantable title to all Pipeline Quality Processed Digester Gas delivered hereunder, free and clear of all liens, encumbrances and claims whatsoever. Seller will indemnify Buyer and hold it harmless from any and all suits, actions, debts, accounts, damages, costs, losses, and expenses arising from or out of adverse title claims of any and all persons to said Pipeline Quality Processed Digester Gas.

5.2 Title to all Pipeline Quality Processed Digester Gas received by Buyer shall pass to Buyer at the Delivery Point. As between the Parties hereto, Seller shall be deemed to be in exclusive control and possession of the Processed Digester Gas deliverable hereunder and responsible for any damage or injury caused thereby until the same shall have been delivered to Buyer at the Delivery Point; thereafter Buyer shall be deemed to be in exclusive control and possession of such gas and responsible for any damage or injury caused thereby.

**ARTICLE 6**
**GAS PRESSURE, TEMPERATURE AND QUALITY**

6.1 Seller shall tender Pipeline Quality Processed Digester Gas for delivery to Buyer under this Agreement at the Delivery Point at pressures sufficient for such Pipeline Quality Processed Digester Gas to enter Buyer's facilities at such point, but in no event in excess of the maximum allowable operating pressure on Buyer’s system which, at the time of execution of this Agreement, is 124 psig. Buyer shall promptly notify Seller of any changes in the maximum operating pressure of the Buyer's system.

6.2 Seller shall tender Pipeline Quality Processed Digester Gas for delivery to Buyer under this Agreement at the Delivery Point at a temperature no less than 40 degrees Fahrenheit and no greater than 100 degrees Fahrenheit. Should Seller tender Processed Digester Gas to Buyer at the Delivery Point at a temperature colder or warmer than such range and Buyer's meter is damaged as a result, then in addition to and without limitation of any other remedy Buyer may have, Buyer shall be entitled to receive from Seller an amount equal to Buyer's cost to repair or replace such meter and any other related equipment affected.

6.3 Seller agrees that it will exercise reasonable care and diligence in tendering Pipeline Quality Processed Digester Gas for delivery to Buyer under this Agreement, and warrants that all Pipeline Quality Processed Digester Gas when tendered for delivery to Buyer hereunder at the Delivery Point shall:

a. be compatible and interchangeable with pipeline gas as defined in 16 NYCRR 229;

b. be within the limits set forth below:

Table 1: Gas Quality Specifications

| Gas Quality Specification | Low | High |
|---|---|---|
| **BTU Content (Heat Content) [BTU/scf]** | 980 | 1100 |
| **Wobbe Number (capped @ 1400 w/ BTU of 1100)** | 1290 | 1390 |
| **Relative Density** | 0.56 | 0.60 |
| **Water Vapor Content [lb/MMscf]** | - | 6.5 |
| **Mercaptans (as Odorant) [lb/MMscf]** | 0.35 | 0.75 |
| **Hydrocarbon Dew Point, [°F] CHDP** | - | 12°F |
| **Hydrogen Sulfide ($H_2S$)** | - | 0.5 ppmv |
| **Total Sulfur** | | <1.0 ppmv |
| **Diluent Gases**<br>**Carbon Dioxide ($CO_2$)**<br>**Nitrogen ($N_2$)**<br>**Oxygen ($O_2$)**<br>**Total Diluents** | - | <br>2.0%<br>2.5%<br>0.15%<br>**Not to exceed 4.0%** |
| **Hydrogen** | - | 0.04 vol% |
| **Total Bacteria** | - | Not Detectable |
| **Mercury** | - | Not Detectable |
| **Other Volatile Metals (including arsenic)** | - | Not Detectable |
| **Siloxanes (D4)** | - | Not Detectable |
| **Ammonia** | - | Not Detectable |
| **Non-Halogenated Semi-Volatile and Volatile Compounds** | - | Not Detectable |
| **Halocarbons** | - | Not Detectable |

Draft 7/15/15

| | | |
|---|---|---|
| **Aldehyde/Ketones** | - | Not Detectable |
| **Radon** | - | <1 pci/L |
| **PCBs** | - | Not Detectable |
| **Pesticides** | - | Not Detectable |

***NOTES:***

1. *Not-detectable for purposes of this specification is defined as a value less than the lowest detectable level for a mutually agreeable standard industry analytical test method*
2. *BTU = commonly referred to as Higher Heating Value (HHV)*
3. *Wobbe = Interchangeability parameter; ratio of BTU content to specific gravity*
4. *In addition to the specified limits above, gas received into Buyer's pipeline system shall be pipeline quality and as such remain commercially free of objectionable materials and merchantable as defined in latest edition of AGA Report 4A "Natural Gas Contract Measurement and Quality Clauses"*

c. be monitored as to conformity with all of the foregoing criteria by manual test or by mutually acceptable continuous monitoring equipment; and Buyer will require quarterly random grab sampling to ensure gas is free of objectionable materials with analytical costs to be reimbursed by the Seller.

6.4 Seller shall maintain in good working order its facilities at the Plant that enable it to ensure that the pressure, temperature and quality of the Pipeline Quality Processed Digester Gas it tenders for delivery under this Agreement fully conform with the criteria set forth in this Agreement.

6.5 In addition to any and all other remedies that it may have, Buyer shall have the right to reject as non-conforming any Processed Digester Gas Seller tenders for delivery under this Agreement that fails to comply with the pressure, temperature or quality specifications set forth in this Agreement, and will maintain suitable equipment at Seller's premise in order to remotely monitor and shut off Seller's supply should it not meet such specifications.

6.6 The Parties shall develop a facility start-up gas quality sampling and testing plan (the "Plan") to ensure all equipment is functioning as and intended in order to provide Pipeline Quality Processed Digester Gas conforming to the quality specifications set forth in Table 1 above. The Plan shall include provisions regarding frequency of initial testing.

## ARTICLE 7
## GAS MEASUREMENT

7.1 The quantity of Processed Digester Gas delivered hereunder shall be measured according, to Boyle's and Charles' Laws for the measurement of gas under varying temperatures and pressures and shall be determined as follows:

Draft 7/15/15

a. the sales unit of the Processed Digester Gas delivered shall be one (1) MMBtu of gas measured as HHV on a real, dry, basis at standard temperature and pressure;

b. the unit of weight for the purpose of measurement shall be one (1) pound mass of gas;

c. the average absolute atmospheric pressure shall be assumed to be 14.73 pounds per square inch; and

d. the temperature of gas passing through the meter shall be determined by the continuous use of a temperature measuring device; the arithmetic averages of the temperature recorded each twenty-four (24) hour Day shall be used in computing gas volumes or continuous instantaneous temperature measurements may be applied to metering instruments to provide the volume computation.

7.2 The metering equipment shall be sealed and the seals shall be broken only upon occasions when the meters are to be inspected, tested or adjusted, and representatives of Seller shall be afforded at least twenty-four (24) hour notice and reasonable opportunity to be present upon such occasions. Buyer shall use reasonable efforts to give Seller more than twenty-four (24) hour notice of such inspections, tests or adjustments.

7.3 Periodic tests of such metering equipment, at intervals not to exceed two times per year, will be made at any reasonable time upon request there for by Seller. If, as a result of any such additional test, the metering equipment is found to be defective or inaccurate, it will be restored to a condition of accuracy or replaced. If an additional test of the metering equipment is made at the request of Seller with the result that said metering equipment is found to be registering correctly or within two percent (2%) plus or minus of one hundred percent (100%) accuracy, Seller shall bear the expense of such additional test. If such additional test shows an error greater than two percent (2%) plus or minus of one hundred percent (100%) accuracy, then Buyer shall bear the expense of such additional test and any necessary repair or replacement.

7.4 All meters shall be adjusted as close as practical to one hundred percent (100%) accuracy at time of installation and testing. If any of the metering equipment tests provided for herein disclose that the error for such equipment exceeds two percent (2%) plus or minus of one hundred percent (100%) accuracy, and the period of inaccuracy cannot be reasonably ascertained, then the period of inaccuracy will be assumed to have begun at the midpoint in time between the discovery of the inaccuracy and the previous meter test.

7.5 Any correction in billing resulting from such correction in meter records shall be made in the next monthly invoice rendered by Buyer after the inaccuracy is discovered. Should any metering equipment fail to register the gas delivered or received during any period of time, the amount of Processed Digester Gas delivered or received during such period will be estimated by the Parties according to the amounts previously delivered or received during similar periods under substantially similar conditions, and upon mutual agreement of the Parties shall be used as the basis for billing for that period.

Draft 7/15/15

## ARTICLE 8
## OPERATION and MAINTENANCE SERVICES, EQUIPMENT REPLACEMENT COSTS

8.1 SCOPE - During the term of this Agreement the Company will perform, or cause to be performed, in a prudent and workman like manner the Services set forth in Section 8.2 below. Upon the mutual agreement of the Parties, the Company may perform additional Services (the "Unscheduled Services") in connection with the Facilities. In the case of emergencies that render the Facilities unsafe, the Company may perform emergency services that it deems necessary to make the Facilities safe (the "Emergency Services"), including shutting off gas supply and the gas delivery. The Company shall attempt to notify Seller prior to commencing any such Emergency Services, however if prior notification is impractical, the Company shall have the right to commence the Emergency Services immediately and to notify Seller within 24 hours thereafter.

8.2 SERVICES - During the term of this Agreement, the Company shall provide the labor and materials necessary to operate and maintain the gas meters, gas regulators, odorant system, gas chromatographs, telephone lines and other ancillary equipment required by the Company in connection with the delivery of Processed Digester Gas pursuant to this Agreement (the "Services"). The Services do not include repairs for damages, malfunctions or failures caused by or occurring as the result of: (a) repairs, adjustments or any other actions performed by persons other than the Company's authorized representatives; (b) failure of components not serviced by the Company's authorized representatives; (c) abuse, misuse or negligent acts of Seller or others; or (d) an event of force majeure as defined in Article 11 hereof. Installation of the equipment described above is the Seller’s responsibility.

8.3 COST OF SERVICES - Seller shall reimburse the Company for the fully loaded cost incurred by the Company in performing the Services, Unscheduled Services and/or Emergency Services.

8.4 EQUIPMENT REPLACEMENT AT END OF LIFE – Seller shall reimburse the Company for the fully loaded cost to replace gas meters, gas regulators, odorant system, gas chromatographs, telephone lines and other ancillary equipment when such equipment reaches the end of its service life.

## ARTICLE 9
## BILLING AND PAYMENT

9.1 On or before the fifth (5th) day of each Month, Buyer shall notify Seller of the quantity of Processed Digester Gas delivered by Seller to Buyer during the preceding Month. Seller shall render a written statement to Buyer on or before the fifteenth (15th) day of such succeeding Month which, upon verification by Buyer, shall be paid by Buyer by the twenty-fifth (25th) day of such Month. If the twenty-fifth (25th) day of any Month falls on a weekend or bank holiday, payment by Buyer shall be due on the next succeeding business day.

9.2 The fully loaded costs incurred by the Company in performing any Services,

Draft 7/15/15

Unscheduled Services and/or Emergency Services will be applied as an offset to the amount invoiced by Seller pursuant to Section 9.1 above.

9.3 AUDITS. Each Party shall have the right at its own expense to examine and audit at a reasonable time and upon reasonable prior notice the books, records and charts of the other Party relevant to this Agreement. Each Party shall use reasonable efforts to make available such records as may be necessary to verify the accuracy of any statements or charges made under or pursuant to any of the provisions of this Agreement. A formal audit of accounts shall not be made more than once each calendar year.

## ARTICLE 10
## ACCESS TO PREMISES

10.1 Seller agrees during the term of this Agreement that it will provide access as may be required by the Company's authorized representatives for the performance of its obligations hereunder. Upon 24 hours' notice, Seller shall grant access to, or obtain access for, the Company's authorized representatives for performance of the Services and the Unscheduled Services. Furthermore, Seller shall grant or obtain immediate access for the Company's authorized representatives for the performance of Emergency Services.

## ARTICLE 11
## FORCE MAJEURE

11.1 The term force majeure as employed herein shall mean acts of God, strikes, lockouts or other industrial disturbances, acts of the public enemy, wars, blockades, insurrections, riots, epidemics, landslides, lightning earthquakes, fires, storms, floods, washouts, arrests, the order of any court of governmental authority having jurisdiction while the same is in force and effect, civil disturbances, explosions, breakage, accidents to machinery or lines or pipe, freezing of or damage to facilities, ·inability to obtain or unavoidable delay in obtaining material, equipment, and any other cause whether of the kind herein enumerated or otherwise, not reasonably within the control of the Party claiming suspension and which by the exercise of due diligence such Party is unable to prevent or overcome.

11.2 In the event of either Party being rendered unable, wholly or in part, by force majeure to carry out its obligations (other than the continuing obligation set forth herein below), it is agreed that on such Party's giving notice and full particulars of such force majeure in writing or by telegraph or telecopy to the other Party within a reasonable time (not to exceed five (5) days) after occurrence of the cause relied on, the obligations of both Parties, so far as they are affected by such force majeure, shall be suspended during such period of force majeure, but for no longer period, and such cause shall so far as possible be remedied with all reasonable dispatch.

11.3 Neither Party shall be liable in damages to the other for any act, omission or circumstance occasioned by, or in consequence of, force majeure, as herein defined. Such causes or contingencies affecting the performance by either Party, however, shall not relieve it of liability unless such Party shall give notice and full particulars of such cause or contingency in writing, to the other Party at the address set forth in Section 13.10 within a reasonable time after the occurrence relied upon, nor shall such causes or contingencies affecting the performance by either Party relieve it of liability in the event of its failure to use due diligence to remedy the situation and remove the cause with all reasonable dispatch, nor shall such causes or contingencies affecting the performance relieve Buyer from its obligation to make payments of amounts in respect of Pipeline Quality Processed Digester Gas delivered.

11.4 To the extent that, in Buyer's sole judgment. Buyer's ability to receive, measure monitor and/or odorize pipeline quality Processed Digester Gas is impaired by conditions on its system including, but not limited to, the performance of routine maintenance or repairs, then Buyer's obligation to purchase and receive such Processed Digester Gas shall be suspended for the duration of such condition.

## ARTICLE 12
## EVENTS OF DEFAULT

12.1 EVENTS OF DEFAULT - The occurrence of anyone or more of the following shall be an "Event of Default” under this Agreement:

(a) Failure by a party to pay/reimburse any amount when due and payable that is required to be paid by the terms of this Agreement.

(b) Failure by a party to perform any covenant, condition or agreement required to be performed by it by the terms of this Agreement that continues for a period of ten (10) days after the required date of performance.

12.2 REMEDIES ON DEFAULT.

(a) The non-defaulting party shall have the right, upon written notice to the defaulting party, to terminate this Agreement upon any Event of Default.

(b) Upon any Event of Default by the Company, Seller, or a designee of Seller, may cure any breach or default of the Company under this Agreement that resulted in an Event of Default (including the failure to perform Services), in which case the full cost thereof shall be reimbursed to Seller by the Company.

## ARTICLE 13
## MISCELLANEOUS

13.1 Except as provided hereinafter, neither this Agreement nor any rights or obligations hereunder may be assigned or transferred, by operation of law or otherwise by either Party without the prior written consent of the other Party, which consent shall not be unreasonably withheld. Notwithstanding the foregoing, Buyer may assign this Agreement and all of its rights and obligations to an affiliate of Buyer at any time upon 30 days prior written notice to Seller.

13.2 Seller shall provide, at no cost to Buyer, all of the electricity and compressed air required for Buyer to operate the facilities that will measure, regulate and odorize the Processed Digester gas delivered by Buyer to Seller under this Agreement at Buyer's facilities for such purposes located at or near the Delivery Point.

13.3 The sale and delivery of Processed Digester Gas by Seller and the purchase and receipt thereof by Buyer are subject to all valid legislation with respect to the subject matter hereof and to all valid present and future orders, rules and regulations of duly constituted authorities having jurisdiction. Neither Buyer nor Seller shall be liable to the other for failure to perform any obligation hereunder where such failure is due to compliance with such valid laws, orders, rules or regulations. If any statute, order, rule, or regulation of a duly constituted authority having jurisdiction over a Party or the performance of this Agreement prevents Seller from charging or collecting the price or prices payable hereunder or prevents Buyer from recovering costs representing the price or prices payable hereunder, the following shall apply notwithstanding any other provision of this Agreement:

a. If Buyer is prevented from recovering any costs representing all or a portion of the price or prices payable hereunder, or Buyer’s recovery of such costs is made subject to refund, Buyer may, at its option, terminate this Agreement by written notice to Seller, effective not less than sixty (60) days after delivery thereof;

b. If Seller is prevented from charging or collecting all or any part of the price or prices payable hereunder, or Seller's collection of such prices is made subject to refund, Seller may, at its option, terminate this Agreement by written notice to Buyer, effective not less than sixty (60) days after delivery thereof.

13.4 This Agreement sets forth all understandings between the Parties respecting the terms and conditions of this transaction. All other agreements, understandings and representations by and between the Parties hereto prior to this Agreement, whether consistent or inconsistent, oral or written, concerning this transaction are merged into and superseded by this written Agreement.

13.5 All headings appearing herein are for convenience only and shall not be considered a part of this Agreement for any purpose.

13.6 The Parties may, by mutual agreement, waive any provision herein; however, a waiver shall not be construed to constitute a continuing waiver hereunder and furthermore, a waiver by either Party of any one or more defaults by the other Party in performance of any provision of this Agreement shall not operate or be construed as a waiver of future default or defaults, whether of a like or different character.

13.7 Seller hereby agrees to indemnify and hold harmless Buyer from damage to Buyer's or third parties' property or injury to persons (including death) to the extent resulting from the negligence of Seller, its servants, agents or employees, while engaged in activities under this Agreement. Buyer shall indemnify and hold harmless Seller from damage to Seller's or third parties’ property or injury to persons (including death) to the extent resulting from the negligence of Buyer, its servants, agents or employees while engaged in activities under this Agreement except to the extent Buyer's Schedule for Gas Service (as filed with and approved by the Public Service

Draft 7/15/15

Commission of the State of New York), limits Buyer's liability. The obligations under this Section shall survive termination of this Agreement.

13.8 THIS AGREEMENT SHALL BE GOVERNED BY AND CONSTRUED IN ACCORDANCE WITH THE LAWS OF THE STATE OF NEW YORK, WITHOUT REGARD TO ANY RULES GOVERNING CONFLICTS OF LAWS THAT WOULD REQUIRE APPLICATION OF THE LAWS OF ANOTHER JURISDICTION.

13.9 This Agreement may be executed in several counterparts, each of which is an original and all of which constitute one and the same instrument.

13.10 Unless otherwise specified, any notice, reque.st, demand, statement, bill or other payment provided for in this Agreement, or any notice which a Party may desire to give to the other, shall be considered duly delivered as of the earlier of the date of the receipt by the addressee or three (3) business days after the postmark date when mailed by ordinary mail or given to the addressee at the addresses listed below:

**BUYER:**

**Notices:**

KeySpan Gas East Corporation d/b/a National Grid
100 East Old Country Road
Hicksville, NY 11801

Attention:
Gas Contracting and Compliance

**Billings:**

KeySpan Gas East Corporation d/b/a National Grid
100 East Old Country Road, 2nd floor
Hicksville, New York 11801
Attn: Comptroller

**Gas Control Center:**

**SELLER:**

**NOTICES and BILLINGS**
(Original)

Draft 7/15/15

(Copy Submitted to)

Draft 7/15/15

IN WITNESS WHEREOF, The Parties have duly executed this Agreement as of the day and year first above written.

**KeySpan Gas East Corporation d/b/a National Grid**

By:________________________________________

**Company Name**

By:________________________________________

Date of Request: April 11, 2016
Due Date: April 21, 2016

DPS Request No. DPS-418 JL-1
KEDNY/ KEDLI Req. No. BULI-435

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, James Lyons

TO: National Grid, GIOP

SUBJECT: Automated Meter Reading - KEDLI

Request:

Provide the following:

1. Referring to p. 84 of the Gas Infrastructure and Operations Panel (GIOP), identify the percent of AMR deployment in KEDLI's service territory that is complete and what deployment KEDLI expects to have completed in Calendar Year (CY) 2016.

2. Table 11 GIOP testimony shows costs associated with Automated Meter Reading for CY 2017, CY 2018 and CY 2019. Enumerate the specific activities and the associated costs, by activity, for AMR for each calendar year shown.

3. Table 11 does not provide costs associated with AMR Replacement; explain why there are no cost projected for AMR replacement for CY 2017, 2018, and 2019? Also, identify when the Company anticipates that it will incur such costs.

4. Identify KEDLIs estimated useful life for these installed AMR devices. If there are different classes of meters and the useful life varies by class, please explain the differences that exists between classes.

5. Provide a chart showing the numbers AMR meters installed by year and projected replacement timeframe.

6. Provide any Cost/Benefit Analyses performed by the Company to support its meter replacement program.

7. The Company identified that these AMR meters are compatible with an AMI upgrade going forward, if such a decision were made by the Company. Describe the activities necessary to upgrade these meters to be AMI compatible and the associated costs. For example, will physical changes need to be made to these meters? If so, what changes will be needed and the anticipated costs (capital/labor/etc.)? What communications infrastructure will be necessary to support such a changeover and the anticipated costs (capital/labor/etc.)? What software changes will be required to support the change from an AMR infrastructure to an AMI infrastructure and the estimated costs for each such software application?

Response:

1. KEDLI's AMR deployment is now 97.5% (580,000 meters) complete. The remaining 15,000 customer meters are expected be completed in CY 2016 (assuming the Company is afforded access to install AMR).

2. The requested information was previously provided in Attachment 5 to DPS 329.

3. As indicated in the Company's response to DPS 329, the forecast AMR costs presented in Table 11 include new installations and replacements.

4. As indicated in the Company's response to DPS 329, the average service life of a typical AMR meter is 20 years. There is no difference between meter classes.

5. Attachment 1 is a chart showing the number of AMR meters installed by year and projected replacement timeframe. The work schedule provides for all AMR installations to be complete in CY 2016, a small number of replacements each year thereafter through 2028, followed by a ramp-up in replacements beginning in 2029 as the meters begin to near the end of their useful lives.

6. As stated in Exhibit __ (GIOP-4) at page 23, the primary driver for the Company's meter replacement program is compliance with state regulatory requirements. There is no available cost/benefit analysis for the mandated meter replacement program.

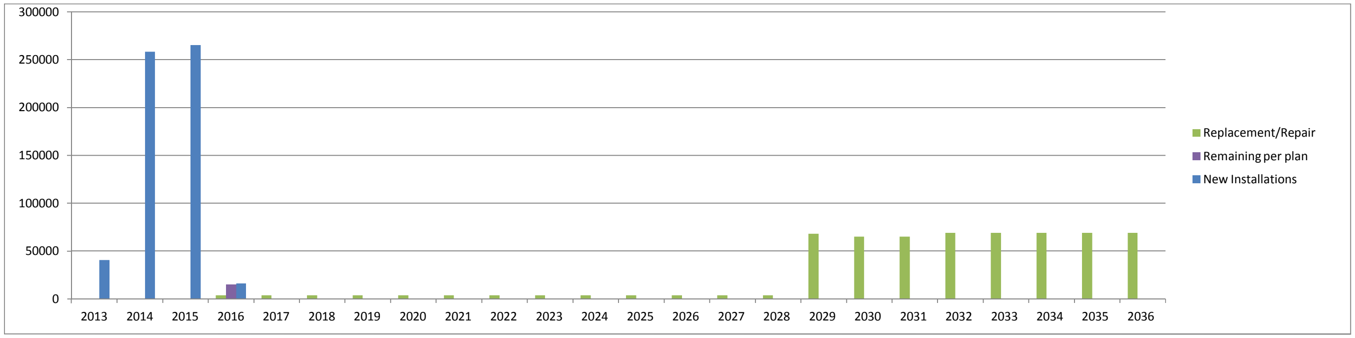
7. The ITRON 100G ERT endpoint is compatible with the ITRON Fixed Network AMI System with no required changes to the meter endpoint. Fixed network systems require the installation of a communications network compatible with the meter endpoints to be purchased and installed. This network is only available from ITRON, the manufacturer of the AMR endpoints being used. The Company has not developed a cost estimate for an upgrade to AMI.

Name of Respondent:
Phillip DiGiglio

Date of Reply:
April 21, 2016

| LI AMR Installations | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New Installations | 40,542 | 258,291 | 265,167 | 16,118 | | | | | | | | |
| Replacement/Repair | | | | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 | 4,000 |
| Remaining per plan | | | | 14,882 | | | | | | | | |

| LI AMR Installations | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New Installations | | | | | | | | | | | | |
| Replacement/Repair | 4,000 | 4,000 | 4,000 | 4,000 | 68,000 | 65,000 | 65,000 | 69,000 | 69,000 | 69,000 | 69,000 | 69,000 |
| Remaining per plan | | | | | | | | | | | | |



Date of Request: April 11, 2016 DPS Request No. DPS-419 JL-2
Due Date: April 21, 2016 KEDNY/ KEDLI Req. No. BULI-436

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, James Lyons

TO: National Grid, GIOP

SUBJECT: Automated Meter Reading - KEDNY

Request:

Provide the following:

1. Table 11 of the Gas Infrastructure and Operations Panel (GIOP) testimony shows AMR Installation and Replacement Costs for Calendar Year (CY) 2017, CY 2018 and CY 2019. Enumerate the specific activities and the associated costs, by activity, for these two AMR categories for each calendar year shown.

2. Referring to p. 89 of the GIOP testimony, identify what AMR deployment in KEDNY's service territory will be complete in CY 2108. Explain why there are no costs shown for AMR deployment for CY 2018 in Table 11 Table 11 shows AMR Replacement Costs in excess of $5 million for CY 2017, CY 2018 and CY 2019. Explain how these cost estimates were developed.

3. The panel on p. 89 indicates that AMR has been in KEDNY's service territory for nearly twenty years, thus a significant number of existing AMR units are at or near the end of their useful lives. Identify KEDNY's estimated useful life for these devices. If there are different classes of meters and the useful life varies by class, explain the differences that exists between classes.

4. Provide a chart showing the number of AMR meters to be installed by year and projected replacement timeframe for the period 2016 to 2036.

5. Provide any Cost/Benefit Analyses performed by the Company to support its meter replacement program.

6. The Company identified that these AMR meters are compatible with an AMI upgrade going forward, if such a decision were made by the Company. Describe the activities necessary to upgrade these meters to be AMI compatible and the associated costs. For example, will physical changes need to be made to these meters? If so, what changes will be needed and the anticipated costs (capital/labor/etc.)? What communications infrastructure will be necessary to support such a changeover and what are the anticipated costs (capital/labor/etc.)? What software changes will be required to support the change from an AMR infrastructure to an AMI infrastructure and what are the estimated costs for each such software application?

Response:

1. The requested information was previously provided in Attachment 5 to DPS-329.

2. The KEDNY AMR project was initially expected to be completed in early CY 2018. However, as discussed in the Company's April 4, 2016 Corrections and Updates testimony at page 7, the work plan has been extended. The revised schedule is reflected in Attachment 5 to DPS-329. The AMR replacement project includes both material and labor costs associated with the annual replacement of approximately 57,000 AMR units per year; both proactive (units > 16 years old) and reactive (units that have failed due to end of life). Attachment 5 to DPS-329 provides a breakdown of the forecast AMR costs for CY 2017 through CY 2019.

3. As indicated in the Company's response to DPS-329, the average service life of a typical AMR meter is 20 years. There is no difference between meter classes.

4. Attachment 1 is a chart showing the number of AMR meters to be installed by year and projected replacement timeframe for the period 2016 to 2036.

5. As stated in Exhibit __ (GIOP-4) at page 39, the primary driver for the Company's meter replacement program is compliance with state regulatory requirements. There is no available cost/benefit analysis for the mandated meter replacement program.

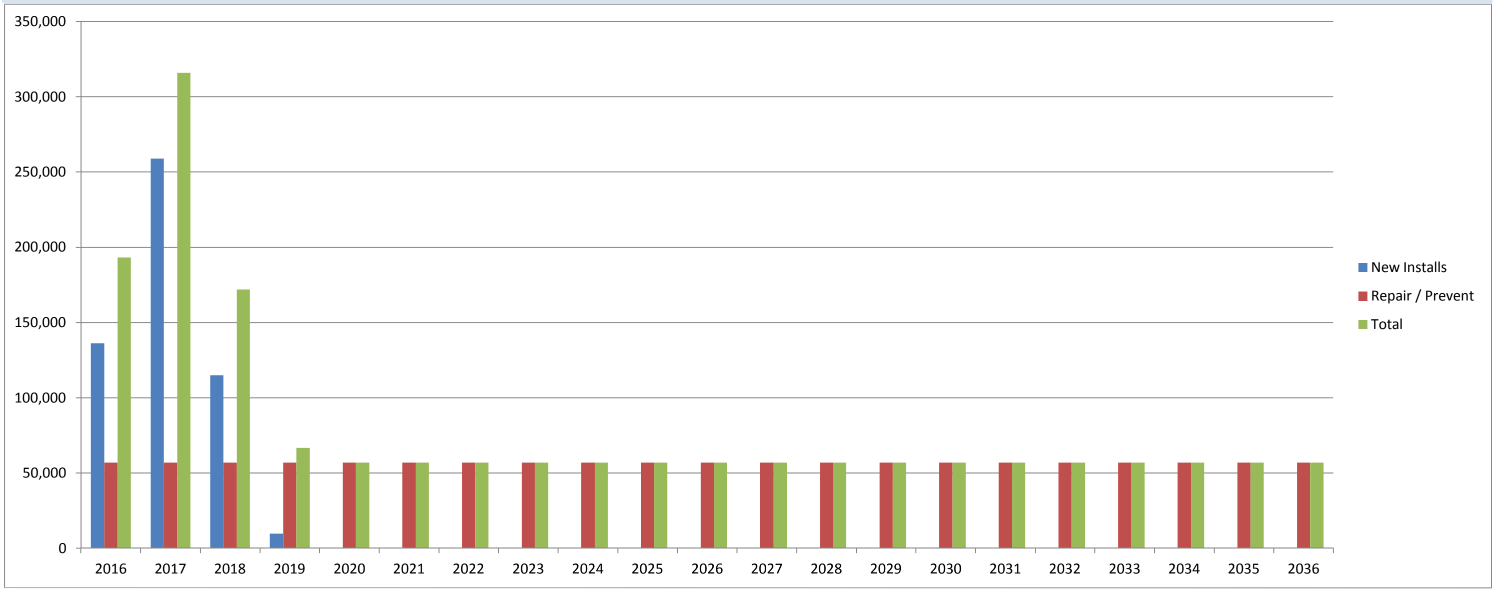
6. For meters installed in 2016 or later, the ITRON 100G ERT endpoint is compatible with the ITRON Fixed Network AMI System with no required changes to the meter endpoint. Meters installed prior to 2016 would need to be replaced to be AMI compatible; there is no upgrade option. In addition, fixed network systems require the installation of a communications network compatible with the meter endpoints to be purchased and installed. This network is only available from ITRON, the manufacturer of the AMR endpoints being used. The Company has not developed a cost estimate for an upgrade to AMI.

Name of Respondent:
Philip DiGiglio

Date of Reply:
April 20, 2016

The Brooklyn Union Gas Company
d/b/a National Grid NY
Case 16-G-0059
Attachment 1 to DPS-419 JL-2 BULI-436


| | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 | 2025 | 2026 | 2027 | 2028 | 2029 | 2030 | 2031 | 2032 | 2033 | 2034 | 2035 | 2036 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| New Installs | 136,200 | 259,000 | 115,000 | 9,800 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Repair / Prevent | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57000 | 57000 | 57000 | 57000 |
| Total | 193,200 | 316,000 | 172,000 | 66,800 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57,000 | 57000 | 57000 | 57000 | 57000 |



Date of Request: April 11, 2016 DPS Request No. DPS-420 JL-3
Due Date: April 21, 2016 KEDNY/ KEDLI Req. No. BULI-437

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, James Lyons

TO: National Grid, Sean Mongan

SUBJECT: Research and Development Costs - KEDLI

Request:

Provide the following:

1. Using the table below, provide five (5) years of data (one table for each year, 2011-2015, showing the annual planned budget, program revenues (surcharges/base rates) collected from customers, actual program expenditures, and reconciled accrued program dollars for each of the three major R&D program areas (KEDLI Internal, NYSERDA, and Millennium). If the amount is $0 for any cell, indicate the $0 amount and explain why the amount is zero.

2. For 2016, provide the same data as requested in question 1, showing the projected/estimated program expenditures, program revenues to be collected during 2016, actual program expenditures to-date, and accrued program dollars for each of the three major R&D program areas ((KEDLI Internal, NYSERDA, and Millennium).

| KEDLI Research and Development 2010 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | | | | |
| **NYSERDA** | | | | |
| **Millennium** | | | | |
| **Total** | | | | |

3. On pp. 19-20, you indicate that Utilization Technology Development (UTD) is currently engaged with more than 60 active end-use technologies. Provide a list of those technologies.

4. To the extent that the company currently engages in internal research and development, identify how these projects differ from those end-use technologies that will be developed by UTD.

5. On pp. 21-22 you show planned cost associated with UTD of $250,000 annually and identify flexibility for the KEDLI to determine which projects they wish to support. Explain where the program dollars will come from that KEDLI plans to direct to projects that have the greatest potential to benefit its customers. For example, will these expenditures come from the $250,000 planned annual expenditures for this program or another source? If these expenditures will come from the $250,000, How much of these dollars will be under the control of the company? If they will come from another source, explain where they originate from.

Response:

1. Please see below:

| KEDLI Research and Development 2011 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $64,085 | $0 | $64,085 | $0 |
| **NYSERDA** | $1,165,393 | $1,034,456 | $1,165,393 | $0 |
| **Millennium** | $850,000 | $849,019 | $858,517 | $9,498 |
| **Total** | $2,079,478 | $1,883,475 | $2,087,995 | $9,498 |

| KEDLI Research and Development 2012 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $40,780 | $0 | $40,780 | $0 |
| **NYSERDA** | $950,213 | $1,056,054 | $950,213 | $0 |
| **Millennium** | | $784,575 | $790,257 | $5,6820 |
| **Total** | $990,993 | $1,840,629 | $1,781,250 | $5,682 |

| KEDLI Research and Development 2013 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $90,084 | $0 | $90,084 | $0 |
| **NYSERDA** | $933,271 | $1,056,054 | $933,271 | $0 |
| **Millennium** | | $1,096,906 | $175,000 | ($921,906) |
| **Total** | $1,023,355 | $2,152,960 | $1,198,355 | ($921,906) |

| KEDLI Research and Development 2014 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $131,131 | $0 | $131,131 | $0 |
| **NYSERDA** | $542,324 | $1,056,054 | $542,324 | $0 |
| **Millennium** | | $1,226,719 | $422,418 | ($804,301) |
| **Total** | $673,455 | $2,282,773 | $1,095,873 | ($804,301) |

| KEDLI Research and Development 2015 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $245,988 | $0 | $245,988 | $0 |
| **NYSERDA** | $1,063,547 | $1,056,054 | $1,063,547 | $0 |
| **Millennium** | | $19,973 | $324,509 | $304,536 |
| **Total** | $1,309,535 | $1,076,026 | $1,634,045 | $304,536 |

Total Program Accruals” are $0 for “Internal Programs” and “NYSERDA” as these are not subject to true-up.

2. Please see below:

| KEDLI Research and Development 2016 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $618,246 | $0 | $0 | $0 |
| **NYSERDA** | $1,063,547 | $1,056,054 | $269,915 | $0 |
| **Millennium** | $657,228 | $6 | $221,146 | $221,140 |
| **Total** | $1,275,474 | $1,056,060 | $221,146 | $221,140 |

Total Program Accruals” are $0 for “Internal Programs” and “NYSERDA” as these are not subject to true-up.

3. Attachment 1 is a list of the 58 active projects in the Utilization Technology Development (UTD) program (as of April 2016). These projects are currently supported by UTD’s membership without participation by National Grid. Additional information about technologies, projects and categories is available at http://www.utd-co.org/.

4. Current internal R&D is focused on short term research (work expected to be 24 months and less duration) and technology to improve gas distribution operations in terms of safety, cost-effective operations, damage prevention, reliability and environmental performance. As such, this research almost exclusively supports the development of technologies for deployment on the Company’s side of the meter (*e.g.*, threat risk model improvements, cured-in place liners technology transfer and trenchless service replacement prototype) not end-use utilization. National Grid’s Three Year Research, Development, and Demonstration Report (Attachment 2) discusses these programs in more detail.

   The UTD program is focused on supporting the development of technologies for application on the customer side of the meter that utilize natural gas, including technologies to improve the energy performance of customers’ buildings or processes with natural gas in terms of life-cycle costs, reliability and environmental performance. The technologies are of interest to National Grid because they support the expanded use of natural gas, including advanced residential applications, distributed generation, commercial HVAC applications such as thermal air conditioning, natural gas vehicles, commercial processes such as foodservice, and renewable technologies. For example, there are more than 7,200 foodservice businesses in the KEDLI service area. Attachment 3 is a 2010 GTI assessment of the energy challenges and technology opportunities in the foodservice industry in areas served by National Grid.

5. The $250,000 to participate in the UTD program is proposed to be included in KEDLI's revenue requirement as an annual operating expense. This is the only funding for gas end-use R&D (other than the internal labor to manage National Grid's participation).

   The UTD program is managed by the Gas Technology Institute (GTI). Each member company appoints a representative to the Board of Directors and a member of the technical program committee.

   Individual project proposals are initially developed by the GTI staff based on their review of relevant technological opportunities and needs. In some cases, projects are conceived by the member companies. For each project identified, the members of the program committee allocate a portion of their company's dues to the projects of interest to their company. A member's funds can only be allocated by a member's vote. Projects that receive sufficient interest, by virtue of the total funding allocated, proceed and those that do not achieve the required minimum funding do not proceed and those funds are available for re-allocation. National Grid's representatives will be responsible for allocating funds to projects that have the greatest potential benefit to KEDLI's customers or for proposing projects if none are sufficiently relevant.

   One of the benefits of the UTD program is the ability, on a project-by-project basis, to leverage the funds of other companies with similar customer benefits and also to leverage external funding from federal or state research programs, such as the US Department of Energy or NYSERDA. Co-funding is usually a requirement or a factor in scoring for DOE or NYSERDA funding and, by pooling funds, the UTD program makes it easier to achieve the minimum required co-funding.

| Name of Respondent: | Date of Reply: |
|---|---|
| Chris Cavanagh/Mary Holzmann | April 21, 2016 |

Keyspan Gas East Corporation d/b/a National Grid
Brooklyn Union Gas Company d/b/a National Grid NY
Case 16-G-0058 and 16-G-0059
Attachment 1 to DPS Request No. DPS-420 JL-3 BULI-437

UTD Project Titles

| Project No | Description | Status |
|---|---|---|
| **Group 1** | | |
| 1.10.A | Web Program Upkeep | Active |
| 1.10.W | Development of an End Use New Technology Roadmap | Active |
| 1.11.D | Gas Fired Conveyor Warewasher | Active |
| 1.11.G.2 | Low Cost Condensing Prototype Phase 2 | Active |
| 1.11.H.3 | Gas Heat Pump Water Heater Reliability Phase 3 | Active |
| 1.11.M.5 | Building America Whole House Retrofit Program (Phase 5) | Active |
| 1.12.P.3 | Air Handler Enhancements for Condensing Combis Phase 3 | Active |
| 1.12.Q.3 | Unplugged Energy Star Water Heater Phase 3 | Active |
| 1.12.U.2 | Gas Heat Pump Modeling | Active |
| 1.13.B.3 | CFS Information and Calculators - Phase 3 | Active |
| 1.13.D.3 | Codes & Standards for Advanced Gas Technologies (Phase 3) | Active |
| 1.13.F | Application of Innovative Gas Heat Pump Design to Space Conditioning | Active |
| 1.13.I.3 | Gas Appliances in Tight Houses (Phase 3) | Active |
| 1.13.L.2 | Validation of mCHP Test Standard ASHRAE SPC204 Phase 2 | Active |
| 1.13.M | Field Demonstration of Model E NextAire Gas Engine-driven Heat Pump | Active |
| 1.14.A.2 | Next Generation CFS Burners - Phase 2 | Active |
| 1.14.B.2 | 2015 CFS Demonstrations | Active |
| 1.14.C.2 | Demonstration of Next Gen Low Oil Volume Fryer | Active |
| 1.14.D | Conveyor Broiler Improvements | Active |
| 1.14.E.2 | Heating System Competitive Performance Phase 2 | Active |
| 1.14.G | Thermally Driven Ground Source Heat Pump | Active |
| 1.14.I | Cold Climate Field Demonstration of the NextAire GHP | Active |
| 1.14.J | Multifamily Infrastructure Challenges | Active |
| 1.14.K | Advanced Systems for Self Powered Water Heating | Active |
| 1.14.M | Enbridge Analysis | Active |
| 1.15.A | CFS Quick Response Project | Active |
| 1.15.B | Demonstration of Demand Control Kitchen Ventilation System | Active |
| 1.15.C | Next Generation Advanced Gas Dryer Development | Active |
| 1.15.D | Low NOx Metal Foam Burner Durability Testing | Active |
| 1.15.E | Gas-fired High-Efficient Liquid Desiccant Air Conditioning and Humidity Control – Commercial | Active |
| 1.15.G | Residential Kitchen Cooking Ventilation Effectiveness | Active |
| 1.15.H | Water Quality Impacts on Compact HXs | Active |
| 1.15.I | TMH Field Evaluations for High Efficiency Residential Heating and Humidification | Active |
| **Group 2** | | |
| 2.11.D | Design and Development of Timed Fill CNG Metering System and Controls | Active |
| 2.12.F.3 | Reliability Assessment of Natural Gas vs. Diesel for Standby Generation Phase 3 | Active |
| 2.12.T.3 | Free Piston Linear Motor Compressor Phase 3 | Active |
| 2.12.U | Gas Quality Sensor (GQS) for Natural Gas and Renewable Gas Fueled Engines | Active |
| 2.13.G.2 | CWI 6.7 liter MD Natural Gas Engine Field Trials Phase 2 | Active |
| 2.14.A | High-Efficiency Gas Fired Rotary Dryer with Heat Pump | Active |
| 2.14.B | Low Cost Low NOx Sensor for Industrial Applications | Active |
| 2.14.D.2 | HeatSponge Evaluation Phase 2 | Active |

| | | |
|---|---|---|
| 2.14.F | Free Piston Linear Motor Compressor Scale Up | Active |
| 2.14.H.2 | CSA Standards Development for Home Refueling Appliances Phase 2 | Active |
| 2.14.I | CNG Fuel Station Safety, Performance, and Best Practices Audit Kit | Active |
| 2.14.K | CNG Composition Impacts on New Generation Engine and Fuel Delivery Systems | Active |
| 2.14.O | Field Validation of Gas Quality Sensor for Natural Gas | Active |
| 2.15.A | On-site Electrical Generation | Active |
| 2.15.B | Valuable Products From Natural Gas | Active |
| 2.15.D | Advanced Retention Nozzle | Active |
| 2.15.H | Modular CNG Storage System Investigation | Active |
| 2.15.I | High Volume Off-road CNG Applications Analysis | Active |
| 2.15.J | Truck Transport Refrigeration Units | Active |
| 2.15.M | CHP Interconnection Equipment Review | Active |
| 2.15.O | FlexCHP Power and Steam | Active |

nationalgrid

**Tae Kim**
Associate Counsel
Legal Department

April 5, 2016

**VIA ELECTRONIC DELIVERY**
Honorable Kathleen H. Burgess, Secretary
New York State Public Service Commission
Three Empire State Plaza
Albany, NY 12223

**Re: Case No. 98-G-1304 - National Grid's Three Year Research, Development, and Demonstration Report**

Dear Secretary Burgess:

The Brooklyn Union Gas Company d/b/a National Grid NY, KeySpan Gas East Corporation d/b/a National Grid, and Niagara Mohawk Power Corporation d/b/a National Grid hereby submit for filing their Three Year Research, Development, and Demonstration Report.

Please direct any questions regarding the enclosed report to Mary Holzmann, Principal Engineer – Gas Research, Development & Deployment at (631) 770-3449 or mary.holzmann@nationalgrid.com.

Respectfully submitted,

*/s/ Tae Kim*
Tae Kim

Enc.

One Metrotech Center, Brooklyn, NY 11201
T: 929-324-4550 ■ F: 917-310-0132 ■ Tae.Kim@nationalgrid.com ■ www.nationalgrid.com

# National Grid

# Three Year RD&D Report

**Prepared for**

**New York State**
**Public Service Commission**

**Albany, NY**

**Prepared by**

**Mary Holzmann**
**Principal Engineer**
**Gas RD&D**

**April 2016**

**Introduction**

National Grid distributes natural gas to 2.5 million customers in Nassau and Suffolk Counties on Long Island and in Brooklyn, Staten Island and parts of Queens in New York City, and large portions of Upstate New York, including the cities of Albany and Syracuse. National Grid also distributes natural gas to 1.2 million customers in Massachusetts and Rhode Island.

In addition to its gas distribution business, National Grid owns and operates electric generation in Nassau and Suffolk Counties of New York State and also distributes electricity to customers in Upstate New York, Massachusetts and Rhode Island.

**Goals of the RD&D Program**

National Grid's Gas Research, Development & Demonstration (RD&D) program is designed to improve distribution operations. Targeted operations improvements involve enhanced public safety, cost reductions, improved worker safety, environmental and regulatory compliance. Within these broad areas, National Grid's ongoing research program focuses on the following technical categories:

- Damage Prevention. Technologies that allow the accurate detection of hard-to-find underground facilities such as plastic pipe with inoperable tracer wire, sewer laterals, or joints on cast iron systems. Technologies that warn of impending damage to underground gas facilities, or detect obstacles in the path of directional drilling machines
- Leak Location. Technologies that allow quicker, more accurate and less costly detection of leaks.
- Integrity Management. Various technologies to facilitate National Grid's compliance with the Pipeline Safety Improvement Act of 2002 and subsequent pipeline safety regulations which includes robotics, cased-pipe, material verification and integrity, improvements in asset tracking and traceability, TIMP and DIMP, crack detection, plastic pipe, and other risk and pipeline integrity management challenges.
- Live Maintenance and Repair. Live Repair technologies eliminate customer downtime by allowing repairs with gas mains in the live, operating condition.
- Trenchless Technology. Techniques that allow pipelines to be rehabilitated with minimal excavation.
- Gas Quality. The Company is engaged in various research projects to help prepare us for the expected changing picture in gas supply. The research is focused on the potential impacts that new supplies may have on our infrastructure and our customers.
- Environmental Technologies. New technologies that could be brought to bear on methane and advanced leak detection methods, residential methane sensors, manufactured gas plant (MGP) site remediation, monitoring, and other projects related to climate change.

- Infrastructure Support. Various projects targeted in improving infrastructure operations, corrosion control, construction and the tracking and traceability of underground assets.
- General Operations Improvement. Various projects targeted at improving operational safety, efficiency and/or worker ergonomics.
- Metallurgy, Welding, and Joining Process Improvements.

Projects active during the past three years within these categories, are described in the body of this report.

**Execution of the Program**

Most RD&D projects within these program areas are performed with a high degree of collaboration via the following research consortia:

**NYSEARCH**
NYSEARCH, whose members consist of 19 local distribution companies (LDCs) and one Pipeline Company in North America, is the research sub organization of the Northeast Gas Association (NGA). The NGA is a regional trade association focusing on education, training, research and development, operations planning and increased public awareness on natural gas in the Northeast US. NGA member companies collectively serve 9.5 million customers in eight states. NYSEARCH was originally created as a committee within the former New York Gas Group but has since become national in scope. In addition to the Northeast, NYSEARCH membership comes from the Middle Atlantic States, Mid-West and the West Coast and Canada. NYSEARCH focuses primarily on Operations projects. The NYSEARCH Staff of four project managers manage an active portfolio of projects within the program areas above. Member LDCs join projects at their discretion, commit funds according to their size, act as project advisors, and may host field demonstrations. For the NYSEARCH program, the Company's budget is set by first analyzing the projects that are approved. The project schedules are then established and a spending forecast is developed jointly with NYSEARCH. The company may contribute "in-kind" expenses towards a project in the form of field demonstrations and those costs are also considered. If a new project is still awaiting approval, a forecast is made of projected spending, again in conjunction with NYSEARCH.

**Operations Technology Development (OTD)**
OTD consists of 25 LDCs throughout North America and is an Illinois based not-for-profit (NFP) company administered by the Gas Technology Institute (GTI). GTI also performs project management services and researches about half the project portfolio. OTD focuses on operations projects. OTD Member LDCs join projects at their discretion, commit funds as they deem appropriate, act as project advisors, and may host field demonstrations. The OTD business model calls for an up-front pre-determined (based on company size) payment of annual dues each calendar year. For the OTD program the Company's annual dues are $750,000. As projects are approved they are funded by the annual dues. Unused funds can be used to offset the following year's dues. The company exercised this option for 2012.

A sub-program within OTD, the Sustaining Membership Program (SMP) is a longer term GTI program focusing on basic science, which usually results in a proof of concept that which is further developed in the OTD program. National Grid terminated its participation in the SMP program effective January 2013.

In some cases, National Grid may choose to enter into development contracts with research providers jointly with other LDCs or by ourselves.

**NYSERDA**

The Company is currently assessed an annual amount of approximately $4.9 Million for the NY State Energy Research and Development Authority (NYSERDA). The assessed rate is based upon NYS Intrastate Revenue – (Sales for Resale and Transmission for Others). The Company has no say in which projects are funded through the NYSERDA program. However, the company monitors the various NYSERDA Project Opportunity Notices (PONS) and may elect to submit a proposal to NYSERDA for cofunding a Company RD&D project.

**Funding**

Part of National Grid's ongoing RD&D program is funded via the "Millennium" Fund and surcharge, authorized by the New York Public Service Commission's February 14, 2000 Order in Case 99-G-1369 (the "Millennium Order") to replace the mandatory FERC pipeline research surcharge. A maximum allowable collection rate of $0.0174/dekatherm on firm transportation and sales is the source of funding for the program. National Grid currently collects $0.0067/dekatherm from its KEDNY operations and $0.0000/dekatherm from its Long Island and Upstate Operations. The winter of 2014-15 was unusually cold with extended periods below freezing. This caused the collection rates, which are tied to dekatherm usage, above the current spending levels for a period of time. Additionally, a great deal of R&D focus has been on residential methane detectors which is not being funded through Millennium but is being funded via company funds through the Long Island Settlement Agreement instead. So we have decreased the collection rates in KEDLI and NMPC in order to levelize balances with current R&D commitments. Since the last report, the changes in spending levels are in part due to National Grid Downstate has been funding the majority of the development of the Explorer 16/18 inch internal inspection robot for un-piggable pipelines in this range of larger diameter transmission piping. While this project benefits our Upstate territory, the larger share has been funded through the Downstate surcharge due to the larger inventory of 16 inch un-piggable pipe there. More recently, projects looking into the use of drones in gas operations will be of greater potential use in our Upstate NY area which will shift R&D investment dollars to Upstate as that work progresses.

Unlike the phased-out Federal Energy Regulatory Commission (FERC) surcharge, the Millennium fund is controlled by National Grid and spent on eligible projects via NYSEARCH, OTD, GTI or other research providers at National Grid's discretion. As specified in the Commission's Millennium Order, in order to qualify for Millennium funding a project must be medium to long term in nature (i.e., projects that are at least twenty-four months or more from becoming a commercially deployable product); 80% of Millennium funds must be spent on co-funded projects and cannot be directed to fund natural gas appliance research or supply/storage projects. The projected budget for the next three years averages $2.7 Million. The Company realizes a high degree of cofunding from other participating LDCs, and from the US Department of Transportation (DOT) Pipeline Safety Research Program. Because of this, the Company's leverage is about 7:1, meaning for every RD&D dollar we spend we realize seven dollars of overall RD&D funding.

National Grid maintains an internal budget to fund projects that do not meet the criteria set forth in the Millennium Order. The budget is $183,000 and typically funds short term "quick hit" RD&D efforts, association (NYSEARCH) dues, and patent protection fees.

Attachment 1 shows actual and projected spending for the Company's Gas RD&D program, Internal, External (NYSEARCH and OTD) and the NYSERDA Assessment.

**Program Management**

The management and administration of the operations program is by National Grid's Gas Materials and Standards, group within the Gas Engineering/Network Strategy organization. Subject matter experts throughout the company are used as needed when specific technical expertise is required on projects.

**Selection of Projects**

The Company uses four criteria to judge the merits of RD&D projects. The first is safety. Some projects are undertaken to enhance the safety of workers in the field, or the general public.

The second criterion is compliance with regulations. An excellent example of this is the transmission pipeline safety regulations. In the Pipeline Safety Improvement Act of 2002, Congress directed the US Department of Transportation to establish and promote a research partnership with industry to develop tools and techniques to improve pipeline safety. Ensuring the highest level of pipeline safety requires tools and techniques that have been developed over the last 10 years, such as the robotics program for internal inspection of unpiggable pipelines.

The third is increased knowledge about gas operations which can lead to increased efficiencies, material improvements and or better techniques for conducting daily operations.

The fourth criterion is financial benefit. The R&D budget is looked at based upon historical spending levels and is adjusted depending upon if there is an increase or decrease in current challenges being addressed and priorities that require research investment are funded. The Company may use a benefit/cost (B/C) ratio test to determine whether RD&D projects should be adopted into our operations. Benefits are the net savings in operational costs that are realized via implementation of new technology. Costs are the project costs to fund and implement the new technology. In some cases R&D studies can also lead to operational savings and the same B/C test applies. However, not all studies have a definitive cost benefit. Studies may lead to increased safety measures or process improvements.

Most projects have multiple benefits, for example, projects undertaken for worker safety can lower injuries and reduce sick time (thereby providing a financial benefit), and compliance with regulations can improve safety of the gas system and the public. A project with a marginal financial benefit may also be approved if it meets one or more of the other criteria.

**Benefits**

National Grid, in collaboration with other funders, has been involved with bringing the following products or increased knowledge to market over the past few years:

- Keyhole Tools and Methods
- Pipe Splitter
- PFT Chromatograph for Leak Detection
- No-Interrupt Service Transfer (NIST) Tee
- Cured in Place Liner Improvements
- Butt Fusion Repair Sleeve (BFRS)
- 4" and 6" Variable Length PE Repair Sleeve
- Remote Methane Leak Detector (RMLD)
- Studies on Plastic Pipe Performance
- A Full Suite of Live Internal Gas Main Video Inspection Devices
- NYSEARCH/Kiefner Interacting Threats Modeling Software
- Cased Pipe Integrity Assurance Model
- Explosion Proof Light Fixture
- Guidance Document on Biomethane
- Explorer Suite of Inspection Robots for the Inspection of Unpiggable Pipelines – Pipetel Technologies, Inc. EXP 6/8, EXP 10/14, EXP 16/18, EXP 20/26, EXP 30/36, Supporting Technologies and enhancements in detection capabilities
- Cased Pipe Annular Space Inspection Robot
- CISBOT
- Acoustic Pipe Locator
- Metallic Joint Locator

**<u>Active Project Discussion</u>**

**<u>Internal Budget – Non-Millennium – NYSEARCH Projects</u>**

Projects that do not meet the criteria set forth in the Millennium Order (i.e., medium to long term and no end use or appliance funding) are funded via National Grid's internal budget. Internal projects (also referred to as Non-Millennium or Traditional R&D) are research that is of short term duration (work that is expected to be completed in less than 2 years) or work that is appliance or storage related.

**T759 - Ergonomic Study to Develop and Test a New Design Needle Bar.** A needle bar is a manually operated tool used to make small diameter holes, called barholes, in paved or unpaved areas over gas mains to allow pinpointing of leaks. During a typical leak investigation as many as 15-25 such holes may be required. The repetitive up-down motion required when using the tool is often a source of soft tissue injury if the user fails to maintain an upright position when using the tool. An ergonomic needle bar with a ratcheting handle was developed. This tool allows the operator to remain in an upright position for the duration of time it takes to create a barhole. The drawback is that the tool is heavier. Field trials were conducted throughout the National Grid territory and the tool failed to gain universal user acceptance. However, these efforts have stimulated manufacturers to continue working independently working towards more ergonomic tool design. The benefit of this work is a reduction in soft tissue injuries.

**T763 - PE Rock Impingement Study.** A study was undertaken to determine whether the requirement for clean backfill around polyethylene (PE) pipe could be relaxed given the high resistance to slow crack growth demonstrated by modern PE materials. In many situations, a common practice is to truck in clean, screened backfill in lieu of using native materials, at an increased cost. Testing performed in Europe has demonstrated that modern PE materials have such superior resistance to point loadings that use of select backfill is no longer required. No such testing had been undertaken in the US so, through NYSEARCH, Jana Labs was commissioned to perform the tests. Medium density and high density PE pipe, which is representative of the PE pipe installed now at the Company, were subjected to extreme point loading to simulate contact with rocks which could be present in native backfill. (Test loadings were so severe that the indentation was visible at the interior pipe wall.) The sample pipes were then pressurized and hot tank tested (standard testing protocol – which compresses many years of testing into a relatively short time period). Tests have shown no harmful effects from extreme simulated rock impingement loading and the projected time-to-failure in normal operating conditions is well in excess of 100 years. This work is an excellent validation of the superior toughness of modern PE materials. Significant cost savings have already been experienced in the Company's New York City Operation.

**T764 - Auto Gas Lamp Field Evaluation.** Working through NYSEARCH, the Company undertook an evaluation of a gas lamp for street lighting that was equipped with an igniter and a photo sensor which would shut off during daylight hours and reignite in the evening. Independent testing confirmed that the lamp and igniter system performed well in lab testing and several lamps were deployed in funders' territory. The benefit of the project is a savings of natural gas during daylight hours, a corresponding reduction of CO2 emissions, and improved customer relations and satisfaction.

**T765 - Gas Interchangeability Study for Installed Residential Appliances.** The addition of new gas supplies (imported LNG, unconventional gas) is expected to accelerate, leading to wider ranges of natural gas compositions. While the industry is expanding supply sources, to date there has been no standardized approach for evaluating the impacts of varying gas compositions on in-service residential gas appliances. The benefits of such a study are to determine the extent to which potentially sensitive appliances exist and to identify which specific appliances are affected based on type, vintage, adjustment practices, and maintenance characteristics. With that information, better decisions can be made about whether adjustments are necessary to those appliances in order to successfully accommodate varying gas compositions. The project consists of two phases; in Phase I, over 2400 appliances were visited in the field and firing rate, percent excess air, CO and NOx formation were measured and flame quality was observed. In Phase II, lab testing was performed on selected appliances (about 20) subjecting them to a wide range of future expected gas compositions to determine their performance. This phase of the study yielded important information about how typical appliances will perform over a wide range of gas compositions and benefits the company by allowing it to more effectively negotiate future tariffs and plan for remedial actions for more sensitive appliance types. This work is nationally recognized. Project results have been shared with the American Gas Association (AGA) and key findings will be incorporated into the next revision of "Bulletin 36," which addresses gas interchangeability concerns. Based on the results of this work an appliance assessment software tool is now available on the NYSEARCH website. NYSEARCH RANGE™ is one of the deliverables of the NYSEARCH Gas Interchangeability for Appliances project which studied and modeled how changing gas composition can impact the performance of in-service residential appliances. This risk assessment model is available to purchase for on-line use.

**T766 - Technology Transfer Improvements**. An ongoing study to investigate specific member lessons learned with successes and failures of technology transfer and to share procedures so that more companies can be successful with a process for cultivating company support and longevity in implementing new technology

**T768 - NYSEARCH/Kiefner Interactive Threats Project.** The project defined and prioritized interacting threats that impact pipeline integrity. A more robust treatment of interacting threats was incorporated in risk models. To ensure that the NYSEARCH/Kiefner Interacting Threats model stays current, PHMSA's annual incident and Kiefner's forensic failure databases are being checked and incorporated into annual software version upgrades.

**T769 – Test Program for Picarro Leak Surveyor**. In early 2012 the Company became aware of a new technology for leak survey manufactured and marketed by Picarro Corp. The technology is vehicle mounted laser based sensing of methane at sensitivity levels never achieved before by standard leak detection technology. Methane at 30 parts per billion (PPB) above background concentrations can be detected. Along with methane sensing, this vehicle based technology also records atmospheric conditions such as wind speed and direction, temperature, humidity and cloud cover. When methane is detected

the Picarro technology plots out an area that should be investigated and pinpointed. The area to be investigated is based on the methane concentration that was detected, and the atmospheric conditions, such as wind speed and direction. This gives operators a good idea from which direction the methane is coming.
Through the NYSEARCH consortium, the company and others wanted to do a side-by-side comparison of Picarro technology to existing distribution leak survey methods in use at the Company. A double blind test protocol was established and for two days the standard company leak survey procedure – which is a walking survey using Bascom Turner “Rover” leak detector – was run on the same days on the same streets as the Picarro mobile survey technology. Results of the comparative surveys for the Company and other project participants have been compiled. No report can be released due to legal agreements with Picarro. This project was completed in Nov. 2014.

**T-770 - Technology Transfer, Demonstration & Post Mortem Testing of Cast Iron & Steel Pipe Lined with Cured-in-place Pipe Liners. See details under Live Inspection, Maintenance and Repair section.**

**T-773 - Trenchless Replacement of Small Diameter Steel Gas Service Lines. See details under Trenchless Technology section.**

**T-774 - Impact of Gasoline/Oil on PE Pipe.** The objective of the project is to understand the impact of external contaminated soil conditions on the external surfaces of PE pipe and develop a practical engineering and operator’s guideline that provides specific instructions for evaluating in-service PE pipe exposed to contaminated soils.

**National Grid Study on Risks Associated With Natural Gas Appliances Immersed In Water.** Flooding and flood damage are not unusual events in the United States (U.S.). According to the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS) data, annual flooded property losses exceed $7.8 billion on average during the past thirty years. Major episodic events such as Hurricanes Katrina and Sandy can substantially raise losses and place substantial strain on natural gas and electric utility operations due to the extensive damage done to delivery infrastructure and customer equipment. This study was undertaken to help qualitatively assess the failure modes and potential risks associated with natural gas appliances immersed in water for extended periods. Survey questions were used to facilitate interaction with several natural gas furnace, boiler, and water heater manufacturers.

In general, funding for “internal projects” is used to pilot new products and technology—e.g. keyhole, live main insertion, leak sealants, or to perform short term studies. Any appliance related work would also be internally funded.

**<u>Millennium Program</u>**

**NYSEARCH and OTD Projects**

## Damage Prevention and Pipe Location

According to the US Department of Transportation (DOT), third party damage is the primary cause of pipeline incidents on LDC distribution systems, accounting for over one third of all reportable incidents. Repair costs due to Third Party Damage are estimated at $10 Million annually, and often result in loss of service to customers. National Grid is funding the following efforts:

**M2001-005 – Handheld Pipe Locator using Ground Penetrating Radar (GPR)**. GPR is high frequency electromagnetic radiation that has proven capabilities to detect underground features but no hand held GPR device existed. The goal of the project is to develop a user friendly GPR device that can be deployed by field crews when standard locating technology cannot precisely locate suspected underground facilities. A portable, light-weight free scanning plastic pipe locator for use by LDCs and construction crews to identify the lateral position of hard-to-find plastic pipe (can also locate other metallic pipe). The target application for this technology is plastic pipe with inoperable tracer wire. Such pipe cannot be located by standard "clip-on" locating technology. The product has been designed, developed and tested. NYSEARCH worked with Pipehawk LLC, a UK company, to develop the technology but attempts to commercialize it in 2006 were unsuccessful. Difficulties arose when attempting to transfer this product to a commercializer for engineering improvements (such as ergonomics) and preproduction testing. Another potential commercial partner, Sensors and Software, a recognized leader in both development and manufacture of GPR locating equipment, had been engaged to explore potential commercialization. This contractor is now assessing the feasibility and potential market for this technology. A successful device would provide company crews with the ability to quickly locate plastic pipe without tracer wire. After multiple attempts with a selected contractor who had interest in commercializing, no additional work or funding was promoted.

**M2002-011 PhIII - FFT Damage Prev Monitoring - Advances with Aura.** Damage Prevention and particularly proactive monitoring for third party intrusion near transmission and distribution pipelines is a high priority for many gas companies. Due to interest expressed by members in revisiting the FFT's fiber optic intrusion detection system, and in particular its advanced system known as Aura™, NYSEARCH renewed this project (renewing the former FFT project that worked with the Secure Pipe product) to test this higher resolution distributed sensor product as it applies to two different test sites with different conditions; one at Woodbridge NJ in PSEG's territory and one in Ontario in Enbridge's territory. Tests and results are finalized. Final Reports for PSEG complete; final report for Enbridge work pending.

**M2002-018 - Proactive Infrasonic Sensor** This system consists of seismic sensors that can be installed near critical gas mains or other facilities and can sense activity near those facilities and send a warning to a control center or other company facility. The system is "trained" to distinguish benign threats (truck traffic, etc) from real threats. Comparable systems on the market now differ in one important distinction; they all require physical contact with the sensor, this system will detect activity as far away as 300 ft. Benefits of this project are reduced incidences of third party damage and associated repairs.

**M2007-007 Advanced Video Surveillance (A-Gas) System**. This project uses a video image approach to detect possible third party damage. Standard video cameras are trained on an area of concern and proprietary software is used to "learn" the scene so that normal activity can be discounted but abnormal activity alarmed. The A-Gas system is available for security applications. The research component of this project is to adapt the technology to the new concept of advanced warning to LDC operators of potential third party damage. In a second phase of the project we are working with the vendor to develop an environmentally hardened version of the camera/software system which can be mounted outdoors without any special environmental enclosures. The benefits of this project are reduced incidences of third party damage and associated repairs.

**M2008-001 – Advanced Development of PipeGuard™ – Proactive Pipeline Damage Prevention.** This system by Magal/Senstar is technically similar to the Proactive Infrasonic Sensor system but is a commercially available system that is used for security applications. The goal of this project is to adapt this security based technology for use in the natural gas industry to be utilized in an underground surveillance mode to detect occurrences at or near the surface to alert the operator of third party activity, presumably excavation, in the vicinity of the installed sensors. This project includes the evaluation of a geophone-based pipeline monitoring capability that will warn an LDC of impending damage to pipeline facilities. Following the initial technical feasibility assessment, through NYSEARCH, the Company is hosting a demonstration site on Long Island to test this technology adaptation. The target goal for detection alarms for backhoe, pneumatic piercing tools, and pavement breakers is 250 feet from the sensing units. This will provide total monitoring coverage of 1000 feet along the pipeline run when two sensing units are installed. It is expected that detection distances for shovels and manual post-hole digging tools will be significantly lessened. Benefits of this project are reduced incidences of third party damage and associated repairs through proactive monitoring in advance of actual work performed by a third party.

**M2011-005 – Fiber Sen System Development and Testing** In the last 10 years advanced damage prevention technologies using fiber optic cable have been marketed. Most of these technologies are suitable for extremely long lengths of transmission piping and one system even uses satellite transmission of data to a central monitoring site in Europe. Systems such as this do not meet the needs of the Company. Through NYSEARCH, the Company became aware of Fiber SenSys Inc., who is interested in developing a shorter version of existing technology which would be more applicable to the needs of distribution companies.

Fiber SenSys proposed to develop a fiber optic cable which can be installed parallel to an existing gas transmission main, or alternately the cable can be incorporated into a new main installation. The system functions by detecting vibrations in the soil around the pipeline. The vibrations alter the characteristics of the laser light in the cable and can be detected and alarmed. Requirements are that the system be able to detect presence of commonly used excavation equipment, while recognizing and filtering out other acoustic signals that would be generated by benign threats such as truck or rail traffic. The system must perform in all types of soil that can commonly be encountered in the Company’s territory. A NYSEARCH member company has offered a test site where a prototype system can be installed and tested. The target cost of the system, depending on length monitored, would be as low as $3000 per mile. The benefit to the Company is enhanced damage prevention and potential avoidance of a major pipeline accident due to third party damage. This project expanded on lessons learned from a prior project related to proactive monitoring for third party damage using fiber optic sensors. The project developed a system for shorter runs of pipe based on the contractor's (Fiber Sensys's) system for longer runs of pipe. The 'short ranger' system was tested and evaluated for gas distribution applications and its technical and economic feasibility was studied.

**M2011-008 – BioBall Test Program.** A NYSEARCH member company has worked with a technology company to develop a simple technical approach to accurately locate sewer laterals. The technical approach is to simply wind a length of copper wire on to a biodegradable “spool” which can be flushed down a commode in a residence. The wire will unspool and standard locating equipment can be connected to it and the location of the sewer lateral can be determined. NYSEARCH member companies want to determine whether the idea is feasible and have funded a test program. The Company has conducted a week long field test program on this technology. Results were mixed; in many cases gaining access to the residence was problematic. In those cases access to the sewer lateral was through an outside cleanout. Where the bioball did deploy successfully, location of the lateral was determined within +/- 2 ft. Interest in this project is high because of a concern with “crossbores,” in which pipe installed via directional drilling inadvertently punctures a sewer lateral. The situation may not be detected for years until the sewer line clogs and a plumber is called by the homeowner, with potentially disastrous results.
The benefit of this technology is accurate location of sewer laterals and subsequent avoidance of a crossbore.

**OTD 1.8.a - GPS-Based Excavation Encroachment Notification** This project focuses on linking Global Position System (GPS) technology with digging operations to provide a warning system to prevent excavation damages to underground facilities. The objective is to develop and demonstrate a system to ensure that excavation activities are occurring within a valid “One-Call Ticket” area (which authorizes excavation) and are not encroaching upon underground pipes and facilities. The Company and other project funders are partnering with Virginia Utility Protection Service (VUPS), a “one-call” center for utility locates, that has been conducting pilot programs to demonstrate the feasibility of using GPS-enabled cell phones (Phase 1) and GPS-enabled locators (Phase 2), and excavating equipment (Phase 3) to call in excavation projects, access information, and prevent unauthorized excavations. The benefits of this project are more accurate and smaller “white-line” (areas needing markout) areas, more accurate locating, and warnings to excavators if they are excavating in unmarked areas. All of this reduces the threat of third party damage. The company is participating in a follow on project to implement a similar pilot program in upstate NY.

**OTD 1.h and 1.10.c – Hand Held Acoustic Pipe Locator.** Plastic pipe without tracer wire remains a vexing problem for LDC locating crews because standard electromagnetic locating techniques will not detect plastic pipe. Ultrasonic waves are ideally suited for this application because they will travel well through solid mediums (soil) but are reflected off of voids, air pockets or lighter density materials. The acoustic locator has shown that it can reliably detect plastic pipe. A follow on to this project (described next) will target location of sewer laterals, an important issue lately as more LDCs are using directional drilling to install gas mains. Accurate location of our buried facilities is the main benefit of this project. Completed 2013.

**OTD 1.10.e – Enhancing Damage Prevention in New York.** The objective is to conduct a pilot project to demonstrate the procedures and technologies for implementing an electronic as-built process and radio frequency (RF) tag based asset locating system. The proposed technology will automate the as-built process by using new high-accuracy GPS technology and aerial photography to document the location of newly installed facilities. RF tags will be used to enhance the locating and mark-out process by providing field personnel with additional asset location information. Phase 3 will develop a prototype system that allows the collection of highly accurate spatial data in urban canyons where traditional GPS technology is ineffective.

**OTD 1.11.e - Crossbore National Database and Risk Model.** As crossbores, where a natural gas line installed via trenchless construction methods, has penetrated a sewer main/lateral. For example, homes with sloping front yards and no basements may have sewer laterals that are close to the surface and therefore more likely to be intersected by a horizontal directional drilling operation. The objective of this project is to gather as many parameters as possible associated with crossbores actually identified in the field. In addition to the Company, other LDCs are gathering data on crossbores. There has not been a unified effort nationally to collect this data. By combining this data into national database users can identify those situations and field conditions where crossbores are more likely to occur in its own territory, and can prioritize and focus remedial action on the highest risk areas. The purpose of the database is to collect information on crossbores root causes, environmental and situational factors, and compile incident reports to facilitate the sharing of lessons learned and increase public safety.

**OTD 1.12.b – Crossbore Detection Using Mechanical Spring Attachment**
In the concluding phase of OTD 1.11.a, "Evaluation of Chemical Detection Methods for Detecting Sewer Lateral Crossbores," one of the project funders suggested a brainstorming session for innovative ideas to detect crossbores. The leading idea is to use a simple spring loaded sensor on a drillhead that would "snap open" upon encountering a void, such as would happen if the drillhead suddenly penetrated a sewer lateral.
GTI engineers will design and test a prototype tool that will detect a hit to sewer laterals during the HDD or mole installation of PE gas pipe. The tool utilizes a low-cost and easy to use mechanical system that is attached to the HDD/mole head during drilling or to the PE pipe during pullback. The mechanical system is activated inside the sewer pipe void; thus locating the lateral and providing a real-time alarm identifying a hit. At the conclusion of the project, commercialization activities will begin. A simple yet accurate

method for detecting a crossbore in this fashion is a tremendous benefit to the company because crews are present to immediately rectify the situation.

## Leak Detection and Methane Emissions

Rapid and more accurate leak detection and location (pinpointing) has always been a research focus for the industry and for National Grid in particular. We are funding the following efforts:

**M2010-002/T-776 – Methane MR Sensor/ new Residential Methane Detector Development Program.** NYSEARCH/NGA has been developing a small, reliable, intrinsically safe, line and/or battery powered, miniature methane (natural gas) sensor based on micro-resonator technology that measures the viscosity of a gas mixture. The sensor would be used in detecting natural gas leaks and other applications. The instrument is being developed for two applications; an analytical sensor for measurement with data output, and as an improved safety sensor for use in residential applications. Due to the high reliability and resistance to false alarms, this program has shifted its focus entirely to the residential sensing application. Following extensive testing of advanced prototypes, precommercial prototypes are being tested by UL and a pilot test program is being implemented following completion of UL testing. This project has produced a novel type of methane sensor using the principle of micro-resonance. The theory behind the sensor is that micro-size tuning forks will vibrate at different frequencies when exposed to a methane/air environment than it would in free air. This concept was uncovered during a technology search undertaken as part of the “Oracle” project. After extensive testing it has been found that this methane sensing device does not exhibit false positives in the presence of many household chemicals which is makes it superior as safety device over currently commercialized devices. It has not demonstrated any false positives.

The sensor is capable of measuring the methane concentration from 0% to 100% in air at different pressures, relative humidity levels and in a wide temperature range. The measurement range of primary interest corresponds to 0-100% Lower Explosive Limit (LEL) with the ability to measure gas concentrations up to 100%. [LEL for methane corresponds to approximately 5% methane/natural-gas concentration in air.] The sensor has a detection limit and an accuracy of 0.25% natural gas concentration in air. The sensor is capable of operating at various gas gauge pressures ranging from 30 to 110 kPa and temperatures of -20°C to 50°C. The response time of the sensor is targeted at 1 second or less. To verify and validate the performance of the MR Methane detector (safety sensor/alarm monitor) a pilot testing program will be implemented. Detectors will be deployed in residential settings to test them under real life conditions under a variety of operational conditions and environments. The following issues will be addressed: (a) having a sufficient number of installations, (b) covering a wide range of housing types, (c) evaluating different detector locations within the homes, (d) selecting locations that expose units to possible interfering chemicals (e.g., masking, false positive) and potentially damaging conditions (e.g., humidity, temperature, chemicals, insects), (e) considering the impacts of ventilation rates and air flow patterns in homes, (f) monitoring performance in all seasons, (g) monitoring performance at various elevations, and (h) validating detector performance before, during, and after the field trial.

**M2014-002 - Leak Pinpointing Inside Pipe.** The overall program goal is clear to design, develop and test an innovative system that can precisely locate gas leaks from inside the pipe. The selected technology needs to apply to a range pipe sizes, 2” – 12” in diameter. During testing the experienced JD7 operator inserted the instrument into the flow loop through an ALH/WASK valve fitting after the simulated leak was created and covered. The first round of testing was designed to determine if the JD7 could detect leaks of various sizes and pressures. This initial round of testing was performed without air flow (fans were off). The JD7 proved capable of detecting leaks as low as 6” water column pressure leaking at the rate of 0.12 scf/hr. and at our top simulated pressure of 40 psig with a leak rate of 52.5 scf/hr. The JD7 was also capable of detecting leaks at various pressures and leak rates in between these upper and lower tested limits. A second round of testing was performed. The JD7 was manually inserted down the test pipe and located the leak without knowledge of the leak location. This testing was conducted without air flow and with air velocities of 2.5 mph (one fan) and 12 mph (both fans). The JD7 located leaks at no flow as small as; 1) 0.70 scf/hr. at 12” water column and 20 psig, 2) between 5.23 and 8.33 scf/hr. at 2.5 mph air velocities at both 5 psig and 40 psig, and 3) at 12 mph air velocity with a leak rate of 52.5 scf/hr. at 40 psig. Although initial flow loop testing of the JD7 at Heath was a success, improvements should be made to the JD7 Gas Investigator in a proposed Phase II of this project in order to improve its efficiency of operational performance. These improvements should subsequently be blind tested in a buried flow loop containing simulated leaks with the capability of varying pressures and flows.

**M2014-004 - Technology Evaluation and Test Program for Quantifying Methane Emissions.** The overall objective of the project is to identify, test and validate what technology or technologies are available that can be applied from a mobile platform in an urban environment to quantify methane emissions rates.

**M2015-002 - SRI Standoff Gas Flow Imaging and Analysis System**. The overall objective of the approved program is to quantify the flow rate from gas distribution leaks using the schlerien optical imaging technique as applied on a portable, field-usable system.

**OTD 1.9.a – GPS Based Leak Survey**. The objective of this project is to develop and utilize a software application that automates leak surveying with GPS. Using standard GPS receivers a leak surveyor’s route is automatically uploaded to company maps and a permanent record of the actual route surveyed is created and preserved. The application attaches GPS coordinates to survey routes and leaks while electronically documenting work to demonstrate compliance. The application also allows the user to create and populate an electronic leak form that can be directly transferred to a back-office leak management system or a Geographic Information System (GIS). New leak detection equipment that is on the market will be linked via software to company maps or images to automatically track routes of leak surveyors, thereby creating a traceable record of survey routes walked. The benefits of this project are reduced time for documentation and more accurate record keeping.

National Grid funded an additional phase of the project to conduct an actual field trial of the technology in a select area in New York City. Due to Hurricane Sandy, the pilot was delayed until April 2013 and was completed in August 2013.

**OTD 1.11.c - Methane Sensor** The goal of this project is a low cost reliable methane sensor for in-home use or use in company facilities (gate stations etc.) to detect and alarm on the presence of methane in air. Instruments are available to do this but typically can be set off by non-methane hydrocarbons which could be present in a house basement, paint thinner or hairspray for example. The testing protocol was designed to test the accuracy and stability of the six KWJ MEMS sensors by testing them at various methane concentrations, different temperatures, different relative humidities, and different interfering gases. In order to execute the testing protocol a testing chamber was designed to monitor and control all of the different conditions. After the completion of several basic testing conditions, the project team concluded that further testing should be terminated. Termination of the testing was recommended for several reasons. Because of our concerns on the path forward of this project, National Grid elected not to continue this effort.

**OTD 1.14.d - Field Measurement of Leak Flow Rate.** The goal of this project is to develop an inexpensive and repeatable device that can provide a measurement of the gas-leakage rates in the field from Class 2 and 3 non-hazardous pipe leaks. The current phase of the project involves improvements on an alpha prototype and upgrading the technology to provide increased accuracy, precision, lower cost, and ease of use. In 2015, an enhanced prototype was placed in a test chamber and subjected to varying levels of methane at constant temperature and humidity. The prototype is Wi-Fi enabled and presents an access point that the user can log into. A web page is presented that displays the parameters being measured by the prototype and allows control of the sampling fan. This allows access to the prototype through a device that supports Wi-Fi and a web-browser. Additional work was performed in the area of calibrating the Figaro methane sensor that is used in the prototype. The goal is to develop an accurate calibration curve that relates the raw sensor output voltage to % LEL with corrections for temperature variation. The current version of the prototype measures the flow through the device accurately but is somewhat limited in the range of flows achievable. The flow sensor represents a constriction in the measurement path of the prototype. At this time a high-powered fan is required to draw samples through the system. GTI is currently considering replacing the thermal flow sensor with a rotating vane type that would lower the requirement on the fan and consequently on the overall power consumption.
The alpha prototype was demonstrated to OTD at the fall 2015 meeting. — A basic demonstration of the Phase 2 beta prototype is planned for the fall 2016 OTD meeting.

**OTD 1.14.g - Residential Methane Detectors Program.** In this program, several discrete initiatives are being addressed as tasks, with the initial work being a consumer behavior study to better understand how customers react to potential leaks and the development of a “Fit-for-Purpose” standard for residential methane detectors. This program also includes a comprehensive pilot program to evaluate commercially available detectors that performed well during laboratory evaluations. — A pilot testing program is currently under way, with detectors being placed in residential homes throughout the U.S.

**OTD 1.15.e - Triple+ Shutoff Valve Pilot Program.** Triple Plus Ltd. has made available the Triple+ NGL™ version 4.0 of its gas leak management system, a product capable of detecting gas leaks and automatically shutting off the gas supply and stopping the leak. The objective for this project is to perform controlled testing of the valve portion of the product. Researchers are collaborating with Triple Plus to evaluate a technology that combines a methane detector with an automatic shutoff valve as a safety solution to prevent risks due to leaks and other events (e.g., hurricanes, earth-quakes, floods). This unit is assembled in-line with existing gas systems. If a gas ball valve is installed, there is no need to cut, replace, or remove existing pipelines or valves. — Plans are being made for a testing program with OTD sponsors.

**OTD 5.14.j - Residual Gas Removal - Identify Technologies, Limitations & Best Practices.** This effort reviews current and new venting equipment and strategies utilized by gas operators to effect safe and timely extraction of in-ground residual gas. The presence of residual in-ground gas poses hazards to the public and nearby infrastructure, complicates leak pinpointing efforts and obfuscates effectiveness of performed leak repairs. A lingering presence of odorized gas can also generate secondary leak reports by the public for extended periods after a leak repair has been completed. Numerous equipment and strategies for venting and dispersing residual in-ground gas exist. A number of field visits to residual gas mitigation job sites were made to evaluate current practices and provide best practice guidance to the industry. In light of findings from industry surveys and sponsor discussions, the frequency of residual gas mitigations requiring more than natural venting strategies such as that provided from barholing, trenching or the use of vented manhole covers, was significantly lower than anticipated. Other traditionally employed devices such as aerators and air movers, that utilize pneumatic power to generate suction via the Venturi principle, are highly effective in the bulk of residual gas extraction scenarios. Though ultimately dictated by local soil and site conditions, the need to utilize dedicated or higher flow capacity vacuum extraction approaches is minimal and reflected by slow market uptake of specialty equipment such as Vapor Extraction Unit (VEU). Safety aspects and some factors dictating how best to elevate extraction efforts in dealing with persistent in-ground gas indications at the site of repaired leaks are summarized in the project report. Due to the low frequency of this issue and demonstrated effectiveness of the most simple, low cost strategies in the majority of residual gas removal scenarios faced by operators, it was agreed that there is no need to propose follow-on quantitative evaluation of techniques as of Q1 2015.

**OTD 5.14.w - Testing Program for Valve with Water Sensor for Storm Hardening.** In this project, researchers are evaluating a valve integrated with a water sensor to assist with storm hardening. Phase 1 testing was completed in 2015. Additional phases will be addressed based on development status and needs of the project sponsors. Evaluations involve a battery of tests, including: visual tests, pressure tests, debris tests, water-intrusion tests, corrosion tests, humidity testing, drop tests, and others. — A Phase 1

Final Report was issued in August 2015. Additional work continues in the development and addition of methane sensor to couple with the valve actuator.

**OTD 7.15.b - Remote Gas Sensing and Monitoring for First Responders.** The safety of workers, first responders, and the general public will be greatly increased by being able to monitor the atmosphere of buildings and other structures remotely. In addition, continuous remote monitoring of various gas levels during known gas leak situations will allow for better and quicker analysis of the situation. The remote sensors can be placed and/or operated in multiple buildings, sewers, and other structures in the area of the known gas leak. The remote device can wirelessly provide real-time information back to first responders, gas company personnel and others in charge of monitoring and assessing the gas levels in the structures. The objective of this project is to create a device to remotely monitor the level of gases during emergency situations. The device will provide critical information to first responders and gas company personnel, allowing them to determine the concentration of methane, CO, and possibly other key indicators inside buildings, sewers, and other structures from a safe distance.

## Integrity Management

The passage of the 2002 Pipeline Safety Improvement Act – which required detailed assessments of all pipelines operating at 20% or higher of specified minimum yield strength (SMYS) - is the driver for this research for National Grid. National Grid is funding innovative research in the areas of wall loss sensing for unpiggable pipelines and novel methods to assess the condition of cased pipe. These challenges have resulted in the Integrity Management area being the largest R&D spending area for National Grid. Within the overall category of Integrity Management there are three project areas:

**Robotics**: In line Inspection (ILI) using smart pigs is considered the most desirable method of pipeline inspection among the three methods (In line inspection, Direct Assessment, Hydrostatic Test) specified by the US DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA), yet many of National Grid's older transmission lines are not piggable. To meet this challenge we participate in the NYSEARCH Robotics program which is developing robotic, self powered sensors for 6" through 36" transmission pipe. These inspection tools are battery powered and are launched "live" into the pipeline and communicate via wireless signal. Pipe wall thickness measurements are either remote field eddy current (RFEC) sensing or magnetic flux leakage (MFL) sensing. The robotics program has received significant support and cofunding from the USDOT and other industry outside NYSEARCH; to date about $8 million has been received from the USDOT alone. The benefits of this technology investment is pipeline safety, ILI, as mentioned, is the most desirable of the three mandated inspection methods, and savings can be considerable, though highly site specific. In this reporting period the Company has funded the following projects:

**M2001-014 - Explorer 2026 Robotic Inspection System for Unpiggable Pipelines using Magnetic Flux Leakage (MFL) Sensing.** Explorer 2026 is a live entry, battery powered untethered robot designed to enter and inspect transmission pipelines 20 in. through 26 in. diameter at pressures up to 750 psi. Wall loss measurements are by industry standard MFL sensing. The design of the robot and sensor specifically overcomes the restrictions that cause a pipeline to be designated "unpiggable." These restrictions include short radius or back to back elbows, mitered bends, presence of plug valves (these are valves that do not have a full diameter opening and won't allow a typical pig to pass through) or no/low flow conditions. The robot is launched "live" into a pipeline and travels under its own power along the pipeline taking wall thickness measurements along the way. Explorer 2026 is fully developed and has completed two of three field demonstrations at host LDC sites. It will be in full commercial operation later in 2013.

**M2003-009 - Explorer 6/8 (Explorer II) Robotic Inspection System for Unpiggable Pipelines using Remote Field Eddy Current Sensing (RFEC)**. Explorer 6/8 is a live entry, battery powered, untethered robot designed to enter and inspect 6 in and 8 in diameter pipelines operating at pressures up to 750 psi. Wall loss sensing is through a novel sensor called "Remote Field Eddy Current" (RFEC) sensing. Development of this sensor was itself a separate R&D effort and the sensor represents advancement over state-of-the-art magnetic flux leakage (MFL) sensing. The reason this new sensing technique was developed is that traditional MFL sensing creates high strength magnetic fields and given the small diameter of these pipelines not enough robot power could be developed to overcome these forces and move the robot down the pipeline. The robot is specifically designed to overcome obstacles that traditionally cause a pipeline to be classified unpiggable, such as mitered bends, back to back elbows, and low or no flow conditions. The robot consists of drive modules, steering modules, cameras on front and back, and the RFEC sensing module in the middle. The robot is placed in a specially designed launch tube which is mounted on standard hot tapping equipment affixed to the pipeline. The robot is then launched into the pipeline under live gas conditions and travels down the pipeline under its battery power at about 15-20 feet per minute, collecting wall thickness measurements. After the conclusion of the "pig run," data is analyzed and a report on anomalies found, if any, is made.

An important part of any R&D project is a serious and robust field demonstration phase. For this project, the Company served as a field demo site at its 6 in dia 473 psi gas transmission pipeline in Oneida, NY. During this 3 day demo, the Explorer 6/8 robot scanned over 4900 ft. of this pipeline and found no anomalies. This scan provided the company with added insurance that there is in fact no corrosion defects present in this high pressure gas main. This robot and its supporting technology has been licensed to Pipetel Inc, a robotic inspection services company in Buffalo NY, and is now in full commercial operation.

**M2011-006 – Robotics Supporting Technologies.** Modifications are being designed that will allow in-line battery recharging (to extend the range), new sensors to detect cracks, and a "rescue tool" that will allow a disabled robot to be retrieved.
In testing conducted to date, battery life is the factor most limiting the range of the robots. It was realized by the company and others that a more efficient way was needed to recharge the batteries than removal of the entire robot from the pipeline. The technology developer, Invodane Engineering Inc. conceived of an innovative method of recharging

the robot via an “in-line” charging system. A charging cable will be inserted through a small tap on the main and the robot can remain in the pipe while being recharged overnight. Based on recent industry pipeline accidents there is increased focus on sensors that can detect cracks. Although less of a threat than corrosion wall loss, crack sensing is the focus of new development efforts. The benefit of this technology is increased assurance of the integrity of the company’s transmission system.

A rescue tool” will be developed that will assist in the retrieval of a failed robot. This will give the company greater assurance that the robots can reliably be placed inside its piping network. On some critical pipelines this may be a requirement before the robot is placed in the pipeline. The project is designing, developing and testing additional sensors to add to NYSEARCH’s inspection platform for unpiggable mains. Supporting technologies that are being addressed under this project include mechanical damage sensor/ovality sensor, crack sensor, MFL sensor for 6/8, bend sensor, methods for cleaning the pipe at the launch point and ahead of the tool and methods for in-line active charging as well as a rescue tool for the commercial system. We are also developing and testing a hardness test module to add to the Explorer series of robotic platforms for internal testing of material hardness and yield strength.

**M2011-009 – Explorer 30/36 Robotic Inspection System for Unpiggable Pipelines using Magnetic Flux Leakage (MFL) Sensing.** The Company and two other LDCs are funding Explorer 3036 which addresses larger size transmission piping inspections in 30” through 36” pipelines. This project is still in the development phase and will incorporate all the features of the existing suite of robotic inspection tools such as live launching, plug valve and short radius bend negotiation, all in pipelines up to 750 psi operating pressure.

**M2013-001- Explorer 16/18 - Inspection of Unpiggable Pipelines.** This Special Project was an Accelerated Development effort cofunded by Invodane to design, manufacture, integrate sensors and supporting technologies and test prior to commercialization.

**M2013-002 - RMD Crack Sensor using Eddy Current Technology.** RMD has developed a new eddy current sensor that in early studies has shown promise for detecting crack defects. The new sensor is different from existing eddy current sensors in two regards: (a) it uses solid state technology instead of the traditional coils (which have inherent limitations in providing high accuracy and detectability), and (b) it is easily and inexpensively fabricated in inflexible and flexible substrates using mass production techniques. The combination of these two factors results in an inexpensive sensor with resolution and sensitivity superior to traditional eddy current sensors. This project first proved the feasibility of using their EC technology for the detection of cracks in natural gas pipelines and is now advancing to development and testing as well as integration onto the EXP series of robotic platforms.

**Cased Piping**: Research into cased pipe assessments is an important part of the transmission pipe integrity management program. Transmission piping placed concentrically within a larger "casing" is a common practice when pipelines pass under major highways, railroads or bodies of water. Assessing the condition of these "carrier" pipes within casings can be difficult if the pipeline is not piggable. The company is involved in several research efforts to address this important issue. The efforts consist of software tools to evaluate casings, and inspection hardware to perform inspections. A very promising technology is "Guided Wave," in which an ultrasonic signal is propagated along a pipeline from a remote location revealing flaws in inaccessible areas of the pipeline.

**M2001-003 - Cased Pipe Risk Assessment Model.** This project involved the construction of a software tool program that prioritizes casings in terms of relative risk. The program considers inputs including, but not limited to corrosion rate, degree of cathodic protection, presence of moisture and wall thickness of the pipe and categorizes casings in terms of probability of failure. Casings with higher risk scores can be scheduled for further follow up inspections while those with lower scores can be monitored. Consequence of failure can also be added to the model, thereby producing a total risk score, which is the product of probability of failure and consequence of failure. Depending on the degree and accuracy of the data that is input into the model, the model can also calculate time to failure in years. A follow on to this project involved lab and field analysis of corrosion rates in various environments. With this information, a corrosion rate can be entered into the model which would be most representative of actual corrosion expected in the field, and not theoretical (overly conservative) rates. This project benefits the company by allowing it to prioritize inspections of riskier casings first and perform remedial actions, if required, on those riskier casings.

**M2007-001 - Mini-camera for cased pipe inspections.** This is a crawler camera magnetically attached to the casing. It can navigate down the length of the carrier pipe returning video image of the pipe. The camera has been deployed successfully at several sites and a follow on phase to the project will incorporate ultrasonic sensors for wall thickness readings and humidity gauges to assess the presence of moisture (a key ingredient that can accelerate corrosion). The mini-camera does not, by itself, provide a complete assessment of the carrier pipe condition but is rather another "tool in the toolbox" when used with other assessment methods such as Guided Wave technology.

**M2007-003 - Multi Technology Validation Testing for Cased Pipe Applications.** This is a testing program for various technologies, which may have promise for inspecting wall loss and other defects on carrier pipes within casings. Technologies tested were guided wave, magnetostrictive sensors (an in-situ type of guided wave), the casing camera, and Time Domain Reflectometry (TDR). Some of the technologies tested are commercially available and some are still in the development phase. The results of this test program gave the company valuable information on to the effectiveness of these various inspection techniques. The two most promising are guided wave and the casing inspection camera. The magnetostrictive sensors were not as sensitive as traditional guided wave, and TDR, although promising, will not be seriously pursued at this time. A new phase of this project has recently been authorized which will focus on more detailed testing of guided wave. All tests are conducted at the NYSEARCH test bed, which is a network of above ground and buried pipe containing machined defects. This is an effective way to compare technologies as all tests are on the same piping components, and defect locations are known only to NYSEARCH staff. However, the company took an additional step and developed a test program for guided wave on its own in-service piping. This project is more fully discussed later in this report.

**M2011-007 – Cased Pipe Inspection via Vents.** National Grid has had success in its downstate territory with the mini-camera for cased crossings, described above, but the drawback to this technology is the requirement for costly excavations to gain access to the casing annular space at the end seal. An alternate approach is to gain access to the annular space from above ground, through small diameter vent piping which is present on casings. Technology to provide this visual inspection does not exist. The technical approach on this project is to use commercially available camera technology and adapt it to travelling down through the vent piping until it reaches the casing annular space. Through a technology search for new technology providers, NYSEARCH has qualified a small robotics company, Honeybee Robotics, to perform robotics work, and they will perform on this project in a two- phased approach with a go – no/go decision point after Phase 1. Phase 1 will demonstrate the feasibility of adapting existing technology to the task of negotiating the vent piping to gain access to the casing annular space. Such access will be constrained by the small diameter and sharp ninety degree bends that are normally present in casing vent piping. Cleanliness of these vent pipes may also be an issue. If the testing reveals that access to most typical casings can be gained, then the project will proceed to development of a prototype system that can enter the annular space and obtain meaningful information. The benefit is compliance with pipeline integrity management regulations at a significantly lesser cost than traditional means of gaining access to a casing. This project is focused on developing and testing concepts of a compact tethered robotic camera. The successful robotic camera is intended to provide the operator with insight about a cased pipe by gaining access to the annular space through a typical casing vent without requiring excavation.

## Other Integrity Management Research

Included here are various projects that contribute to our understanding of, or help us meet, transmission or distribution integrity management requirements.

**M2005-003 - Design, Construction & Operation of Regional Test Bed.** An above ground and below ground pipe network that has been built specifically for testing new inspection technologies by member gas engineers. This 1200 foot network features different coatings, known anomalies of different sizes, varying soil types, varying welds with good and bad weld practices, different joints and other features for future use on other gas operations purposes. The test bed site is a NYSEARCH/NGA site that is leased from New York State Electric & Gas in upstate New York (Johnson City near Binghamton).

**M2007-005 - TransKor Remote Inspection Testing (Magnetic Tomography).** The magnetic tomography method (MTM) is a commercial, non-intrusive, above ground method of pipeline inspection developed in Russia by TransKor. Through NYSEARCH, the Company became interested in this technology as an additional “tool in the toolbox” for transmission pipeline assessment. Although other above ground assessment techniques are in use today, they rely primarily on detection of coating failures. MTM measures the inherent magnetic field surrounding a metallic pipeline and detects stress risers in the pipeline by analysis of the pipeline’s magnetic field. Stress risers are indicative of wall loss, welds, manufacturing defects, or mechanical damage such as dents or gouges. A test program is underway by the Company and other LDCs who are members of NYSEARCH to thoroughly test the capabilities and accuracy of the MTM. The ultimate goal of the test program is to evaluate the performance of MTM and have it recognized by PHMSA as an “other technology” suitable for transmission pipeline assessment. MTM could provide a significant benefit to the company’s Integrity Management plan by providing a much less expensive and more thorough assessment method which requires only a simple walk-over of the transmission pipeline being assessed.

**M2009-001 - Holistic Review of Distribution Integrity Management Plan (DIMP) Risk Practices and Models.** In 2010 the Pipeline and Hazardous Materials Safety Administration (PHMSA) issued regulations requiring operators of natural gas distribution systems to implement a formal distribution integrity management program. The regulations are not prescriptive and don’t require specific types of inspections and assessments as do the transmission integrity regulations, but they require operators to risk rank their distribution system. The Company undertook this project to more fully understand exactly what type of risk modeling may be best suited to analysis of a gas distribution system. Some of the projects’ findings suggest that age of the distribution piping alone is not a complete indicator of risk, but other factors such as material type, location, and potential for operator error all factor into a relative risk ranking. Availability of data on the distribution system is also key to developing a reasonable and useful risk model. (For example, although age, material type and location of pipeline segments are certainly known, various component types or specific installation practices are not always known with the same certainty.) Conversely, overloading a risk model with too much specific data does not result in a useful risk tool either.
The final report on the project provides suggestions on a risk management approach and guidelines on making decisions on purchase or development of a specific risk model. The benefit is information and guidance to the company regarding the best method to risk rank its distribution network.

**M2012-003 – Enterprise Level Assessment of Data Management Systems.** This project addresses a relatively new requirement for gas distribution operations, namely to establish traceability – from initial manufacture to installation – of gas system piping components, and a means to track the location and installation parameters of these components, and integrate this information into existing company data management systems. The best methods of doing this, both from a hardware and software perspective, are being explored in this project. The company is funding this project to gain important information about this new industry initiative, but because we are conducting active field demonstrations via a similar OTD project (OTD 5.11.m) we will only be observers for this project.

**OTD 2.11.d - RSD X-Ray.** This non-destructive examination (NDE) method has advantages over traditional X-Ray. For example, radiation levels are reported to be lower, and resolution can potentially be higher. Additionally, images can be displayed in real time. As opposed to traditional X-Ray, which requires through-the-wall penetration from the radiation source to a film on the back side of the weld, RSD X-Ray works on the principle of backscatter, or reflection of the X-Ray signal. The detector can be outside the pipe, co-located with the source. Before such a new technique is adopted it needs to be tested to demonstrate that it is capable of identifying flaws in welds with the same sensitivity and accuracy as traditional X-Ray. GTI will work with the vendor of this equipment to perform blind tests to demonstrate this. The results of the blind tests will indicate whether the project should proceed and whether equipment and techniques should be developed for practical applications in the gas industry. If successful, this method of non-destructive examination (NDE) could also be applied to pipeline integrity assessments of existing transmission pipeline segments via incorporation on to a pipeline pig, or a robotic internal inspection device.

Using Nucsafe’s Scatter X-ray Imaging (SXI) technology, the first iteration of this investigation utilized standardized PE disks with precisely measured defects placed in the fusion interface. The objective was to develop a repeatable methodology of introducing specific defects into the fusion interface and to scan a sufficient number of replicates that would allow probability of detection statistics to be calculated. A set of calibration specimens was prepared at GTI and sent to Nucsafe for scanning. The scan results showed that while the disks were detectable the interfaces between the disks and the pipe dominated the signal and masked the included defects in many instances. The initial approach was abandoned in favor of that utilized in OTD Project Number 2.6.e which was more successful.

**OTD 4.7.g - Yield Strength Determination.** Operators with incomplete records need a better way to determine the yield strength of their pipeline segments if it is unknown. Current regulations require that operators either take a full size cutout of the pipeline and subject it to laboratory testing, or assume a low value of 20,000 psi. Obtaining full size cutouts is disruptive to pipeline operations as it would require a full shutdown of the pipeline. Assuming 20,000 psi could result in the pipeline being in an (assumed) over pressure condition when in fact it may not be. GTI developed a method to determine the yield strength of a pipeline through lab testing of “sub-size” samples. The samples can be obtained easily by using standard hot tapping equipment without shutting down the pipeline. A follow on phase to the project will utilize sophisticated statistical techniques to possibly lower the number of sub-size coupons required for given lengths of pipeline. The benefit to the company is a less expensive and less disruptive method for positive determination of yield strength, should any of the company’s records be incomplete.

**OTD 4.8.a - Guided Wave Equivalent to Hydrotest.** The objective of this project was to perform a validation effort to allow the use of GWUT as an acceptable inspection technique by demonstrating the ability of GWUT to perform equal to, or better than, a hydrotest. The specific objectives of this project were to perform the following: Compile data from GWUT inspections that have been validated by design, ILI, or direct measurement, Demonstrate that GWUT finds defects that would pass a hydrotest (therefore substantiating that GWUT will find all larger defects), and Provide a validated methodology for a new standard. Data collection involved gathering all available and acceptable data from prior GWUT inspections and the associated dig records (defect geometry, pipe diameter, wall thickness and grade). Data was only accepted and reported in this study if the GWUT could be verified through direct inspection. The collected data was used to calculate the failure pressure for rupture using the most conservative federally approved methodology, i.e., ASME B31G for all validated data points. The validation calculations were undertaken to confirm or substantiate the following hypothesis: GWUT misses no defects that would fail a hydrotest, and GWUT misses no defects that were found in the direct examination (i.e., determine the False Call Rate). The percentage wall loss vs. anomaly length diagrams plotted to B31G confirmed that GWUT is equivalent to hydrotesting. The GWUT methodology found all those anomalies that would have been found by the hydrostatic testing and GWUT also found anomalies that were too small to have been detected and would survive in a hydrostatic test to a pressure equivalent to the pipe's Specified Minimum Yield Strength (SMYS).

**OTD 4.8.i - Extended Reassessment via Wax Fill of Casings.** A proper wax fill of a casing eliminates the threat of external corrosion on the carrier pipe by removing any electrolytes in the annular space between the casing and the carrier pipe and replacing it with a dielectric medium (the wax fill). Although techniques for filling casings with wax are well known, there has been no known technique for validating the effectiveness of the wax fill operation so that assessment intervals could be extended. For this project, corrosion monitoring techniques and techniques to determine the completeness of the initial wax fill operation have been developed. Casings were filled with wax and monitored to determine the extent, if any, of corrosion. To simulate actual field conditions, water was left in some of the test sections prior to filling the annular space with wax as well as through ports made through the casing wall and water forced into created voids. Such testing conditions were extreme. Upon post examination, after 1 year of service, extremely low corrosion growth rates were found, at a much lower rate than would be expected. Longer term testing could provide additional data to verify if the corrosion rate drops, stabilizes or does neither over time. More work would be required to quantify actual corrosion rates over a longer time period

**OTD 4.9.a - Leak vs. Rupture Boundary.** The current Pipeline Integrity rule requires that all pipelines operating at 20% or higher of the specified minimum yield strength (SMYS) are subject to the more stringent transmission integrity assessments. (20% is thought to be the lower limit of pipeline stress at which pipelines fail by rupture). However, there remained questions as to whether 20% is a realistic lower limit. With the support of the USDOT, investigations of past failures coupled with detailed mathematical modeling can confirm that the 20% limit is overly conservative and a more realistic lower limit may be 30%. The Company may then elect to designate certain pipeline segments as covered under the new Distribution Integrity Management rules. GTI investigated over 20,000 pipeline failures worldwide and was able to draw conclusions as to the parameters that cause pipes to fail via leakage vs. rupture. Not only yield strength but also diameter, pressure, and toughness are factors that determine whether pipes fail by rupture or leakage. The project results showed that for most modern pipeline materials the leak-rupture boundary is more like 30%. Using the results of the project, operators can – with proper regulatory approval – place their pipeline segments in the appropriate integrity management program. The benefit would be that company resources can be directed to assessing the more vulnerable pipeline segments.

**OTD 4.11.f and T 768 (non-Millennium Project) - Understanding Threat Interactions.** Part of an operator's Transmission Integrity Management program is a relative risk assessment of the various threats that could impact a pipeline. There are various risk models in use that can quantify the relative risk of pipeline failure via the threats that are present. What is not so well developed is a ranking methodology that accounts for threats that can interact, or occur simultaneously on a pipeline segment. For example, what is the additional risk to a segment if external corrosion occurs on a manufacturing defect, or if earth movement occurs in an area with a defective weld? This project will examine a realistic combination of multiple threats that can reasonably be expected and will calculate the additional risk of failure to a pipe segment due to the presence of these interacting threats. This is timely work since the Company and others have been questioned during safety audits by regulators on their methodology for addressing interactive threats. This benefits the company by allowing the most accurate risk ranking and subsequent assessment of the integrity of those segments. Because this is an important issue the Company funded two parallel projects. The first is a short term effort through NYSEARCH that focuses on (but is not limited to) evaluating interacting threats through the existing Kiefner Model, which many LDCs use today. This effort took far longer than expected but an algorithm is now available (Nov. 2015) for use in determination of the risk associated with interactive pipeline threats. Yearly updates will be made to this model as incident data is reported and updated through the DOT under a 5-year contract with the developer. The second is a longer term more theoretical approach by GTI which could provide more overall flexibility.

**OTD 4.12.b – Correlating Pipeline Operation to Potential Crack Initiation and Growth.** Based on recent industry events coupled with new or proposed regulations, the gas industry is expected to increase the amount of pressure, or "hydrostatic" testing on existing pipelines. In addition to a standard pressure test (in which the pipeline is pressure tested to 1.5 times its operating pressure) there is the possibility that operators would be required to perform a "spike test" in which the pipeline is raised to 90% of yield strength (which could be significantly higher than a normal hydrostatic pressure test).
Such pressure testing, while having advantages over other integrity assessments, can cause cracks to initiate and/or grow. This has been observed in other industries (boiler tubes) but is not well understood in the gas industry. The Company is aware of the advantages of pressure testing but wants to understand the risks that could present themselves due to pressure and spike testing. GTI will leverage previous work done in

the boiler tube industry to develop a model to predict crack growth due to pressure testing. Validity of the model will be tested by subjecting actual pipe specimens to laboratory pressure cycling which can simulate years of pressure testing and/or pressure excursions in a matter of hours. The deliverable of the project will be a model that will relate historical and planned pipeline operations to potential crack initiation, growth and arrest. This benefits the company by insuring that pressure testing does not degrade the pipe segment being tested, with the associated possibility that the pipe could fail while in service.

**OTD 4.13.a - DIMP Consequence Model.** The objective of this project was to develop a model that quantifies the consequence of failure for distribution systems and DIMP based factors such as population density, proximity of critical infrastructure and business districts, failure mode based on material properties, gas migration patterns, soil and surface conditions, pressure and potential energy. The deliverable of this project is a DIMP consequence model that operators and software vendors can incorporate into existing risk modeling tools.

**OTD 4.13.b - Demonstration of 3D Scanners for Anomaly Assessment.** A validated tool that eliminates manual data collection of in-the-ditch anomaly measurements using a pit gauge will improve data quality and increase operational efficiency. Automating the process of measuring anomalies found through ECDA and ILI runs could be achieved through various 3D scanning devices. This project’s goals are to validate and demonstrate the performance of 3D scanners for automated in-the-ditch anomaly measurement and assessment of corrosion, dents and gouges. The two 3D scanners that were tested demonstrated the ability to provide more accurate and reliable anomaly assessments compared to manual pit-gauge measurements. Recommendations for further assessment include: 1) Evaluate the cost of the products in relation to the value that they provide in terms of improved data accuracy and reliability and time savings during data collection and management. 2) Ensure that 3D scanners are compliant with federal and state regulations.

**OTD - 4.13.c EMAT Sensor for Small Diameter and Unpiggable Pipe**. This project goal is to develop a bi-directional electromagnetic acoustic transducer (EMAT) sensor that can be used to assess small diameter and unpiggable pipelines containing reduced diameter fittings and other restricting features. Phase 2 focuses on constructing and testing a field-ready prototype based on the success of the bench-scale prototype sensor developed in Phase 1. This research will enable natural gas pipeline operators to identify defects that are traditionally difficult to find and assess and therefore improve system integrity and public safety. The EMAT sensor will be designed to find and characterize cracks in welds and pipe walls. PHMSA is co-funding phase 2 effort with industry funders of this project.

**OTD - 4.13.d.3 - Hydrotest Alternative Ph 3.** The third phase of this program is to identify and validate inspection and assessment technologies that are equivalent to a 1.25x Maximum Allowable Operating Pressure (MAOP) hydro-test for Integrity Verification Process (IVP) compliance.  Phase 2 created the Finite Element Analysis

(FEA) critical flaw data and collected Probability of Detection (POD) data for Electromagnetic Acoustic Transducer (EMAT) and Acoustic Resonance Technology (ART) sensors. Phase 3 will create the critical flaw curves that will allow a comparison to In-Line Inspection (ILI) tool detection capabilities. The deliverable of Phase 3 will be a tool that operators can potentially use to demonstrate equivalence to a hydrotest for a specific pipe segment. The ability to use internal and/or external inspection tools to perform an integrity assessment as a regulatory acceptable alternative to hydro-testing would ensure the operator of the safety of the pipeline and provide significant cost savings in complying with new regulations. It would also provide operators an integrity assessment solution for those critical pipelines that cannot be taken out of service. Furthermore, hydro-testing may increase risk by introducing water that cannot be removed and may accelerate crack growth for certain susceptible pipeline materials. Acceptable alternative methods to hydrotesting are a critical need.

**OTD - 4.14.a Fitting and Component Catalogue for IVP.** The goal of this project is to develop a catalogue of legacy fittings and components to assist operators in identifying and characterizing assets to comply with PHMSA's Integrity Verification Process (IVP). The envisioned catalogue will contain pictures, descriptions, strength class ranges, and material and mechanical properties. A catalogue of legacy fittings and their characteristics will assist operators in complying with pending federal regulations, specifically the new IVP requirements. An industry catalogue will reduce the cost of gathering and compiling this information and provide support for strength requirements and assumptions when a fitting can be positively identified. This project has encountered issues with obtaining suitable documentation of data for inclusion in the catalog. Initially critical documentation had been located via the internet (only 2 copies existed) and one copy was ordered but the shipment never arrived. The other copy is not for sale and is owned by Chinese interests. Securing composite catalogs of vendor products and parts from the desired pre-1970 era are actively being worked and GTI is in the process of obtaining a paper copy of a large document from Gulf Publishing via loan that may include useful information. Digitizing and collating the potentially thousands of relevant vendor catalog pages from Gulf documents could ultimately lead to generation of a searchable online tool for LDC use. This effort would likely require significant resources outside the scope and budget of this project.

**OTD 4.14.c - Surface Indentation for Material Characterization Correlation of Surface Properties Based on Vintage.** There is a need to develop correlation factors to relate surface properties to actual material properties to allow surface indentation techniques to be used for material property validation for pipelines. These correlation factors will be based on pipe vintage by decade. Past research has proven the ability of surface indentation techniques such as stress-strain microprobes and hardness testing to accurately determine material properties of pipes within a localized area, but variations in material properties through the wall are problematic for local interrogation techniques. GTI will develop probabilistic confidence intervals that will allow operators to use surface indentation techniques by applying correlation factors to pipe materials that may have through-wall variability. The ability to characterize material properties, particularly yield strength, of in-service pipelines without taking the line out of service or removing samples will significantly reduce the cost of complying with existing and pending federal regulations. Backfilling records with material property information such as yield strength and toughness also improves integrity management through system knowledge that allows enhanced modeling and analysis. It is anticipated that the results of this research will facilitate the regulatory approval of stress-strain microprobes and hardness testing to characterize material properties of in-service pipe. It will also empower internal inspection tools (such as PRCI's signature pig under development or TDW's MFL tool that may be able to detect signatures) to use surface readings from the inside of the pipe to be applied to the entire pipe wall.

**OTD 5.8.e - Tracking and Traceability.** One of the requirements of a Distribution Integrity Management program is to "know your system." But there is no industry standard for manufacturers to mark gas piping and appurtenances with critical manufacturing information nor is there a standard for LDCs to record data when installing permanent additions to their gas systems. On the manufacturing side, date of manufacture and lot number need to be recorded in a standard fashion across industry, and installers need a standard way to record location of the installation and identify the crew doing the work. For this project, GTI and a subcontractor formed a steering committee to identify which commonly used materials should be identified, and what pertinent information should be recorded. The steering committee consisted of manufacturers and LDCs. An ASTM F2897 standard was developed to which capture the results of the Steering Committee's decisions and a bar coding protocol was agreed upon. A future phase of the project will develop methods to record, store, and retrieve, if necessary, data on installed components.

**OTD 5.9.j - Gas Distribution Model.** With Distribution Integrity Management Program (DIMP) regulations now in place, operators will be developing data collection strategies to ensure compliance. One tool that could help operators in this process is a non-proprietary, industry standard data model for distribution assets and operations. A standard data model, the Pipeline Open Data Standard (PODS) model was developed to assist transmission operators in managing their data and ensuring regulatory compliance. The PODS model is an open, industry-standard data model that has successfully been used for over ten years to reduce the cost of implementing software and improve interoperability for the pipeline industry.

Now with DIMP there is a similar need for an industry-standard data model for distribution assets and operations. Gas Technology Institute (GTI) initiated a program to develop the Gas Distribution Model (GDM) to meet this need with three specific purposes. First, the model will be used as a data exchange function between operator data models and vendor's software products to reduce the need for customization. Second, the model can store both transmission and distribution data and will facilitate vertical data integration. Third, GDM could be used as the primary data model for operators to avoid the need for internally developing a model. The Company engineers and IS personnel felt that such a data model would benefit the business and also would facilitate transition to the new SAP system. The GDM initiative brought together a diverse group of operators, vendors, and industry experts to collaboratively develop a GIS-neutral model that holds promise to reduce the cost of software implementation and improve interoperability. GDM is a flexible model that will grow and expand with continued use and development.

**OTD 5.11.m – Intelligent Utility Installation Process (Asset Tracking and Traceability).** This project will develop methodology and suggest field processes for capturing data during new installations. It is a logical follow on to the requirements of recently enacted DIMP regulations which require operators to "know their systems." It also will provide the means to implement the results of the "Tracking and Traceability" project which created an industry standard for manufacturers to mark their products with manufacturing data. A key component of the Intelligent Utility Installation project is to achieve standardization across industry. When this project is implemented the company will benefit by knowing precise attributes of its distribution system and will be able to quickly react to reports of possible defective pipe material or fittings.

**OTD 5.15.b - Roadmap for an Enterprise Decision Support System (EDSS).** By striking the proper balance between competing influences, operators will maximize business health. There is a growing realization among operators and regulators that ad hoc decision making, based on the latest crisis, is not the optimal method for enterprise management and ultimately system reliability, safety, and efficiency. The objective of this project to develop an Enterprise Decision Support System (EDSS) technology roadmap. The EDSS will allow LDC operators to integrate all data and business knowledge sources into a decision support system that will optimize policies related to: risk mitigation, safety, code compliance, customer satisfaction, environmental stewardship, efficient operations and future growth. It is increasingly necessary to optimize various operational decisions based on predefined rationale coupled with comprehensive knowledge of data/system inputs and a methodical risk analysis. Enterprise decisions and risk analysis that will be supported through this process include repair vs. replace vs. rehabilitate, predictive threat interactions and consequence of failure, risk based prioritization of O&M activities, scenario analysis for various risk mitigation strategies, economic analysis, amongst others. Additionally, new asset-based data streams are continually being developed as directed by distribution and pipeline integrity programs as well as the relative ease in which large volumes of system data can be collected. The EDSS will integrate these disparate data streams into a logical system capable of rationalizing the inputs to enable sound decision making. The deliverable of this project will be a well formulated roadmap that provides guidance on how to realize an EDSS. This roadmap will be used to execute a series of stage-gate linked projects that progressively move us towards the goal of a fully functional EDSS.

## Plastic Pipe Research

The bulk of piping added to LDCs' networks each year is medium or high density polyethylene (PE), or plastic pipe. Last year alone, the Company added over 500 miles of such pipe to our system. Working with NYSEARCH and GTI, the Company is involved in several research projects designed to improve our understanding of PE performance and develop new products.

**M2000-001 - PE Repair Sleeves for Damaged PE Pipe.** As an alternative to squeeze off and cutout of minor defects on PE pipe, the Company and others are developing, through NYSEARCH, repair sleeves to reinforce PE pipe in the area of the butt fusion joint, or along the length of the pipe. During routine operations such as new service additions or main extension, minor damage – not causing leakage - can be noticed on the existing PE pipe that is uncovered. The substandard conditions noticed can be either a scratch or gouge on the pipe itself, or a questionable appearing butt fusion joint. The solution, up to now, is removal of the defective pipe segment. Removal is usually accomplished by first "squeezing off" ahead of and behind the pipe segment in question, then cutting it out and replacing it. As an alternative, the PE repair sleeve can be fitted over the defective area in question and fused on to it. The fitting is designed to withstand line pressures up to 124 psi but will not be installed if an active leak is present. The benefit of this technology is lowered repair costs and improved reliability of PE piping systems by reducing the amount of "squeeze-offs" made. These repairs can also be made without causing an outage, whereas a squeeze-off may require a short outage if the pipe is a one way feed.

**M2006-002 – Butt Fusion Integrity**. This project examines current butt fusion parameters such as pressure and temperature at the joint interface with an aim towards optimizing them. Through a novel test method, the "whole pipe creep rupture test" several test fusions are made and subject to this laboratory destructive test. This test more accurately simulates stresses that actual in-service pipe experiences, and results of these tests can serve to further refine butt fusion parameters and associated procedures.

**M2008-010 – UV Degradation of PE Pipe.** The Company wants to understand, through testing, what the real time limit for PE pipe to withstand UV exposure without a harmful effect would be. Current USDOT regulations specify two years but the current version of ASTM D2513 (the industry standard for manufacture and use of PE pipe) specifies an outdoor storage limit of 3 years for medium density PE pipe and 10 years for high density PE pipe. But this current standard has not been accepted by the USDOT, who recognize the previous version which limits outdoor storage to 2 years. This project was undertaken to demonstrate, through testing, that pipe stored outdoors longer than 2 years is still suitable for use. Both non-destructive and destructive tests have demonstrated that pipe stored outdoors for three years is suitable for use. The work now is to present the information to the USDOT and request a rule change. The benefit to the Company will be immediate; National Grid recently discarded over $300,000 worth of PE pipe that exceeded the 2 year requirement.

**M2009-008 – Ultrasonic Inspection Device for PE Butt Fusions.** The aim of this project is to develop a field instrument to rapidly and easily examine butt fusions in the field, providing on-the-spot assurance of the integrity of a newly made butt fusion joint. A low cost user friendly butt fusion inspection device has been a goal of gas industry research for quite some time. Such a device gives greater assurance of butt fusion quality by allowing "on-the-spot" inspections by field crews or supervisors actually doing the work. The Welding Institute (TWI), located in the UK, is a leader in plastic pipe research and was selected to carry out this work in a phased approach. In the first phase, an instrument was configured to examine and return information on the presence or absence of flaws in the butt fusion. The next phase of the project is to determine which flaws can be accepted and which will cause the pipe to fail. This is done via destructive testing; fusions with varying degrees of flaws are subjected to testing and a “library” of flaws is developed and flaws are categorized as either “causes failure” or “does not cause failure.” Based on similar European technology for metric sizes, the objective is to develop and test a nondestructive tool for examination of butt fusion joints (particularly for use with advanced PE materials). This project has taken advantage of significant research already performed by The Welding Institute (TWI) for the European gas and PE piping industries. Extended long term testing is being performed because the test protocols/data from Europe showed that U.S. failures do not occur as rapidly and to test to failure, different conditions needed to be imparted. The significance of this extensive testing is that NYSEARCH and TWI are developing acceptance criteria for use in a tool that does not require a trained technician. Other phased array NDE tools are either not state-of-the-art OR they require a trained technician. In its final form, the instrument will examine field fusions and compare them to fusions in the “library” and be able to give a simple “good fusion” or “bad fusion” reading. The benefit of this work is greater assurance of the quality of a butt fusion and increased safety and reliability of the gas distribution network.

**OTD 5.13.c - PE Pipe Splitting—Technology Evaluations, Enhancements, and Standardization of Tool Kits** A research team is evaluating and refining existing PE pipe-splitting equipment and developing guidelines. In October 2015, manufacturers performed various pipe-splitting activities with plastic-pipe-replacement construction techniques. — Researchers are seeking additional field sites for this project.

.

## Live Inspection, Maintenance and Repair

The Company is always looking to minimize customer downtime or gas main shutdown during routine maintenance activities. The following projects help us meet this goal.

**M2001-006 - Development/Testing/Commercialization of Real Time Gas Distribution Sensor Network - Phase I-V.** This distribution sensing system is intended to provide network sensor data acquisition, robust wireless communication and encrypted data accessible for pipeline monitoring and assessment. Data from these real-time sensors will include pressure, temperature, humidity, flow volume, and direction. The objective of the program is to complete development and testing to the point where Enetics/Telog can commercialize the technology.

**M2008-003 - Evaluation of Rapid Crack Propagation.** A study to model and test the existing ISO correlation formulas used to determine rapid crack propagation in PE pipe. Through this project, it has been determined that existing formulas are overly conservative and need to be changed.

**M2014-001 - sUAS Technology - Regulatory & Technology Assessment**. The objective of the project is to evaluate regulatory issues and technology of small unmanned aerial systems (sUAS) devices as applied to gas industry inspections and surveys. Further, NYSEARCH has been investigating development of methane leak detection module and control system capable of using at tree-top level for leak survey and methane emissions measurement on a sUAS.

**M2014-005 - Critical Valve Operability.** The objective of the project is to develop a method of confirming valve position and provide validation of a critical valve operability test.

**M2016-001 (Millennium); T-770 and T-776 (non-Millennium) - Cured In-Place Composite Liners projects and Technology Transfer, Demonstration & Post Mortem Testing of Cast Iron & Steel Pipe Lined with Cured-in-place Pipe Liners.** The objectives of the project were to: 1) gain understanding and support from regulators using Cured-in-Place Pipe (CIPP) Liners as a rehabilitation technique for cast iron and steel pipe, 2) provide an engineering assessment to advance the understanding of liner/host pipe interaction and demonstrate structural equivalence towards repair/remediation of lined pipe/appurtenances, and 3) validate the effectiveness of CIPP-lined cast iron and steel pipe through examination of past studies & further demonstration and lab testing.

**M2016-001 (Millennium) - Chemical Longevity & Post Mortem Slow Thermal Cooling Testing of Field Aged Cured-In-Place Lined (CIPL) Cast Iron and Mechanically Joined Steel Pipe.** The primary objective of this proposed Phase II project is to further address regulatory concerns by testing field aged extracted cured-in-place segments as they interact with host steel or cast iron pipe to demonstrate the actual impact of slow thermal cooling and perform chemical aging longevity evaluation tests to (100) years. Six test segments of CIPL pipe, three steel (12”-16” diameter) with a mechanical coupling, and three for cast iron (12”-16” diameter) are proposed to be extracted after years of gas service and will be further tested using a solid foundation of protocols by scientists at Cornell University. The cast iron pipe will be flexed to create a circumferential crack prior to testing. Project goals include: 1) performing thermal testing to simulate actual slow cooling in the field, and, 2) conducting independent tests to examine the chemical longevity of a new CIPL pipe to a (100) year life cycle equivalent, 3) completing a workshop with funding member SME’s and Cornell professional staff on “best practices” for evaluating corrosion and structural limitations of host steel and cast iron pipe segments, and, 4) providing a platform that encourages industry and regulatory dialogue regarding the use of CIPL pipe as an option for the renewal of our aging pipeline infrastructure. This will involve preparing information so that the gas industry sponsors develop a unified approach to addressing levels of host pipe corrosion acceptable for CIPL use in field aged CI or steel pipelines.

**OTD 2.11.a - Above Ground Leak Repair Systems Testing.** The Company and other LDCs desire to qualify various repair products that are sold for repair of above ground leaks on natural gas piping as a permanent repair system. The application is for above ground meter piping on distribution systems. No use of these products on below ground piping is contemplated. Two available products are being tested. Initial tests will be short term testing to establish the proof, or “burst” pressure of the repair system. These tests

are complete with burst pressures found to be well above (by an order of magnitude) normal operating pressures. Plans for long term testing are now underway.
A successful outcome of this project would be that these repair systems would qualify as a permanent repair thus repairs can be made more inexpensively than a shutdown and rebuild of meter piping, with the associated inconvenience to the customer.

**OTD 2.12.e - Selection of Liners Composites for the Rehabilitation of Distribution and Transmission Lines.** This project is an evaluation of the use of composite pipes and cured-in-place (CIP) liners in the rehabilitation of gas distribution and high-pressure lines. The replacement and rehabilitation of these pipeline systems in congested, urban areas with very limited right of way space is particularly problematic. This project investigates the trenchless rehabilitation options of these pipes.

**OTD 2.13.b - Guidelines for Special Permits for Structural Composite Rehabilitations.** The objective of this project is to develop guidelines for submitting special permits to state and federal regulators to request approval to use composite materials for structural pipe rehabilitation. The need for new techniques to repair and replace pipe will continue to increase as infrastructure continues to age. While open trench replacement will be the most cost effective technique for many applications, some situations will require the use of trenchless or alternative techniques that use the host pipe as a conduit for installing a new pipe. Composite materials hold much promise for rehabilitating aging infrastructure, including high pressure pipes. Composite materials can have properties that are superior to steel and can be installed in flexible configurations. Guidelines for submitting special permit requests will reduce the cost and time associated with filing the application. Guidelines will also improve the likelihood of obtaining approval through a special permit by ensuring that permit applications are complete and address the issues that are of interest to state and federal regulators. Other means are being explored for regulatory acceptance, as such; this project is temporarily on hold.

**OTD 2.13.c - Long-Term Evaluation of Liners and Composite Pipe Materials.**
An engineering assessment was conducted to improve testing methods for predicting the long-term performance of liners and composites used in the rehabilitation of aging gas distribution and transmission lines. The focus was on high-pressure (up to 350 psig) composites and liners installed using trenchless technology. — A Final Report containing guidelines is being prepared.

**OTD 2.14.a - Composite Repair Wrap for Polyethylene Systems**
Researchers are evaluating a new composite pipe-wrap system for the repair of damaged PE gas pipe. Efforts are under way to establish the correct combination of adhesive and wrapping material. — Repaired specimens are being monitored under long-term hydrostatic pressure testing.

**OTD 2.14.b - Steel-Pipe-System Repair Technique**
A novel repair method for live leaking steel-infrastructure applications was developed and tested. The method uses a mold, resin, and composite wrap to provide safe,

permanent repairs. The goal is to have the technique applicable to steel couplings, threaded joints, cast-iron bell joints, and service tees. Testing is complete and a patent for the technology was filed. — A Final Report is being prepared. Discussions with potential manufacturers are under way.

## Trenchless Technology

The Company's primary research effort in this program area is to find ways to complete maintenance with minimal excavation. These technologies will lower cost and result in less disruption to the customer.

**M2010-001 – Service Tee Renewal** The purpose of this project is to develop a means to renew a service tee under live conditions without an excavation. Gas mains can be rehabilitated via cured in place lining with minimal excavations. Steel service lines are routinely renewed by inserting plastic tubing, with no need to shut the main down. An alternate process, called "Renu" seals the interior of a steel service line with access gained at the meter. The weak link in this process is the service tee, usually made of carbon steel, which is not routinely replaced during the above mentioned gas main and service rehabilitation projects. The Trenchless Technology Center, retained by NYSEARCH to conduct this research, focused first on an appropriate sealant that would effectively seal the interior of the service tee. Spray coatings, liners, and mechanical seals were investigated. A hybrid mechanical seal concept was judged the best of the three alternatives but significant design challenges existed, mostly related to delivery of the sealing system down the length of the service line to the tee (up to 100 ft in some cases). Because of the uncertainties associated with these approaches the Company and the other funders will request proposals for alternate solutions.

**T 773 (non-Millennium) - Trenchless Replacement of Small Diameter Steel Gas Service Lines.** The objective of the project is to design, develop and test a new system for extracting small steel services, bare or wrapped in the size range of ¾" – 1 ¼" diameter to replace them with same size or larger size PE pipe. If successful for the smaller steel services, the contractor and cofounder also envisions a Phase II to address steel services with diameters of 1 ½" and larger.

**OTD 2.8.e - Structural Liners – Technology Search**. Large diameter cast iron mains can be effectively rehabilitated by lining them and Ngrid has been using this technology successfully since 2003. The current approved liner for use on gas systems relies on the structural integrity of the host pipe. For this reason, lining is generally limited to cast iron or protected steel pipelines. If a liner could be developed that had structural properties (meaning it would resist external loads such as traffic loading) more pipelines could be candidates for lining.
Four liner manufacturers who make structural liners for other industries (water) were contacted and their products' capabilities were discussed. One manufacturer seems to have a product that may meet the requirements for gas service and further evaluations will be required. This project would benefit the Company by expanding the available pipelines that could be rehabilitated by lining as opposed to replacement, resulting in lower cost and less disruption to the community and customers.

**OTD 5.10.f – Cold Assisted Pipe Splitting** One of the methods to renew deteriorated steel pipe is to split it by pulling a tool with cutters through it. A new length of PE pipe is attached to the rear of the cutter. When the cutter emerges from the pipe, the new length of PE pipe remains as the new gas carrier. This can be a cost effective rehabilitation method but many times the splitting operation is difficult because of the ductility of steel pipe. This project investigated whether liquid nitrogen or some other cryogenic liquid could lower the temperature of a steel pipeline to a level at which the pipe would transition into the "brittle" zone and be easier to split.
GTI Engineers determined that the quantities of cryogenic liquid required would be excessive, and further found that during testing; the cooling effect was not uniform through the length of the pipe. Since the project had reached a go / no-go milestone the Company decided not to continue further funding.

## Gas Quality

The gas supply picture for the Company's service territory – and indeed for much of the nation – is evolving, and unconventional supplies such as LNG, shale gas, biogas, and gas from other geographic regions will soon be a part of our supply picture. While research into supply itself is outside the scope of the Millennium funding mechanism, the effect that these diverse supplies may have on our existing infrastructure is a new and growing R&D area for us.

**M2005-005 – Gas Interchangeability for Installed Components** A multi-phase study investigating LDC coupling components and associated materials and whether varying gas compositions in a range of temperatures and pressures can create leakage in the couplings. This project studies the effect that a wide range of future expected gas supplies from non-traditional sources may have on installed infrastructure components such as gaskets, O-rings, seals, and diaphragms. Anecdotal evidence exists that suggests that gas supplies outside of normal expected limits may have been the cause of component failure in two east coast LDC distribution systems, but no definite conclusions can be reached, and no similar studies have ever been undertaken. This test program is designed to determine, through controlled laboratory testing at GTI test facilities, whether gas composition changes affect the performance of elastomer components mentioned above. Baseline and test gasses were agreed upon and procured, and infrastructure components were removed from the field and sent to the GTI lab for testing. Components are cycled through a "baseline" gas (the gas normally expected) and then cycled through several "test" gases (representing future expected supplies). During this cycling, pressure and temperature are also varied. The results of this test program will allow the Company to take action by removing and replacing components determined to be "at risk" or set new supply tariff limits with a scientific basis for setting them.

**M2011-002 - Storage Effects on Gas Quality -** A portion of the gas entering the Company's system comes from underground storage in geological formations. There is anecdotal evidence that gas leaving storage can have different properties than gas entering storage, for several reasons. These reasons can include presence of water or other substances in the storage formation, temperature variations in the formation (which could affect dew point), blending (or lack of blending) and others. None of this is well understood or modeled. The Company would like to understand this better from the perspective of the ultimate effect on our distribution system. This would help us better negotiate tariffs for gas delivered that would not have harmful effects on pipe materials as well as gaskets, seals and diaphragms. NYSEARCH commissioned a subcontractor for a two phase effort; the first phase is a literature search which will identify the key parameters that affect gas quality in storage. Assuming a successful outcome of the first phase, a second phase would develop a predictive model so that ultimate gas qualities can be more accurately projected. This benefits the company by enabling it to better predict quality, set tariff limits that recognize the potential for change in the quality of the gas in storage, and ultimately insure the integrity of our infrastructure.

**M2011-003 – Odor Masking.** Odor Masking is a phenomenon recently observed in gas distribution systems in which the odorant, although present in the required concentrations, is not perceptible to the human sense of smell. It is manifested by no odor or a markedly different odor than is usually associated with natural gas. This is different from Odor Fade, in which the concentration of odorant is lowered due to its being absorbed by the pipe (common in new piping systems) or by trace constituents in the gas stream. The Company is concerned about this issue because absence of the characteristic gas odor will prevent recognition of gas leaks or other hazardous situations.
Odor Masking is not well understood but the Company and other NYSEARCH members are working with Cardiff University in the UK and a professor there who has done some research in this area.

It is known that pairs of compounds, called “antagonistic pairs” can act together to change the perception or intensity of an odor and that this reaction actually occurs in the human nose or brain. In Phase I of this project, researchers at Cardiff University have demonstrated that certain chemicals that can be present in a natural gas stream can mask the odor of some sulfur compounds that are commonly used in odorant. This was shown by actual tests involving volunteers at the university who ranked the intensity and pleasantness of these chemicals before and after mixing. The Phase 1 work will attempt to identify as many of these antagonistic pairs as possible. In Phase II, just beginning now, researchers will attempt to identify where this human response is taking place. This is important because it will lead to certain mitigative strategies depending on where the response takes place.

The ultimate goal and benefit of the project is a practical pipeline operator guideline on how best to mitigate this phenomenon. For example, the guideline could call for tariff limits on certain trace constituents be set at a lower level, or it could recommend the use of certain odorant types that are more resistant to masking. A successful project outcome would eliminate the situation where a gas leak goes undetected with potentially catastrophic results, such as the Texas school explosion in 1937. The project identified the causes and mechanisms associated with a phenomena that is not fully understood, odor masking. The overall goal was to develop guidelines to mitigate odor masking and anticipate issues that arise from variations in gas quality. While the mechanisms were identified and confirmed, the program did not move to distinct measures for mitigation due to results that unveiled more issues to resolve in terms of human variability in terms of concentration sensitivity. Status is “Complete” until parallel work determines need

**M2013-003 - WKU Advanced Chemical Sensor.** Through the TecFusion/Oracle program, NYSEARCH identified the smart nose technology of Western Kentucky University (WKU). This technology uses nanosensors to develop a smart nose that is rather sensitive and can be used to also detect a certain gas signature. The Western Kentucky University (WKU) project first completed a feasibility study for using an “artificial nose” system to detect a series of analytes of interest to the natural gas industry. The nanosensor technology leads itself very well to small, low power instruments, ideal for field deployment. This project is now advanced to development and testing of advanced prototypes.

**OTD 7.8.a – Pipeline Quality Biomethane: Guidance Document for Landfill and Water Treatment Conversion.** This is a national study and sampling program to determine acceptable gas quality for introduction of landfill and wastewater-derived biomethane into Ngrid’s distribution system. No such standard exists in the US today. Information was assembled on landfill and wastewater biogas production, treatment, gas quality standards, and test protocols surrounding biogas production and use. A lab test program was executed testing raw and processed biogas samples for over 400 chemical species. A guidance document was prepared for safe interchangeable use of landfill and wastewater treatment biomethane in LDC networks. The results of this project show that these biomethane sources can be safely introduced into LDC networks.

**OTD 7.9.c – Assessing Acceptable Siloxane Concentrations in Biomethane**
Siloxanes are a class of compounds that are silica-based and found in many personal hygiene and health care products. As such, they enter waste streams and can be found in biomethane produced from landfill or wastewater biogas cleanup systems. There is evidence that siloxanes, when combusted, can result in excessive deposits of silicon dioxide on boiler tubes or gas turbine blades. The Company is also concerned because the effect of siloxane on standard infrastructure components is unknown. GTI is assessing industry data and attempting to determine what levels of siloxanes in biomethane would lead to issues with end use equipment or pose indoor air quality issues. In addition to the acceptable concentration of siloxane, other unknowns must be understood, such as where, and at what ratio, the biomethane enters the LDCs’ distribution systems, and what flows and velocities can occur at the end use equipment. This project fills an important knowledge gap and allows the company to prepare for the introduction of another non-traditional supply into our existing infrastructure.

**OTD 7.10.a – Trace Constituents in Natural Gas.** Significant research to identify the complete range of trace constituents in natural gas has not taken place in 20 years. In that time span, non-conventional supplies are entering LDC systems and these supplies are expected to have trace constituents in them. The objective of this project is to build a database of trace constituents specific to current supplies of gas flowing into LDC systems. The Company will use this database to assess new gas supplies from unconventional sources such as shale gas to see whether these new supplies are compatible with existing supplies. Routine analysis of natural gas supplies is an established practice. Heating value, specific gravity, hydrocarbon content, and some inerts such as nitrogen are measured periodically, but trace constituent analysis is not routinely done. A partial list of trace constituents of concern would include halocarbons, volatile organic compounds (VOCs), siloxanes, ammonia, trace metals, and bacteria. Comprehensive knowledge of the presence and amount of these constituents would allow intelligence to be placed on setting limits for these constituents in future supplies.

**OTD 7.10.b - Odor Fade.** Odorants used in the gas industry in North America all contain sulfur, carbon, and hydrogen and belong to a category of chemicals known as organosulfurs. The most common odorants used are alkyl mercaptans such as t-butyl mercaptan, alkyl sulfides such as dimethyl sulfide (added to lower the freezing point of the mixture), and tetrahydrothiophene (a cyclic odorant). This project was designed to investigate causes of odor fade in natural gas distribution systems. A preliminary literature survey reviewed the availability of current and historical data. It concluded that the primary causes of odorant fading include: 1) surface interactions of odorants with different pipe materials, 2) scrubbing or dissolution by condensates or cleaning fluids, 3) chemical reaction/oxidation of odorant with other components in the gas stream, and 4) other system state variables. Thermodynamic prescreening was one tool used to look at the possible reactions involving more common blend stock odorants. In addition to forming (mainly) disulfides and iron sulfides, mercaptans might also decompose or react with trace gas processing constituents (e.g., methanol). Analysis of data collected by funders over the study period indicated that: most odor fade events were reported to have been prompted by weak sniff test results and most respondents reported performing follow-up quantitative analyses. No instances of solvent odors were reported. Two odor fade events were reported with plastic (PE) pipe, the others with steel pipe. Ambient temperature ranged from 20-90°F. All events involved a single source of natural gas. No pipe cleaning was mentioned as having been employed by any of the respondents. Odorants involved were t-butyl mercaptan mixtures with either dimethyl sulfide, i-propyl mercaptan, or tetrahydrothiophene; no odorizer operational issues were noted. Supplementary odorant injection was employed to increase odorant levels by all but one of the respondents. Findings include: analysis of TBM loss in plastic pipe with respect to temperatures. THT loss with respect to temperature, TBM reactivity with steel pipe vs. plastic pipe material, and steel pipe and odorant levels of TBM and THT in relation to presence of rust. When water was introduced into the steel reactor, the rate of loss increased further. Water by itself had no effect (as seen in the inerted reactor tests), but had a significant effect when iron was present. Initial modeling of the 1-step versus multi-step reaction mechanism showed the multistep mechanism to be more robust. The information gained in this project was used to prepare a suggested revision to Chapter 7 of the current edition of the AGA Odorization Manual, last revised in 2000. This study was completed end of 2014

**OTD 7.11.a – Gas Quality Resource Center.** The Gas Quality Resource Center is intended to provide technical support necessary to identify and fill knowledge gaps regarding potential industry issues associated with changes in gas composition profiles in North America. The Resource Center will provide a centralized “clearing house” for information related to gas quality, analysis of current flowing gas supplies in North America, identification of constituent trends across identified regions, analysis of current technical regulatory trends associated with pipeline tariff negotiations and identification of research needed to help fill information gaps ultimately aimed at maximizing supplies while balancing the needs of pipeline integrity and end use concerns. The resource center would maintain information on gas compositions and pipeline tariffs, and would serve to identify and launch research as appropriate related to gas quality issues. Issues such as odor masking or siloxane levels are examples of the types of research that could result from the Company’s participation in the Gas Quality Resource Center.

**OTD 7.11.b – Trace Constituents Sensors** This project will identify candidate sensors or sensor technologies for measuring, perhaps in real-time, trace constituents in new gas supplies, such as landfill gas, biomethane derived from a variety of biomass sources, and unconventional supplies such as shales, tight sands and coal bed methane. The Company is aware that its future fuel mix will include renewable and unconventional gas. The need to understand the composition of a new gas supply and to monitor its components is increasing as the number and variety of sources grows along with their frequency of introduction into the natural gas pipeline network. The project will proceed on a phased approach, future supplies must be identified, and constituents of concern present in these supplies also need to be identified. For some new supplies such as landfill gas, research into gas trace constituents had already taken place, for others for example shale gas, less information exists. Once the constituents have been identified, instruments that can sense these constituents will be identified and assessed. The benefit of this work is the ability to monitor the composition of new gas supplies and the associated capability of protecting our distribution assets.

**OTD 7.15.a - Real-Time Gas Quality Sensor.** The introduction of shale gas and upgraded biogas into the gas transmission network is increasing the importance of accurate and regular monitoring of the natural gas heating value and composition. Currently used gas chromatographs (GC) are expensive and slow. The project objective is to demonstrate development of a practical, reliable, and real-time gas quality sensor (GQS) that can detect changes in gas quality (heating value, and concentrations of methane, ethane, propane, butane and carbon dioxide concentrations) in real time and can provide this data to the operators of an LNG plant or other facility.

## Environment

Projects in this area are focused on new technologies to more easily and cost effectively remediate MGP sites. A more recent focus in the Environment area is related to Climate Change Concerns.

**M2001-002 – Management of Impacted Sediments.** The company formed and led this project, which was funded by other NYSEARCH members as well as a national consortium of industry and the US Navy. This project studied the correlation between polycyclic aromatic hydrocarbon (PAH) concentrations in manufactured gas plant (MGP) sites and the actual bioavailability of these compounds to living organisms, with the goal being more realistic guidelines for site remediation. Not all PAHs at MGP sites are actually bioavailable, and therefore harmful, to organisms and the environment. This project developed a new analytical method to determine actual bioavailability. Benefits include the potential of a greatly reduced remediation area. A final report has been submitted and accepted by the project funders as well as the USEPA, the NY State DEC and the NY State Department of Health. In February 2012 the NY State DEC issued a remedy decision based on the new analytical method for the city of Hudson NY (Water Street) company site. Savings realized for this one remediation are approximately $26M.

**M2008-006 – Expanding the function of No Blow Tools.** Tools to make "live" taps into gas mains are commercially available but during certain operations small amounts of blowing, or escaping gas are present. A set of innovative tooling was developed to enable plug insertion or removal, or insertion of stoppers. This benefits the environment by reducing the amount of methane (a greenhouse gas 21 times more potent than carbon dioxide) released into the atmosphere, and also contributes to worker safety. A second phase of the project developed an innovative method to reinject gas into an adjacent main segment rather than blow it off to atmosphere during a special test called a "flow test." This method reduced greenhouse gas emissions and lessens customer concerns and complaints.

**M2009-003 – Adaptation to Climate Change**. The company and others recognize that there are two aspects to climate change, how we, through our methane and CO2 emissions, affect climate change, and how we, as LDCs, adapt to climate change effects and impacts that are certain to occur in the future. To meet this latter goal the Company and others commissioned a study that investigated a range of future climate models, predicted maximum and average expected temperatures and sea level rise, and developed a framework for estimating risk and remedial action to address those climate changes. Phase II examined more detailed flood risks at the local level for sponsoring companies. The benefits of this project will be the development of a gas-industry specific risk-based framework for addressing the impacts of climate change on a broad geographic level to give LDCs quantitative information on which climate effects and impacts to focus on and which portions of our natural gas infrastructure are most susceptible to those climate impacts. A final report has been issued and sea level rise has been identified as the main threat to a natural gas distribution system.

**M2010-002/ T 776 – Methane MR Sensor/Residential Methane Sensor Pilot Testing Program.** See details under Leak Detection and Methane Emission section of this report.
**M2010-004 – Soil Vapor Intrusion** The work in this project involves characterizing manufactured gas plant (MGP) coal tar vapors so that volatile organic compounds (VOCs) can be conclusively identified as either coming from an MGP or from some other source. For example, benzene, a constituent in coal tar, could also be present in a dwelling from common household sources. If compounds such as benzene are identified near a dwelling, current regulations require extensive sub-slab (below the basement or slab of a dwelling) sampling at a cost of $10,000 per dwelling. However, if MGP coal tar can be ruled out as the source of the contamination, less expensive investigations would be warranted.

**M2011-004 – Carbon Calculator.** The Company has been voluntarily reporting fugitive methane emissions since the mid-nineties and is committed to reducing its carbon footprint. One component of that carbon footprint is carbon dioxide emissions resulting from normal construction activities. The intent of this project is to quantify the emission reduction that would result from choosing a less energy intensive method of construction. For example, there are two alternatives to installing a new gas main. The first is traditional open trench, where a trench 18 in wide by 3 ft deep is excavated along the proposed length of the installation. In an alternate method, the pipe may be installed via directional drilling. This latter method is quicker, uses less equipment for a shorter time, and eliminates the bulk of new paving that must be applied. But up until now there has been no way to quantify the reduction in emissions. This project involves quantifying the emissions that result from each step of the construction process.

NYSEARCH, together with the North American Society for Trenchless Technology (NASTT) is working with ETA/Environ, to develop the spreadsheet tool. In the first phase of the project, subject matter experts from the participating companies are quantifying types and time on the jobsite of various pieces of construction equipment used on various construction activities. Then, ETA/Environ will use the latest EPA "non-road" emission factors to compile emission rates for the various pieces of equipment. In the final step, ETA/Environ will create a robust, user friendly spreadsheet tool to enable gas company managers to compare the carbon impact of alternative constriction practices.

There are several benefits from this project; determining the construction methods with the least environmental impact, validating the additional (environmental) benefit to public authorities who may be skeptical about the use of a newer or non-traditional construction technique; and it could allow the Company to be proactive in tracking and reporting (if required) these emissions.

**OTD 6.8.a - Carbon Management Information Center.**
The Carbon Management Information Center (CMIC) was established in 2007 to serve as an on-line clearinghouse for relevant carbon management information. The CMIC serves the gas industry, its customers, and other stakeholders by developing resources and analytical tools to provide clear, concise, and technically-sound information on issues related to reducing the nation's energy consumption, source energy codes and standards, and carbon emissions.

**OTD 7.9.d and 7.10.c – Improving Methane Emission Estimates for Natural Gas Distribution Companies**. The Company and other LDCs have been voluntarily reporting fugitive methane emissions from their distribution systems under the US Environmental Protection Agency (EPA) "Star" Program since the 1990s. With the recent passage of EPA "Subpart W" LDCs are now required to report these emissions.
To report emissions from its piping network, which account for over 80% of the Company's fugitive emissions from its gas distribution system, the EPA allows the use of emissions factors, expressed in terms of cubic feet of methane per mile of pipe per year.

Different pipe materials have different emissions factors. The factor is simply applied to the mileage of pipe in the system and total emissions are reported.

These emissions factors were developed in the early nineties via a testing and measurement program sponsored by the USEPA and conducted by the Gas Research Institute and subcontractors. The factors have never been updated and the Company and industry in general, are aware that the factor for plastic (PE) pipe is unrealistically high. For example, a similar study in the UK conducted in the early 2000s resulted in a leakage factor for PE pipe that is one half the value used in the US. PE piping systems are fabricated with improved materials and installed under better quality control than in the nineties, and the emissions testing program for PE pipe done then only contained six data points – for the entire nation!

Working through GTI and subcontractors, and with the knowledge of the USEPA, the Company and others are replicating the test methods from the previous study and attempting to develop a more realistic emission factor. Project funders (there are 18 LDCs participating) are identifying leaks in the field and the GTI team measures them. In parallel with conducting the leakage measurement (which involves exposing the leaking pipe segment) an alternate measurement technique is being applied which involves only surface measurement of leakage. If the two separate techniques agree, more field measurements can be taken with the less expensive surface measurement technique. Several field tests have taken place so far with others scheduled. After the PE leakage factor is revised, a second phase of this project will revise the factors for cast iron and bare steel pipe materials. The benefit of this project is more accurate reporting and a better representation of the company's contribution to greenhouse gas emissions.

## Infrastructure Support

The following projects benefit overall company operations in areas such as safety, sensing and measurement, advanced material research, community and customer concerns, and general operations improvements.

**M2009-002 - Mercaptan Sensor Development**. To insure proper odorant levels in natural gas, LDCs are required to perform a periodic "sniff test." The human nose can detect odorant levels in the ppb range and if the gas is properly odorized this provides adequate warning to the public that gas is present at levels well below the "lower explosive limit" (LEL). However, sniffing by humans is subjective and technicians performing these tests can sometimes be desensitized to the odor of mercaptan. Also, the recently identified phenomenon called "odor masking" can cause the characteristic odor of mercaptan to change or disappear. This project aims to develop a portable sensor that can detect mercaptan in the ppb range. It would not replace the sniff test – which is required by code – but would supplement those tests, and would also be installed in areas where odor fade or masking is suspected, to verify that proper odorant levels are present. The technical approach is a unique combination of standard gas chromatography and a relatively new technology called differential mass spectroscopy. This technology was discovered via the NYSEARCH "Oracle" project mentioned above. Feasibility testing has been successfully completed and a prototype instrument is being built. Due to an instability issue, re-design work was attempted by the first contractor in place of additional field tests. With that work not solving the problem, NYSEARCH sought additional expertise and is now working with UC Davis to resolve the engineering issue associated with instability before going to advanced prototyping and testing. The benefit is advanced warning of possible odorant deficiencies.

**M2010-002/T-776 – Methane MR Sensor.** See details under Leak Detection and Methane Emission section of this report.

**M2010-003 – PCB Absorption in PE Piping.** Every year the Company discards quantities of polyethylene (PE) pipe that have been removed from service because they have been damaged by third parties, or for other miscellaneous reasons. The Company ships such pipe to a special landfill that accepts PCB-contaminated pipe because there is no EPA-approved method for decontaminating PE pipe potentially exposed to PCBs. The Company determined that the same approved procedures used to clean and decontaminate steel pipe may be applicable to PE pipe, if it can be proven that PCBs are not absorbed into the wall of PE pipe. Such testing has never been conducted for PE pipe. This is a Material Science Study to evaluate whether there are particular PE pipe characteristics that interact with PCBs. Address decontamination issues so that abandoned PE pipe can potentially be left in place. The Company, through NYSEARCH, engaged Jana Labs – a respected plastic pipe research and testing laboratory – to conduct this testing. The tests are underway with Jana. Pending a successful outcome of the test program, the Company will work with the USEPA to create a standard for cleaning and decontaminating PE pipe so it may be discarded in a normal fashion.

**M2011-001 – Self Healing Pipe.** Through the NYSEARCH "Oracle" Program, the Company has become aware of advances in material science through nanotechnology. Several concepts related to advanced materials were addressed and the two most promising were self locating pipe (pipe containing materials that would respond to conventional above ground locators, thereby solving the problem of broken or malfunctioning tracer wire) and self healing pipe. (Self locating pipe was discussed among NYSEARCH members and the group, after careful consideration, decided not to pursue that technology at this time.) The Company and other NYSEARCH members want to explore further the concept of self healing pipe so this project was authorized. Our investigations indicated that the addition of different types of nanoparticles into polyethylene (PE) material can enhance its mechanical or electrical properties. One type of adder can actually induce self-healing capabilities in the base PE material. A crack in the material will release a bonding agent and lab experiments conducted by others show recovery of up to 75% of tensile strength of the base material. The Company wants to pursue this further and feasibility discussions with manufacturers will commence. This is a long term project with ultimate benefits realized perhaps 25 years into the future. The project will be carefully monitored and will proceed in phases. Reduction in distribution pipeline incidents due to damage is the benefit of this research. The objective of the program is to develop a new generation of PE based pipes with self-healing properties for use in the natural gas industry. Following completion of the feasibility study, additional work was completed to prove that the PE pipe when altered for the self-healing nanomaterial would retain its required strength properties and at those conditions, still provide self-healing capability. It has been proved that the strength properties are maintained. Additional research is necessary as to evaluation of all conditions and development of various PE piping appurtenances. NYSEARCH is reframing the program to move from feasibility testing to more advanced development.

**OTD 1.12.b - Cross-Bores Detection Using Mechanical Spring Attachment.** Research is under way to develop a tool that will detect a hit to a sewer pipe during the installation of a gas pipe. A prototype for field testing was built that uses a mechanical spring system that is activated inside the sewer pipe void to provide a real-time alarm identifying a hit. Laboratory and field tests were conducted in 2013-2014 and a patent application for the technology was filed. In testing, the tool was able to successfully indicate the voids in pipes which were hit (i.e., providing positive indications). Several modifications of the proto-type may be performed with future commercializers. — A report on the results of field-test activities is being prepared.

**OTD 1.13.a - Real-Time, Multiple Utility Detection During Pipe Installation Using HDD Systems.** Research and testing is being conducted on an acoustic-based technology to detect obstacles during horizontal directional drilling (HDD) operations. The ultimate goal is to develop a system that can automatically and rapidly detect buried pipes/obstacles in front of and adjacent to the drill-head of HDD machines. The system was tested with seismic/noise sources and under differing attack angles to pipes. Post-processing data showed that the acoustic system was able to achieve the average pipe detection accuracy of ± 2.1' during the trials. — New and improved noise sources are being developed for further evaluation.

**OTD 1.14.e - Plastic Pipe Locating—Alternatives to Traditional Tracer Wire.** OTD along with GTI and 3M submitted a White Paper to DOE/PHMSA for a project that would have a very similar work scope as this current OTD project. The proposal resulted in an award from PHMSA with work expected to begin in the fourth quarter. The revised scope of the project is to develop an electronic marking system that will provide locatability on various-diameter HDPE and MDPE pipes. The project will also assess the technology capabilities versus pipe diameter, burial depth, and pipe-burial methods (horizontal directional drilling, open trench, etc.) —The contract for the new PHMSA-supported project is being finalized.

**OTD 1.15.a - Cross Bores—Sewer System Cleanout Safeguard Device.** This project focuses on the development of a safety device that provides the ability to seal the sewer-system cleanout opening in the event a natural gas line (inadvertently installed in a sewer) is struck by a power auger or other mechanical tool. The project team finalized a prototype cap design. Based on evaluations, 35 split caps were manufactured and shipped to sponsors for evaluation. — The project team has been in discussions with a manufacturer regarding commercialization of the split-cap safety device.

**OTD 1.15.d - Improved Camera Imaging to Identify Cross Bores.** The objective of this project is to provide an evaluation of imaging systems with the potential to work in conjunction with various types of trenchless pipe-installation technologies (including the use of horizontal directional drilling equipment with drilling mud) and still be able to positively identify a cross bore. An initial patent/literature search produced no new information on sewer camera technology. This, along with discussions with experts in the industry, indicated that there is little that can be done to improve this technology without additional technology platforms. Subsequently, several potential alternative platforms were identified. — Communications are being arranged with project sponsors to discuss the technologies identified and deter-mine future plans.

**OTD 2.7.d - Cold Adhesive Repair and Joining of Polyethylene Pipes with Minimal Surface Preparation.** In this project, researchers tested a cold-adhesive repair technique in an effort to develop an economical, reliable, and safe technology to quickly and effectively repair damaged plastic gas pipes. Long-term test results of PE pipes patched with the repair method found that the patching system can be effective. Testing also resulted in additional information about the effective application of the adhesive. — A Final Report on the project is being prepared.

**OTD 2.10.b - In-Service Field Evaluation of Polyurea Coating Systems.**
As a follow-up to a previous project, research into field-applied polyurea coatings for gas industry use is being conducted on promising coatings. Long-term field trials will be performed to evaluate these coatings and determine a cost-effective coating-application method and process for structural liners. — Installation and evaluation of the coating was successfully completed at a sponsor site in November 2015.

**OTD 2.11.a - Development of a System for Repair of Aboveground Leaks.**
Researchers are conducting a thorough evaluation of repair methods for leaks on aboveground piping in an effort to establish a basis for choosing the right repair method for a specific leak, establishing levels of adequate preparation, and providing the proper installation for increased reliability. Prototype test samples were constructed to simulate aboveground leaks from varying levels of corrosion (pin holes) and from threaded joints. Test samples were fabricated, fitted with the corresponding repair systems, and hydrostatically tested to failure. — Testing is ongoing.

**OTD 2.12.a - Integrated Expert Monitoring and Training System for Butt Fusion.**
A set of critical fusion variables is being developed to provide an integrated technology package for use in pipe-fusion training and field operations. The goal is to produce a system capable of flagging marginal fusions in all operating conditions. In the third quarter of 2015, all butt-fusions and low-temperature high-speed tensile tests were completed and creep testing initiated. A significant amount of test data post-processing was completed and correlation of the test data to butt-fusion conditions initiated. — A Final Report is being prepared.

**OTD 2.14.c - Assessment of Squeeze-Off Location for Small-Diameter Polyethylene (PE) Pipe and Tubing.** Researchers developed a model for predicting the effects of squeeze-off on small-diameter PE pipes. Mechanical testing was tailored specifically for the squeeze-off mod-el to capture the application's conditions. Technicians prepared a total of 230 specimens for testing. The results from the squeeze-off FEA model indicate that a squeeze-off can be performed at a distance three pipe diameters from a fitting with any size pipe. The project team initiated efforts to revise ASTM F1041; however, feedback received from ASTM indicates the project needs to address squeeze-off near mechanical fittings as well. This additional scope of work is to be submitted to the project sponsors for consideration.

**OTD 2.14.e - Guidelines/Best Practices for Scraping PE Pipe and Fittings**
Research is focused on the development of a functional set of improved, up-to-date guidelines for PE pipe and fittings that take into account current tooling and practices (e.g., scraping) while addressing the variables associated with fusion execution. Information from survey results was combined with data from previous projects and a test matrix for the pertinent tools was developed.

**OTD 3.8.a - Addressing Jackhammer Noise Abatement.** In urban areas of the Company's territory there is increasing pressure from city officials to lower the noise of commonly used construction equipment. Evening and weekend work, such as is required for emergency response work, only amplifies this need. Pneumatic jackhammers are among the noisiest of commonly used construction equipment. National Grid, in New York City, experimented with insulated fabric jackets that are placed around the jackhammer and while these helped to reduce noise levels, a more permanent solution is desired. The Company and others are working through GTI to try to engage jackhammer manufacturers to examine the design of a typical jackhammer to see if there is any opportunity to reduce the noise produced. It is recognized that noise from a jackhammer is produced from three distinct sources, the internal piston operating inside the cylinder, the air exhaust, and the bit striking the pavement.

The objective of the project is to engage manufacturers and determine whether they are open to a basic redesign effort of their tools to make them less noisy. GTI identified several manufacturers but only one was willing to attend a meeting to discuss the intent of the project. As a result, the project will most likely not proceed to Phase 2, which would have involved detailed noise analysis and would have served as the basis for a redesigned jackhammer.

**OTD 3.14.a - MBW Soil Compaction Survey Enhancements.** The SCS fills a need to verify soil compaction levels during field operations (excavation back-filling). The memory media that was used in the previous version of the SCS is cumbersome to use and has become obsolete. The industry practices in field data collection have also evolved considerably since the SCS was first introduced. The objective of this project is to upgrade the capabilities of the Soil Compaction Supervisor (SCS) to make it compatible with modern Geographic Information System (GIS) data capture practices as well as more user friendly through better data logging and reporting capabilities. Initial efforts will also be investigated to determine the SCS's ability to be correlated to a standard proctor value or range. The ability to attach metadata such as GPS coordinates and photos to compaction data is now wanted for entry into a GIS. Transferring compaction data from a mobile device to a GIS with the additional capabilities available on mobile devices (GPS, camera, etc.) will be incorporated into the data acquisition for the compaction record. By redesigning the SCS, a useful tool will continue to be available and the data generated can be directly imported into utility GIS or other data systems. Capturing and archiving the soil compaction data will help ensure that compaction is being performed properly (quality control) and will enable a utility to validate proper compaction to jurisdictional and/or regulatory authorities. The testing portion of the project seeks to better understand the correlation of the SCS data with that from a nuclear densitometer to provide a lower cost alternative.

**OTD 3.14.b - Update ASTM Standard of DCP Compaction Control.** Through this project, interactions were made with ASTM to update its current standard on the five-pound Dynamic Cone Penetrometer (DCP) compaction control device. The ASTM standard D7380-08 (Test Method for Soil Compaction Determination at Shallow Depths Using 5- lb. DCP), which was developed in an earlier OTD project, completed the balloting process of its standards in September 2015. The OTD-developed standard passed both the sub-committee ballots with no negatives. —The project team is following up with the ASTM Publications Committee to complete the process of adding the new version to the ASTM 2016 standards publication.

**OTD 5.6.e – Portable Propane Air Temporary Residential Supply, Phase II**
Many routine gas operations require temporary disruption of service to customers. Replacement of aging gas mains requires a brief interruption while the service is transferred from the old main to the new main. Meter change activities also require a brief shutdown. Rehabilitation techniques such as cured-in-place lining can require an outage lasting 12 hours or more. In such cases compressed natural gas (CNG) bottles can be used but they are heavy and cumbersome. The propane air mixer has been under development since 2006. It mixes propane from a standard gas barbecue tank with air and delivers the mix at the proper heating value. A prototype was built by GTI engineers and subjected to extensive operational and end use testing, including local field testing in Chicago. Tests were successful with the exception of results with one particular brand of water heater, which shut down on high flame temperature. Phase II of this project will redesign the unit to produce a cooler flame and the testing will be repeated on a mix of appliances. Firing rate, flame temperature and emissions will be recorded. If the testing is successful (meaning all appliances performed within spec on all tests) then a new phase of the project will investigate commercialization of the unit. The benefit is better customer service using a more efficient and ergonomic method.

**OTD 5.7.p - GPS/GNSS Consortium.** The project objective is to facilitate the sharing of information related to the use of GPS, Global Position System [US reference] and GNSS, Global Navigation Satellite Systems (International reference) technology for utility operations. The GPS/GNSS Consortium is a cost effective way for utilities to better understand this rapidly growing technology field and how GPS technology can best be applied to daily operations to create operational efficiencies, enhance regulatory compliance, and improve the quality of field collected data. The program activities include technology development and integration, workshops, pilot projects, demonstrations, best practices/standards development and general information sharing. Over the last two years, the GPS Consortium has focused on technology development that will reduce the cost and complexity of deploying GPS for routine construction and O&M activities. A Real Time Kinematic (RTK) base station has been installed, on GTI's main campus. This base station was built using GNSS Consortium funds in 2014 and continues to be an important asset for GNSS and GIS research at GTI. The following emerging technologies were selected for evaluation; Garmin GLO, Swift Navigation Piksi RTK Kit, uBlox Neo-7P & EVK-7P. Additionally, the following well known legacy units were tested to provide base-line comparisons; Trimble GeoExplorer XH, Navcom SF-3040, Geneq SxBlue III. GTI has completed testing and results are currently being compiled.

**OTD 5.8.a - Automated Welding.** This project will identify and select an automation manufacturing partner, develop a beta prototype automated welding unit, and create procedures to perform the welds on various types of tees and nipples. Throughout the project, the project team will work with the selected manufacturer(s) to assist with the implementation of the unit as a commercially viable product for the industry. A final report will document these efforts.

**OTD 5.8.d - Tool for the External Classification of Pipe Contents**
Research is being conducted to develop a practical tool that can detect "live" three-phase electrical cable in pipe without breaching the pipe wall. The ultimate objective is to develop an affordable tool that could be carried in each crew truck. The current project phase involves the construction and demonstration of a pre-production proto-type tool. Recently, the main focus was to debug the software required to perform the Fast Fourier Transform (FFT) on the vibrations detected on a pipe. The hardware platform was demonstrated to run the FFT library functions correctly; however, the signal level captured was somewhat low. This will need to be corrected in the hard-ware by adding amplification between the vibration sensor and the processor. The project is behind schedule and potentially will require additional time. — Software and hardware modifications are under way.

**OTD 5.08.e.2ab - Enhanced Material Tracking and Traceability-Development of Standardized Protocols/Identifiers for Meters, Regulators, and Transmission Pipelines, Phase 2 (TEJ).** The objective of the program is to utilize the previously established base-62 di encoding system methodology and develop a series of unique identifiers and format to characterize pertinent information for meters and regulators conforming to ANSI B109 requirements. TEJ continued its work related to proposed changes to ASTM F2897 to incorporate key data related to transmission pipeline components (pipe / appurtenances). The initial ballot for the F17.60 subcommittee ballot was submitted in December 2013 (one negative and five comments were received). The negative has been resolved and proposed ballot has been revised accordingly. The revised amendments were submitted for concurrent main and subcommittee voting. Provided that the ballot is approved, all the necessary identifiers required to produce a 16-character code schema to mark transmission pipeline components should be in place. It is important to emphasize, even with the proposed changes in place, this simply provides all the elements needed to develop a similar 16-character code for transmission components and satisfy the objective of this phase of the program. Additional work will need to be incorporate these requirements within applicable API 5L standards and resolve underlying procurement practices and supply chain considerations within utility companies.

**OTD 5.9.h - North American Outreach Manufacturer Outreach Program**
Research was conducted to identify promising technologies that are under consideration but not currently under development by qualified North American manufacturers. The focus was on prospective products or technologies and that have sufficient commercial value to natural gas utilities to justify submission of a funding proposal to OTD. — A Final Report detailing project results is being prepared.

**OTD 5.10.d - Remote QA QC.** Development of a remote monitoring program with map based application for smartphones and tablets for field data capture and documentation will advance utility operations and quality inspections. The goal of this project will develop a mobile application with a supporting step-by-step field procedure for its use including guidelines. The focus is to develop technologies and protocols to allow operators to remotely monitor and record the quality of various operations. The quality of field work can then be monitored in real-time using a step-by-step procedure, GPS-enabled cameras, and a web-repository to capture, store, and share photos and create permanent records. Using smartphones to capture time-stamped photographic documentation during field operations improves quality and enhances quality control, particularly for new installations. Field crews, both in-house and contractors are encouraged to follow specifications and procedures because pictures are used to document important steps. Using remote QA/QC methods allows 100% of new installations to be monitored by a quality inspector or office manager and support staff, no matter where they are, they will be able to view pictures of all new installations in real-time and share information. Further, pictures are captured in a GIS environment and can be stored for long-term usage such as validating regulatory compliance, future locating, and engineering operations.

**OTD 5.11.a – Dewatering System for Mains.** Excessive amounts of water in gas mains can cause service outages. This “water intrusion” is particularly prevalent in low pressure areas where groundwater can enter into a gas main through leaky joints in high water table areas. The normal solution is to locate the area of water intrusion and pump the water out. This project is investigating novel methods to remove residual moisture that can be present even after water is pumped out. Two methods that have been investigated are desiccant and molecular sieve technologies that can more permanently dry out the interior of a gas main, and chemical additives such as methanol foam which can allow moisture to flow out of low points and not collect there. Once the feasibility of such methods is evaluated, the next step in the project will be to decide whether the successful technology can be adapted to installation on a gas distribution system. This project will decrease the amount of customer outages in areas prone to water intrusion. Completed June 2015.

**OTD 5.12.b – Development of a Portable Flash Fire Suppression** System. During live gas operations the potential for rapid ignition of natural gas (a flash fire) is present. Although workers follow strict safety procedures and are protected with fire retardant clothing and breathing air apparatus, bodily harm can occur within milliseconds if an ignition were to occur. A true industry need exists for a system that can rapidly detect and extinguish flash fires. The project was initiated in GTI's Sustaining Membership Program (SMP). Two separate and distinct challenges were investigated, the ability of a sensor to detect a flash fire in less than ½ second, and the ability of a fire suppression system to limit injury as low as is reasonably achievable. In testing at GTI facilities both concepts were proven; a UV detector reliably detected fires within 30 milliseconds, and two separate suppression systems, high velocity air, and nitrogen extinguished the fire but each had some drawbacks needing further investigation. The Company is extremely interested in this project and Safety Dept. personnel will act as advisors to the GTI project team. A successful outcome of the project will be a portable flash fire suppression system that will effectively detect and extinguish flash fires should they occur and be simple to deploy. Enhanced worker safety and avoidance of serious or even fatal injuries is the obvious benefit of this research.

**OTD 5.12.g – Evaluation and Adaptation of Kleiss Inflatable Stoppers for the US** Natural Gas Industry. Current line stopping equipment in the natural gas industry has been used since inception (~ 50 years) in the same trim without substantial re-design. This equipment certainly works but is heavy, costly to maintain, and is somewhat time consuming and labor intensive when the installation of the necessary components required are taken into account. New line stopping equipment that may reduce these problematic issues, while providing the same assurance of safety and performance, could contribute to substantial time and money savings when incorporated into day-to-day operations. Through a technology search such equipment was sourced. This apparatus is produced by a European Vendor, Kleiss and Co., and has shown promising performance. The objective of this effort is to evaluate these existing medium and high pressure inflatable stoppers as an alternative to currently employed stopping equipment for use on US natural gas distribution systems. GTI will test and evaluate this inflatable stopper suite of tools (capable of stopping off line pressures of 60 psig at pipe diameters up to 24-inches). Deliverables include the development of testing criteria and a program to evaluate the current offering. In addition, it will identify the necessary modifications to the bagging system(s) and identify deployment fittings required to meet the US natural gas industry standards so that the system may be introduced and deployed for use in the US.

**OTD 5.12.o and 1.14.h – Guidelines for Cast Iron Winter Operations and Cast Iron Winter Patrols study.** The Company and others want to know the best methods for determining when to initiate winter frost patrols on their cast iron (CI) piping systems. Simply starting the patrols when the ground temperature or air temperature reaches a certain limit may not be optimum. There are other factors, in addition to temperature, which may influence the propensity of CI piping to break in frost conditions. Some of these factors are diameter and pressure of the main, age, soil type, and presence of other adjacent underground facilities. The ultimate deliverable of the project is a practical guideline for operators as to when to initiate frost patrols. GTI was selected to perform the study and is investigating – through examination of LDCs' records - the frequency of breaks in the presence or absence of the potential breakage factors. The study is not complete but has already determined that diameter is a key variable and that most breaks take place on smaller diameter piping and, at least for one LDC, there is no record of breakage for pipelines larger than 18" diameter. As more data is accumulated and analyzed patterns like this should emerge. The end result should be a fact-based guideline, based on the above parameters that affect breakage, stating exactly when, and for which segments, winter frost patrols should begin.

Under OTD 1.14.h, the company did an evaluation with GTI using Picarro's CRDS and some of Picarro's latest algorithms to evaluate if this advanced leak detection system and methodology could improve our winter patrols and identify CI breaks more rapidly. The frost conditions were extreme during the course of the investigation which was ideal for the study. However, it was found that numerous passes are required and the processing of the data took a great deal of time. GTI is evaluating the data to determine if there was significant improvement in detection, however to date, this has not translated into cost savings with this approach for CI winter patrols.

**OTD 5.13.d - Transmission Cut In Valve.** The development of proposed cut-in valve system will give operators options for the placement of valves without the need to shut off the flow of gas along with the benefit of greatly reducing the cost of installation. This valve concept can lead to: faster installation times especially in urban environments, no need for flow control and/or bypass of gas, single excavations with no need to stop off the flow in the pipe and no need to install a bypass, enhanced safety, and lower cost of installation. This system will be a unique design that meets all material and performance expectations while delivering a compact and fast alternative to traditional valve installation methods. It will be developed to provide important performance and installation benefits to pipeline operators working under difficult conditions and with critical needs. Initially, a concept transmission EZ Valve will be developed for sizes up to 12-inches with working pressures up to 300 psig. After initial proof of concept, a 6 inch prototype valve will be constructed.

**OTD 5.13.f - Low-Cost Collision-Avoidance System**
Efforts are under way to develop a low-cost, low-speed, collision-avoidance system that would provide gas industry utility vehicles the ability to provide driver alerts and, when necessary, automatic braking. A complete set of laboratory-based testing scenarios was conducted using an experimental test apparatus to generate datasets that represent typical driving maneuvers. Field tests of a wireless tablet PC user interface were completed. For testing, a video system was successfully integrated with the test hardware. — A video is being prepared to demonstrate the capabilities of the system.

**OTD 5.13.g - Post Disaster Risk Assessment with LiDAR and GIS.** The project objective is to develop pipeline risk assessment tool to identify high risk pipe segments after post-disaster events to prioritize repair and restoration activities. This work is performed along with a DOT-funded project with Rutgers, the State University of New Jersey, to develop a mobile mapping platform that harnesses commercially available technologies to provide remote sensing data collection capabilities and to implement a GIS-based platform for data management and pipeline risk assessment. Progress thus far: the risk assessment approach and model is completed, the Bayesian Network has been integrated into a web-based computer model, and a case study is being entered into this model to estimate damage potential of pipe segments at Ortley Beach, NJ after hurricane Sandy.
The results are pending at this time.

**OTD 5.14.a - RFID Testing Program.** A testing program is being conducted to compare the performance and features of multiple radio frequency identification (RFID) and related technology solutions for locating and tracking gas utility assets. RFID tag installations were completed for the 3M Marker Ball, the Berntsen Infra Marker, and the Eliot Marker System. Programming of tags, along with user experience and impressions, were recorded. Assets targeted for RFID tagging included a mix of steel and PE systems from existing pipe test beds in addition to available utility hook-ups (gas, electric, and water). — The project team is in the process of locating, reading, and testing all installed above- and below-ground tags.

**OTD 5.14.b - Smart Leak Repair Form.** A smart leak repair form will improve the quality of data collected during the leak repair process and will lead to improved threat identification and risk assessment for DIMP. The objective is to develop a system to capture more detailed information to allow for more granular analysis to be performed, such as the identification of leak trends. Development of a Fault Tree Analysis and Decision Tree logic will be employed in this framework to resolve issues concerning proper identification of root causes and categorization of failures. The objective of the sponsors is to define an appropriate logic for electronic data collection forms.

**OTD 5.14.d 2a – Tracking &Traceability for Transmission Phase 2a: Standards for MTR and Coating Reports and Phase 2b: Data Collection Technology.** The goal of this project is to develop standards, guidelines, and technology for tracking and traceability of transmission pipe and components. The ability to automate the process of capturing and storing tracking and traceability information for transmission pipe will improve data quality and reduce risk. Data quality will be improved by using electronic records and barcode scanning to capture data essential for MAOP calculations and integrity management. Eliminating manual, paper-based data collection will reduce the occurrence of human errors when capturing and transferring data into the asset management system. In addition to data quality, operators will have access to pipe and coating data that can be used for threat identification and risk modeling as part of integrity management. The results of this project will provide the industry with a standardized approach for capturing pipe, appurtenance, welding and coating data. Phase 1 identified data collection requirements, developed barcode labeling specifications, and created a design document for field data collection software. Phase 2a will create standardized forms for Mill Test Reports (MTR) and factory applied coating information. Phase 2b will create technology to capture manufacturer information using standardized barcodes and develop and test the technology in a proof-of-concept project. Phase 3 (future) will create standardized forms and technology to capture field welding and field applied coating data. GTI will propose a Phase 3 to develop standards and technology for data collection of field applied coatings and field welding operations.

**OTD 5.14.f - Battery and Electric Powered Tool Evaluation, phase 1.** The use of battery-powered power tools in Class 1 Division 2 environments is limited by most LDC's best practice policies; however, this project aims to investigate this topic to propose alternative ways to improve safety of these highly useful devices.

**OTD 5.14.n - Construction Compliance Monitoring System.** The goal of this project is to develop a risk-based Construction Compliance Monitoring (CCM) system to assist operators in ensuring and quantifying the compliance of new construction. The CCM system will be composed of a model and software. The system will assess new construction work from a system-risk perspective and will deploy audit resources based on the probability and consequence of failure for specific job sites. It will identify high risk construction activities, generate prioritized audit schedules, provide electronic audit forms on tablet computers, collect audit results, and quantify the level of compliance using industry-standard statistical methods. This project will create the CCM model and a proof-of-concept system that will be tested with one operator. Full commercialization will be pursued in a second phase, if desired by OTD. The deliverable of this project will be a model and software sufficient to prove the concept and demonstrate the value of a compliance monitoring system. Provide documentation of compliance that can be used in communicating with regulators, insurance providers, or in the event of potential litigation. The benefits of the project: Maximize the efficiency of resources devoted to ensuring compliance. Implementations of this methodology may reduce the number of field inspectors required to achieve the desired level of confidence by targeting and optimizing the deployment of audit resources, improve construction performance and efficiency, and continuously improve risk management efforts by better understanding the sources and frequency of installation error.

**OTD 5.14.p - Developing Devices to Use with the Jameson Directional Insertion Tool** The objective for this project was to evaluate and modify devices or attachments for use with the Jameson insertion tool to increase the use and capabilities of live in-pipe inspection. A survey was conducted to obtain information on the current tooling and practices for live camera insertion, water removal, and digital mapping. Tests were performed to evaluate the ability of a camera to be inserted into a two-inch PE pipe through various access fittings. Tasks related to water removal and mapping-device insertion have not moved forward as survey results did not identify any devices that sponsors are currently using. — A Final Report is being prepared.

**OTD 5.14.t - Methods to Detect Inserted Plastic in Steel Mains.** This is an investigation into the feasibility of techniques for detecting inserted PE pipe. Three methods were considered as the most promising from an ease of field application perspective: 1) flow noise, 2) rate of cooling, and 3) modal analysis. Measurement of flow noise and/or cooling rate should work for large volume flows and the results are a function of flow rate, becoming ambiguous when volume flow decreases to zero. Using a combination of the two requires developing a method relating flow noise to cooling rate that is different for pipes with an insert and no insert. Because gas flow in a main varies greatly (including zero flow), a method independent of gas flow would be preferable for this application. An impulse modal analysis, being independent of gas flow, was seen as the most promising for identifying inserts across the largest range of flow conditions. Practical, reproducible, and easy to apply methods for generating and detecting the acoustic waveforms were identified. This technique can be used on the crown of the pipe. Measurements were performed indoors on bare, 2-inch diameter steel pipe found a large number of acoustic vibration modes. The amplitudes of the frequencies are different and depend on the insert diameter and the separation distance between the impact point and transducer location. Although the spectra are complex and additional work is required, the indoor results suggest it should be possible to distinguish among no insert and various insert diameters. Similar measurements were made in the GTI's pipe farm. The 2 and 4-inch diameter steel pipes were longer, coated with fusion bonded epoxy, and buried at both ends beneath raised earthen berms. The frequency range was greatly reduced and any differences between inserted and non-inserted pipe were small at best. It is unclear whether the reduced spectral content of the signals is due to earth and/or pipe coating attenuation, or variations in the method of attachment for the accelerometer to the external pipe surface. Additional work would be required to determine if any of the three techniques are feasible. The work performed to date has been on the impact modal analysis technique. As noted above, promising results from the indoor work did not translate to the outdoor setup with soil and coating interactions. This work was completed in 2015.

**OTD 5.14.u - Evaluation of Geospatial Technologies.** The purpose of this project is to evaluate two new geospatial technologies that could have engineering and operations applications for operators. The technologies to be evaluated could include wearable augmented reality devices (such as Google Glass) and handheld 3D mapping tools (such as Google's Project Tango). This project will test select technologies at GTI and local utility sites and develop recommendations for applications such as leak survey guidance, facility location and attributes, equipment repair, mapping of new and existing facilities, and emergency response. There are many advancements being made in the consumer hardware space and that the hardware and devices being developed can hold a lot of potential for the gas industry. Through efforts such as this project, research on new technologies can identify applications for the gas industry. Not every technology is going to provide the benefits that are intended, but through testing and identification of these technologies, ongoing research can bring new technologies to the gas industry. Microsoft HoloLens and other successful technologies such as Google Project Tango were identified in this project as technologies showing potential for further gas applications from which the company and the entire gas industry may benefit.

**OTD 6.6.a - Keyhole Consortium**. This GTI program develops continuous improvements and innovations to small hole (keyhole) technology. Keyhole excavations involve 18” diameter road openings to perform many routine operations that would traditionally require a 4 ft. x 4 ft. opening. Soil is vacuumed out and work takes place from street level using special long handled tools. This reduces paving costs and in many cases the 18” core is reused – set back in the excavation so there are no paving costs associated with the work. The Keyhole Consortium meets twice yearly; Company representatives attend with other LDCs and manufacturers. At the meeting common issues and needs are discussed and new research ideas are generated.

**OTD 7.14.a - Next Generation Water Clean-up Technology.** The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) has proposed IVP regulations that will require operators to verify the integrity of transmission pipes without pressure test records. These regulations could potentially require the industry to hydrotest up to 90,000 miles of in-service pipe. Cleaning and disposing of the hydrotest water is a significant component of the overall cost of hydrotesting. The objective of Phase I of this project is to conduct a technology review and business case to quantify the cost of disposing of water using current methods and the potential savings that could be achieved with new technologies. It is anticipated that development and implementation costs will be significant, thereby warranting a formal business case prior to pursuing technology development or technology transfer. Results of the industry survey taken in this project indicates that conventional management of pipeline discharge waters most often includes either hauling of the water to a publicly owned treatment works (POTW) for disposal or field-based filtering of the water through a ring of hay bales. The POTW alternative requires significant expense in transportation and in discharge fees; all costs connected with this option often exceed $0.50/gallon (2014 dollars). The hay bale alternative (whereby water is forced through a ring of hay bales) is sometimes used in the field, but the method only seems to work for the control of oils and greases and suspended solids but is not effective in removing many soluble organic compounds of concern such as benzene. Clearly, a second generation treatment system is needed that allows low cost field based treatment that is reliably compliant with water quality criteria specified in permits for water reuse and discharge to surface waters. Primary treatment systems used by industry in the past such as sedimentation and dissolved air flotation have been effective in control of suspended solids and free oil and grease. Granular activated carbon (GAC) is effective in removal of soluble organics, but becomes expensive when treating waters that are greater than 1-5 mg/l of total organic carbon (TOC). Biological treatment can be used to remove soluble organics, but the process requires too much of a footprint to be practical. Chemical oxidation, however, can be used for oxidizing most of the soluble organics while taking up a very small footprint. What is needed, however, is a chemical oxidant that is easy to handle and use in the field as a part of the integrated mobile treatment system. A review of commercial chemicals indicates that many of them are not suitable for implementation in a highly mobile, treatment system applied to 1-2 day processing of hydrostatic test waters. A list of information gaps is described in the report; these gaps can be resolved with research and development concentrated on the oxidation step of the advanced treatment flowsheet.

On the basis of this technical evaluation, it is recommended that the industry consider development and optimization of the manganese dioxide oxidative process for the conditioning of pipeline discharge wastewaters. This development work should be pursued in the context of an integrated prototype that includes all of the treatment steps that preceded and follow the oxidation process.

## Cathodic Protection, Coatings and Corrosion Related

**M2012-001 - Development of a Corrosion Sensor Array.** This project will attempt to develop a novel method of monitoring for external corrosion on a gas pipeline by installing an “array” of sensors on a pipeline. If successful, pipeline operators will have another “tool in the toolbox” for monitoring critical pipelines for external corrosion. This project utilizes an existing microsensor-based system to provide corrosion monitoring of full sections of gas pipelines. The project will initially modify the system and then assess its suitability for the natural gas industry through lab testing. The core technology employed is the micro-linear polarization resistance sensor developed originally for aerospace applications.

**OTD 2.9.c - Field Applied Pipeline Coatings**. Modern pipe materials are factory coated and these coatings stand up very well as long as they are not damaged by external forces. However, in locations where field welds or other field installed fittings are present, the necessary pipeline coating needs to be field applied. Field applied coatings vary in quality and are not always installed under ideal environmental conditions such as would be present in a pipe coating factory. This project tested the performance of several different types of coatings on buried pipe at Gas Technology Facilities in Chicago.
Throughout the world, a variety of generic coating systems are commonly applied to field girth welds, including the following: (1) fusion bonded epoxy (FBE), (2) heat shrink sleeves (HSS), (3) liquid applied coatings, (4) composite systems, and (5) tapes/wraps. Eighteen (18) manufacturers supplied seventy-five (75) different coating systems for the test program. The coatings were installed by the manufacturers on a network of 8” and 24” steel piping buried in rocky, sandy, and clay-like soils. Coating systems were unearthed and examined at 2, 5, and 7 year intervals. Some coatings exhibited no rust on any of the pipes in any soil, and other coatings exhibited rust on pipe in all soil. A key conclusion of the test program is that strict adherence to the manufacturers’ recommended installation procedures is absolutely necessary. A final report on project results has been prepared. The benefit is improved pipeline safety and assurance that superior products, from a long term performance point of view, are installed on company facilities.

**OTD 5.9.c - Mitigating Electrical Interference on Cathodic Protection Systems.** Electrical interference can impair or negate the effect of cathodic protection systems. The objective of this project is to understand the types of interference that can be present near pipeline systems and make recommendations to mitigate the effect of these interferences. Interferences can be steady state, such as would be present from adjacent high voltage power lines or transient, caused by a lightning strike or power line surge.
To implement the project, GTI selected three host sites and installed data logging instrumentation on cathodic protection systems there. Transient events and steady state

interference data is being gathered. The results of the data gathering exercise will be recommendations for enhanced equipment or better surveillance of cathodic protection systems to better protect them. Enhanced integrity of piping systems protected by cathodic protection is the benefit of this research.

**OTD 5.9.f – Cathodic Protection Monitor**. The objective is to develop and deploy a Cathodic Protection Monitor prototype that stores monthly CP readings. GTI has partnered with 3M to develop a completely encapsulated, direct burial monitoring device. A 3M handheld locator/reader is used to retrieve the readings electronically from above ground without requiring a direct connection. The data, consisting of 12 sets of monthly readings, can be downloaded from the handheld devices as tabular data. The first version of the CP Monitor has been successfully tested; as a result of testing additional product requirements were identified. The objective of Phase 2 is to develop and test a modified CP Monitor prototype with some or all of the following features: ability to record AC potential readings to detect stray currents, increased data storage, improved range with the ability to capture readings from a moving vehicle, programmable data recording intervals, and ability to transfer data to other handheld devices via Bluetooth for direct GIS integration. The benefit is improved monitoring of CP performance on protected piping, with the potential cost savings of making mobile readings

**OTD 5.11.n – Quality Control Procedure for High Potential Anodes.** The Company recently has been experiencing quality problems with magnesium anodes as delivered from manufacturers. Anodes that appear – upon visual inspection – to be sound have been experiencing premature failures in the field. Quick and simple voltage tests may initially reveal that the anode is generating the required voltage potential but this may be indicative of good quality of the surface layer of the anode only. If the entire anode is not of the same quality and purity the anode will deteriorate prematurely. The standard industry test for measuring anode purity, ASTM G97, is expensive and time consuming and it is not practical to conduct this test for all new anodes received. Therefore, there is an industry need for a quicker test that can validate the requisite quality and purity of anodes. GTI has received anodes from project participants and is currently evaluating alternate methods of testing them that can give results similar to the G97 test. As an indication of the need for this project, GTI reports that the project has experienced delays due to the time consuming nature of the G97 test, which is being performed in parallel as a control. The benefit is better assurance of the quality of materials received and installed in the company's gas system.

**OTD 5.12.n – Advanced Tools for Improved AC Corrosion Prevention and Mitigation**. Alternating Current (AC) corrosion is not common but can occur if gas mains are in proximity to railroads or overhead electric transmission lines. When it does occur, the corrosion rates can be rapid, thus the need for the Company to quickly identify and mitigate the occurrence of AC corrosion. The company is working with GTI on this project and they have proposed a two part solution, a model to predict rates of AC corrosion, and a calculator to determine the most effective mitigation measure. The project will draw heavily on existing work done by the National Association of Corrosion Engineers (NACE) and the Company's and other funders' experience. The final deliverable of the project will be the model and calculator, which can be used to prioritize inspections and gauge the impact of various mitigating measures on both new and existing gas pipelines.

**OTD 5.14.x - Risk-Based Atmospheric Corrosion/Leak Survey Considerations**
A study reviews historical and current data on atmospheric corrosion of indoor service piping. A detailed review of the published, peer-reviewed literature related to field data on indoor corrosion was made. A comparison of the fundamental principles of indoor and outdoor atmospheric corrosion was made. The research conducted compares and contrasts indoor atmospheric corrosion to outdoor corrosion for iron and steel piping materials. In addition, thousands of recent inspections in NY and New England States were completed on outdoor and indoor services by operators the data was collected and statistically analyzed to determine the trends and drivers behind the observed corrosion rates. A similar analysis was completed on exclusively indoor leak survey data from LDC operators. Finally, all the findings were summarized and related to risk-based considerations for setting appropriate inspection intervals for indoor service piping. This art of the study was completed in late 2014.

## General and Other Areas Not Covered Elsewhere

**M2001-013 - Millennium Website Development.** A project for maintenance and upgrading of NYSEARCH's website and for use by the NY LDCs who utilize NYSEARCH as a clearinghouse for reporting to the NY PSC on the use of the Millennium R & D funds

**M2002-008 - Oracle Technology Concept Investigation.** Through the NYSEARCH research consortium, the Company and others fund a concept known as "Oracle." The purpose of this program is to look outside the gas industry for novel technology solutions to gas industry needs. In the past, technologies from the military, biomedical, and telecommunications industries have been tracked. More recently, our focus has been sensor technologies using fiber optics or nanotechnology, and material science advances. Applications from these industries, when identified, will be funded as separate projects. An example of that is a current effort to take nanocomposite particles used in plastic in other industries and create self-healing PE pipe. Another example that came from this is the methane sensor using tuning fork technology.

**OTD 5.14.c - Improving Cybersecurity for LDCs - Needs Identification & OTD 5.15.a Cybersecurity Collaborative.** Initiated in February 2014 an initiative to review and to provide information on the status of cybersecurity R&D activities for LDCs and identify the short and long-range needs for cybersecurity capability improvement for LDCs. A workshop was conducted on April 16-17, 2014 at GTI facilities in Des Plaines, IL. Day 1 included presentations by representatives from GTI, AGA, DHS and SRI to orient the attendees to cyber related activities focused on the energy sector and natural gas specifically. Day 2 was dedicated to sharing lessons learned and identifying technology needs and gaps, and prioritizing project ideas. A summary report was prepared which identifies the industry need and business value of addressing cybersecurity issues, and summarizes the cybersecurity lessons learned for the participating utilities, A follow on effort under OTD 5.15.a continues as a multi-year collaborative program between natural gas distribution companies and the Department of Homeland Security (DHS) to address the high priority cybersecurity issues of participating members through a focused outreach and education process and a technology evaluation and transfer initiative.

**OTD 6.14.a - Quality Audit Program for Natural Gas Utility Suppliers.** Distribution Integrity Management regulations encourage utility companies to place a new focus on supplier and supply chain quality. Identifying threats and mitigating risks starts with the manufacturing process. Reducing supply chain risk requires a comprehensive and well-coordinated supplier audit program to ensure that the integrity of the supply chain is controlled and that the supplier is following policies and procedures required by customers and regulators. The purpose of this effort is to develop an audit program and provide natural gas utility operators with a mechanism to collaboratively audit supplier's quality management systems. The program will conduct an independent and unbiased assessment on behalf of participating operators to provide a reliable and standardized approach for monitoring suppliers. Participating operators will benefit from a collaborative program by creating efficiencies and promoting information sharing. Supplier audits identify non-conformances in manufacturing, shipping, engineering change, invoicing, and quality processes. After the audit, the supplier and auditors jointly identify corrective actions which must be implemented by the supplier within an agreed-upon timeframe. A future audit ensures that these corrective actions have been successfully implemented. While the need for enhanced quality audits and monitoring programs is increasing, the availability of resources to conduct these programs is decreasing due to operator's focus on operations and efficiencies. Therefore, there is a need for a coordinated collaborative audit program to allow gas utilities to efficiently monitor supplier processes. Participation in the collaborative program will provide value in the following ways: create efficiencies and cost savings by consolidating audits into one program, increase the number of audits performed, create leverage and increase influence with suppliers, utilize RAB/IRCA certified auditors with extensive experience, provide a high quality audit due to consistency and standardization of audit methodology and allow internal resources to focus on the core business rather than auditing. National Grid has participated in the development and pilot which has helped us review and improve our own auditing process but we are currently evaluating if we will continue in this GTI program.

## Joint Industry Projects

The following three projects have been are jointly funded and managed between DET NORSKE VERITAS, DNV, and various industry co-funders:

**Development of Industry Best Practices for Hot Tap Branch Connections Joint Industry Project (JIP)** – a welding procedure is being developed and draft sent out to the group for comments, particularly for preheat. Concerns for maintaining preheat on a flowing pipeline are to be addressed.

**Development of Industry Best Practices for Girth Weld Repair** The objective of this JIP is to develop industry best practice for repair of pipeline girth welds during new construction activities, which will include the development and qualification of a suite of repair welding procedures in accordance with Section 10 of the Twenty-first Edition of API 1104. A guideline for selecting an appropriate procedure for a given application will also be developed. The scope will also include the development of guidance pertaining to other technical aspects of girth weld repair and repair welder qualification (e.g., preheating requirements, inspection requirements, time delay prior to inspection, minimum-required and maximum-allowable repair length, practical limits on wall thickness, etc.) that will be used to develop a generic company specification for repair of pipeline girth welds during new construction.

**Validation of the ASME Procedure for Estimating Lower Bound Yield Strength of Pipe from Hardness Data.** Forty-nine pipe samples representing a wide range of age, size, grade, composition, and manufacturing method were tested to demonstrate the validity of using hardness test data to estimate lower bound yield strength (YS) of steel pipe. Three different types of field portable hardness testers were used on each pipe sample. The hardness testing was performed in accordance with ASME CRTD-Vol. 91. The hardness test results were converted to estimated lower bound YS values using the correlations described in ASME CRTD-Vol. 57. The estimated lower bound YS was compared to the results of standard API 5L tensile tests. In addition, the metallurgical attributes of each pipe were characterized to determine if certain subsets of pipes produced better (or worse) correlations of estimated lower bound YS to YS determined from tensile tests. The results showed that hardness data can be used to estimate conservative values of lower bound YS using a range of different confidence levels.

## National Grid Managed Projects

National Grid funds projects outside the NYSEARCH and OTD consortia and manages them ourselves or jointly with other LDCs. The following two projects are jointly funded and managed between National Grid Downstate and Consolidated Edison Co (Con Ed)

**M2001-009 - Construction Interference Cost Reduction (CONCORD) Program.** National Grid and Con Edison, along with the Urban Utility Center of Polytechnic Institute of New York, are working with New York City to introduce trenchless technologies to the city’s construction program. Trenchless technology – as compared to traditional “open cut” construction – can save National Grid and Con Edison significant dollars by eliminating the need to relocate our gas facilities if they interfere with the city’s new construction. We have introduced new trenchless technologies to the city’s engineers, conducted training programs, performed lab testing, and these efforts have culminated in New York City’s decision to rehabilitate two miles of a major water main in Manhattan via a trenchless method. This method involves insertion of a plastic liner into the existing cast iron water main and few adjacent gas facilities will need to be relocated. Con Ed estimates significant savings. If this program is successful and NY

City adopts trenchless technology for future construction, the savings to National Grid and Con Ed could be significant for years to come.

**M2002-015 Cast Iron Sealing Robot (CISBOT):** National Grid and Con Edison jointly fund and manage this project to design, construct and test a live, tethered robot that will internally seal cast iron joints. National Grid has the highest inventory of cast iron pipe in the nation, over 6000 miles, with over 2600 miles in the State of New York alone (Source, US DOT report). Cast iron is a very durable material but over time the joints – mechanical connections packed with jute and lead – can dry out and are the source of leakage. National Grid's predecessor company, KeySpan, partnered with Con Edison of New York to jointly fund the development of CISBOT. The robot was built by ESI Corp of Toronto, Canada. Upon completion of the robot Con Ed and National Grid entered into an agreement with ULC Robotics, a small high tech firm located on Long Island, to 'commercialize' the device and ultimately become the service provider for the CISBOT services. This is a typical business plan for high tech deployment in the gas distribution sector; ULC Robotics performs this type of work as their main line of business. To date, National Grid has spent over $2.2 Million on the project, with a similar amount funded by Con Edison. CISBOT is designed to seal joints in 16" through 36" diameter cast iron gas mains operating at pressures up to 25 psi. An excavation will be dug at a convenient point along the gas main and a special fitting is installed on the main which allows a 12" opening to be cut into the main in "live" conditions with no shutdown required and no blowing gas. (This is a fairly common procedure in the gas industry.) The CISBOT robot is then inserted into a launch tube and the launch tube is attached to the fitting on the main. The launch tube is purged of air with nitrogen and then a valve is opened and natural gas fills the launch tube. The robot is then lowered into the gas main. A tether connects the robot with external power and communication, and a small tube in the tether contains the anaerobic sealant which is used to seal the joints. An operator drives the robot using onboard cameras as a guide and stops at the first joint. A small hole is then drilled into the joint at a predetermined spot. Once the hole is drilled, a nozzle is inserted up into the drilled hole and anaerobic sealant is pumped into the hole, saturating the joint. Cameras on the robot are positioned to view the wicking action of the anaerobic fluid and pumping is stopped when the operator judges that a particular section of the joint is filled with sealant. The robot is then repositioned to a different "clock position" around the circumference of the joint and the drilling and sealing operation is repeated. Once the operator judges that the joint is sealed the robot will travel down to the next joint and the process is repeated.

CISBOT is undergoing an extensive program of field demonstrations over the past three years in New York City and Boston. Costs for the demonstrations outside NY State are borne by the area conducting the demonstration. In parallel with the demonstrations, the Company and Con Edison are negotiating a Commercial License with ULC Robotics. The cost of the service will be determined by ULC Robotics prior to their offering the service as a commercial business. National Grid NY and Con Ed will receive a discount from the stated list pricing. Because the final cost of the service has not yet been determined, it is difficult to accurately predict savings but assumptions can be made.

The basis for our assumed savings of $2.5M annually is to assume that CISBOT is deployed to a main segment where 50% of the joints are or will soon be leaking. Per job that's about 15 joints at an estimated cost of $3000 per joint to repair, total cost $45,000. This figure can vary depending on the final pricing structure set by ULC Robotics. Standard repair including a tight sheeted pit is estimated at $20,000 per repair for total repair cost of $300,000. Actual costs for tight sheeted pits in congested urban areas have been reported as much higher but this is a conservative estimate. Based on these assumptions the net savings is about $255,000 per job. Assuming full successful deployment of CISBOT, 10 such jobs per year could be performed, resulting in annual savings of $2,550,000.

National Grid expects to deploy this technology in its large diameter cast iron mains in New York State and Massachusetts. Any royalties received will be returned to NY ratepayers through the Millennium Fund.

Attachment 2 shows spending for these projects described above.

## National Grid Gas R&D Spending

Includes Ngrid Downstate (KeySpan) and Ngrid Upstate (NMPC)

Calendar Year Expenditures ($)

| | Actual | | Projected | | |
|---|---|---|---|---|---|
| **Year** | **2014** | **2015** | **2016** | **2017** | **2018** |
| National Grid Internal Program | | | | | |
| Utilization | $ 104,800 | $ 211,426 | $ 758,574 | $ 170,000 | $ 170,000 |
| Operations | $ 57,708 | $ 28,476 | $ 200,000 | $ 263,000 | $ 263,000 |
| Ngrid Labor and Expenses | $ 229,692 | $ 184,741 | $ 201,640 | $ 207,689 | $ 228,094 |
| **TOTAL INTERNAL** | **$ 392,200** | **$ 424,643** | **$ 1,160,214** | **$ 640,689** | **$ 661,094** |
| National Grid Millennium Program | | | | | |
| NYSEARCH Projects | $ 2,265,234 | $ 1,311,235 | $ 1,571,000 | $ 1,687,000 | $ 1,150,000 |
| OTD Projects | $ 750,000 | $ 870,279 | $ 750,000 | $ 750,000 | $ 750,000 |
| National Grid Projects | $ 40,000 | $ 103,502 | $ 352,000 | $ 400,000 | $ 450,000 |
| **TOTAL MILLENNIUM** | **$ 3,055,234** | **$ 2,285,016** | **$ 2,673,000** | **$ 2,837,000** | **$ 2,350,000** |
| **TOTAL MILLENNIUM AND INTERNAL** | **$ 3,447,434** | **$ 2,709,659** | **$ 3,833,214** | **$ 3,477,689** | **$ 3,011,094** |
| **NYSERDA Assessment** | $ 3,565,124 | $ 4,906,042 | $ 5,000,000 | $ 5,250,000 | $ 5,550,000 |
| **TOTAL R&D PROGRAM** | **$ 7,012,558** | **$ 7,615,701** | **$ 8,833,214** | **$ 8,727,689** | **$ 8,561,094** |

Note: Total spend, from books of Company

| PROJECT NUMBER | PROJECT | START DATE | END DATE | TOTAL NGRID COMMITMENT | TOTAL SPEND 2013 | TOTAL SPEND 2014 | TOTAL SPEND 2015 | TOTAL NGRID SPEND Joe YEARS |
|---|---|---|---|---|---|---|---|---|
| M-2000-001 | Variable length sleeve - NYSEARCH | 2000 | 2013 | $ 147,356 | | $ 29,586.33 | | $ 111,970.00 |
| M-2000-004 | Explorer Commercialization, Phase I | 2000 | 2006 | $ 341,239 | | $ 14,906.96 | | |
| M-2001-002 | Mgmt of Impacted Sediments - NYSEARCH | 2001 | 2011 | $ 430,061 | | | | $ 430,061.00 |
| M-2001-003 | Cased Pipe Risk Assessment Model | 2001 | 2011 | $ 274,472 | | $ 4,007.04 | | $ 184,501.00 |
| M-2001-005 | PipeHawk Hand-Held Pipe Locator - NYSEARCH | 2001 | 2013 | $ 435,090 | | $ 23,892.72 | | $ 392,895.00 |
| M-2001-006G | Development / Testing / Commercialization of GASNET(tm) - Phase V | 2001 | open | $ 392,485 | | | $ 31,593.94 | |
| M-2001-009 | Interference Avoidance/UUC Technology Demo Lab | 2001 | 2010 | $ 475,000 | | | | $ 446,000.00 |
| M-2001-013 | Millennium Web Development | 2001 | ongoing | $ 37,998 | | $ 5,751.81 | $ 1,612.19 | |
| M-2001-014 | InspectionTool for Unpiggable Facilities - Automatika (TIGRE) | 2001 | 2011 | $ 967,261 | $ (9,098.34) | | | $ 959,781.00 |
| M-2002-008 | Technical Expert (Oracle) to ID Quantum Leap Technologies | 2002 | ongoing | $ 53,931 | | $ 13,585.11 | $ 179.87 | $ 29,396.00 |
| M-2002-011 | FFT AUra Damage Prevention Systems - Testing Program - Phase III | 2002 | open | $ 202,380 | | $ 109,480.05 | $ 43,194.73 | |
| M-2002-015 | CISBOT-Live IP CI Joint Sealing (KSE/ConED/ESI/ULC) | 2002 | 2013 | $ 2,356,825 | | | | $ 2,219,476.00 |
| M2002-018 | Infrasonic Sensor for Remote Pipeline Monotoring - NYSEARCH | 2002 | 2010 | $ 129,711 | | | | $ 104,858.00 |
| M2003-009 | Explorer II | 2003 | 2012 | $ 483,030 | | $ 24,727.35 | | $ 451,452.00 |
| M2005-003 | Test Bed Maintenance and Improvements | 2005 | ongoing | $ 110,108 | | $ 518.11 | $ 1,225.31 | |
| M2005-005 | Gas Interchangeability for LDC Infrastructure | 2005 | 2014 | $ 753,336 | | $ 96,150.43 | $ 25,514.42 | $ 644,948.00 |
| M2006-002 | Butt Fusion Joint Integrity | 2006 | 2011 | $ 70,198 | | $ 9,776.81 | | $ 53,213.00 |
| M2007-001 | Mini-camera for Cased Crossings | 2007 | 2012 | $ 150,952 | | $ 10,491.88 | | $ 228,563.00 |
| M2007-003 | Multi Technology Validation Testing for Cased Pipe Applications | 2007 | 2013 | $ 73,315 | | $ 897.85 | $ 2,952.00 | $ 49,676.00 |
| M2007-005 | Testing Program for Remote Inspection-Transkor | 2007 | 2012 | $ 133,080 | | $ 15,387.64 | $ 1,803.50 | $ 75,901.00 |
| M2007-007 | Technology Advancement in Damage Prevention Tools and Communications | 2007 | 2011 | $ 91,973 | | $ 7,268.87 | | $ 64,243.00 |
| M2008-001 | Third Party Detection - Magal | 2008 | 2013 | $ 58,297 | | $ 5,522.13 | $ 4,202.49 | $ 29,419.00 |
| M-2008-005 | Developing Platelet Technology for use in Gas Transmission and Distribution Centers | 2008 | open | $ 23,280 | | $ 23,279.52 | | |
| M2008-006 | Expand Function of No Blow Tools to Reduce GHG | 2008 | 2012 | $ 122,329 | | $ 6,055.00 | | $ 82,078.00 |
| M2008-010 | UV Degradation of PE Pipe | 2010 | 2013 | $ 14,125 | | | | $ 8,070.00 |
| M2009-001 | Holistic Review of DIMP Practices and Models | 2009 | 2012 | $ 48,750 | | $ 3,995.78 | | $ 44,409.00 |
| M2009-002 | Mercaptan Sensor Development | 2009 | open | $ 330,462 | | $ 60,282.16 | | $ 266,030.00 |
| M2009-003 | Adaptation Study | 2009 | 2012 | $ 23,500 | | | | $ 23,500.00 |
| M2009-007 | Particulate Dispersion Study | 2009 | 2011 | $ 75,000 | | | | $ 60,516.00 |
| M2009-008 | Ultrasonic Evaluation System for PE Butt Fusion | 2009 | open | $ 133,700 | | $ 20,632.90 | | $ 2,079.00 |
| M2010-001 | Service Tee Renewal | 2010 | open | $ 73,170 | | $ 27,692.85 | | $ 20,118.00 |
| M2010-002 | Methane MR Sensor Development | 2010 | open | $ 126,730 | | $ 12,318.70 | $ 41,955.00 | $ 23,265.00 |
| M2010-003 | PCB Absorption in PE Piping | 2010 | 2013 | $ 194,000 | | $ 60,613.68 | | $ 121,228.00 |
| M2010-004 | Soil Vapor Intrusion | 2010 | 2012 | $ 83,100 | | $ 39,199.82 | | $ 43,877.00 |
| M2010-005 | Guided Wave Test Program | 2010 | 2012 | $ 175,000 | | | | $ 95,082.00 |
| M2011-001 | Self Healing Pipe | 2011 | open | $ 232,442 | | $ 123,440.62 | $ 45,986.48 | $ 7,397.00 |
| M2011-002 | Storage Effects on Gas Quality | 2011 | 2013 | $ 26,555 | | $ 9,470.17 | | $ 12,628.00 |
| M2011-003 | Odor Masking | 2011 | open | $ 126,695 | | $ 89,198.22 | | $ 23,158.00 |
| M2011-004 | Carbon Calculator | 2011 | open | $ 24,450 | | $ 1,156.83 | | $ 12,234.00 |
| M2011-005 | Fiber Sen System Development and Testing | 2011 | open | $ 71,248 | | $ 32,464.79 | $ 28,342.19 | $ 6,316.00 |
| M2011-006 | Robotics Supporting Technologies | 2011 | open | $ 1,020,009 | | $ 411,841.51 | $ 169,306.28 | $ 152,941.00 |
| M2011-007 | Cased Pipe Inspection via Vents | 2011 | open | $ 386,760 | | $ 168,393.96 | $ 94,646.85 | $ 41,630.00 |
| M2011-008 | BioBall Test Program | 2011 | 2013 | $ 37,630 | | $ 37,630 | | $ - |
| M2011-009 | Explorer 30 - 36" | 2011 | 2013 | $ 500,000 | $ 64,500 | | | $ 435,000 |
| M2012-001 | Development of Corrosion Sensor Array | 2012 | open | $ 72,310 | | $ 20,811 | $ 49,013 | $ - |
| M2012-003 | Enterprise Level Assessment of Data Management Systems | 2012 | 2014 | $ 33,900 | | $ 33,900 | | $ - |
| M-2013-001 | Explorer 16/18 - Inspection of Unpiggable Pipelines | 2013 | 2015 | $ 1,230,915 | $ 307,730 | $ 615,460 | $ 307,725 | $ 1,230,915 |
| M-2013-002 | Non-Destructive Inspection of Gas Pipes Using AMR Sensors for Eddy Current Testing (ECT) | 2013 | open | $ 342,668 | | $ 2,883 | $ 45,940 | |
| M-2013-003 | Integrated Nanosensors for Analysis of Chemical Compounds in Natural Gas Applications (WKU Advanced Chemical Sensor) | 2013 | open | $ 189,885 | | $ 4,563 | $ 152,422 | |
| M-2014-001 | Aeryon sUAS Technology - Regulatory & Technology Assessment | 2014 | open | $ 131,880 | | | $ 10,396 | |
| M-2014-002 | Leak pinpointing inside pipe | 2014 | open | $ 27,380 | | | $ 8,717 | |
| M-2014-003 | Picarro Methane Emissions Analyzer System | 2014 | open | $ 129,748 | | | $ 129,748 | |
| M-2014-004 | Technology Evaluation & Test Program for Quantifying Methane Emissions Related to Non-Hazardous Leaks | 2014 | open | $ 54,210 | | | $ 14,825 | |
| M-2014-005 | Critical Valve Operability | 2014 | open | $ 18,155 | | | $ 7,033 | |
| | | | | $ 14,248,084 | $ 363,132 | $ 2,177,234 | $ 1,218,335 | $ 9,188,824 |
| Keyspan dues | | | | | $ 55,000 | $ 55,000 | $ 60,000 | |
| NMPC dues | | | | | $ 33,000 | $ 33,000 | $ 33,000 | |
| | | | | | **$ 451,132** | **$ 2,265,234** | **$ 1,311,335** | |
| | | | | | | | | |
| OTD 1.08.a | GPS-Based Excavation Encroachment Notification | 2008 | open | $ 134,269 | $ 19,176 | | | $ 134,269 |
| OTD 1.08.a.CA | GPS Based Excavation Encroachment Notification for ROW Monitoring- CA (GTI) | 2008 | open | $ 33,142 | $ 33,142 | | | |
| OTD 1.08.c | GPS-Enabled Leak Surveying and Pinpointing (see 1.9.a) | 2008 | open | $ 50,000 | | | | |
| OTD 1.8.f | Electromagnetic and Acoustic Obstacle Detection Refund | 2004 | 2011 | $ 24,599 | $ (12) | | | $ 24,599 |
| OTD 1.8g | Acoustic Sewer Lateral Locator | 2008 | 2012 | $ 80,289 | $ 7,300 | | | $ 72,989 |
| OTD 1.09.a | GPS Leaks - Phase 2 (from 1.8.c) | 2009 | 2013 | $ 129,080 | $ (437) | | | $ 121,780 |
| OTD 1.h and 1.10.c | Hand Held Acoustic Pipe Detector and tech transfer | 2003 | 2013 | $ 287,260 | | | | $ 287,260 |
| OTD 1.10.e | Enhancing Damage Prevention in New York | 2010 | 2015 | $ 16,500 | | | | |
| OTD 1.11.a | Chemical Methods to detect crossbores | 2011 | 2011 | $ 2,870 | | | | $ 2,870 |
| OTD 1.11.c | Low-Cost MEMS Methane Sensor Platform Phase 1 | 2011 | 2015 | $ 30,000 | | | | $ 30,000 |
| OTD 1.11.e | Cross Bores - National Database and Risk Model | 2011 | open | $ 35,000 | $ 3,000 | | | $ 35,000 |
| OTD 1.12.b | Cross-Bores Detection Using Mechanical Spring Attachment | 2012 | 2014 | $ 10,000 | $ 5,314 | | | $ 10,000 |

| PROJECT NUMBER | PROJECT | START DATE | END DATE | TOTAL NGRID COMMITMENT | TOTAL SPEND 2013 | TOTAL SPEND 2014 | TOTAL SPEND 2015 | TOTAL NGRID SPEND Joe YEARS |
|---|---|---|---|---|---|---|---|---|
| OTD 1.14.d | Field Measurement of Leak Flow Rate | 2014 | open | $ 9,994 | | $ 5,000 | $ 4,994 | |
| OTD 1.14.g | Evaluation of Residential Methane Detectors | 2014 | open | $ 85,000 | | $ 85,000 | | |
| OTD 1.14.g.2 | Evaluation of Residential Methane Detectors-Phase 2 | 2014 | open | $ 32,097 | | $ 15,446 | $ 10,000 | |
| OTD 1.14.g.2a | Evaluation of Residential Methane Detectors-Phase 2 Pilot | 2014 | open | $ 175,000 | | | | |
| OTD 1.14.h | Picarro Surveyor Winter Patrol Implementation | 2013 | 2015 | $ 572,500 | | $ 25,000 | $ 547,500 | |
| OTD 2.07.a | 2.7.a Refund | | | | $ (9,014) | | | |
| OTD 2.8.e | Structural Liners and Sleeves - Technology Search | 2008 | 2013 | $ 12,132 | | | | $ 12,132 |
| OTD 2.9c | Field Applied Coatings | 2009 | 2012 | $ 67,000 | | | | $ 67,000 |
| OTD 2.11.a | Development of a System for Repair of Above Ground Leaks | 2011 | open | $ 44,611 | $ 4,375 | | | $ 40,236 |
| OTD 2.11.d | RSD X-Ray for Metallic Pipe Assessment - Testing and Validation | 2011 | 2012 | $ 20,000 | | | | $ 20,000 |
| OTD 2.11.d Refund | 2.11.d Refund | | | | | | $ (2,737) | |
| OTD 2.12.e | Selection of Liners Composites for the Rehabilitation of Distribution and Transmission Lines | 2012 | 2015 | $ 15,000 | $ 15,000 | | | |
| OTD 2.13.b | Guidelines for Special Permits for Structural Composite Rehabilitations | 2013 | open | $ 38,000 | $ 38,000 | | | |
| OTD 2.13.c | PHMSA Accelerated Dynamic Testing for Long Term Evaluation of Liners and Composite Pipe Materials add (PHMSA-21501) | 2013 | open | $ 39,063 | $ 25,000 | $ 14,063 | | |
| OTD 2.14.a | Composite Repair Wrap for Polyethylene (PE) Systems | 2014 | open | $ 5,000 | | $ 5,000 | | |
| OTD 2.14.b | Pipe System Repair Technique | 2014 | open | $ 40,000 | | $ 20,000 | $ 20,000 | |
| OTD 2.14.c | Assessment of Squeeze off Location for Small Diameter Polyethylene (PE) Pipe and Tubing | 2014 | open | $ 8,190 | | $ 5,000 | $ 3,190 | |
| OTD 2.14.d Refund | 2.14.d Refund | 2014 | | $ (17,964) | | $ (17,964) | | |
| OTD 2.14.d | Universal PE Entry Fitting | 2014 | cancelled | $ 20,000 | | $ 20,000 | | |
| OTD 2.14.e | Guidelines/Best Practices for Scraping PE Pipe and Fittings | 2014 | open | $ 1,251 | | $ 1,000 | $ 251 | |
| OTD 2.b | Service Applied Main Stopper | | | $ 152,078 | | | | |
| OTD 3.8a | Jackhammer Noise Abatement Issues | 2008 | 2010 | $ 20,000 | | | | $ 36,463 |
| OTD 3.9a | Backfill Evaluation & Ecoroads | 2009 | 2012 | $ 24,295 | | | | $ 30,869 |
| OTD 3.14.a | Soil Compaction Supervisor Enhancements | 2014 | open | $ 36,355 | | $ 25,000 | $ 8,934 | |
| OTD 3.14.b | Update ASTM Standard of DCP Compaction Control | 2014 | open | $ 1,000 | | $ 1,000 | | |
| OTD 4.7.g | Yield Strength | 2007 | 2012 | $ 27,672 | $ 2,500 | | | $ 25,172 |
| OTD 4.08.a | Guided Wave Validation as Hydro Equivalent | 2008 | 2015 | $ 52,843 | | | | |
| OTD 4.8.i | Extended Reassessment Interval Validation Through Dielectric Wax Casing Fill | 2008 | 2012 | $ 58,929 | | | | $ 58,929 |
| OTD 4.9a | Leak vs. Rupture Boundary | 2009 | 2012 | $ 68,048 | | | | $ 68,048 |
| OTD 4.9.a Refund | 4.9.a Refund | | | $ (99) | | | $ (99) | |
| OTD 4.11.f | Understanding Threat Interactions for Risk Analysis (GTI) | 2011 | 2013 | $ 30,000 | | | | $ 30,000 |
| OTD 4.12.b | Correlating Pipeline Operations to Potential Crack Initiation Growth Arrest (GTI) | 2012 | open | $ 74,678 | $ 30,000 | $ 14,678 | | $ 30,000 |
| OTD 4.13.a | DIMP Consequence Model | 2013 | 2015 | $ 55,200 | $ 30,000 | $ 25,200 | | |
| OTD 4.13.b | Validation of 3D Scanners for Anomaly Assessment | 2013 | 2013 | $ 25,000 | $ 25,000 | | | |
| OTD 4.13.c.2 | PHMSA EMAT Sensor for Small Diameter and Unpiggable Pipe Phase 2 Construct and test field ready prototype | 2013 | open | $ 10,000 | | | $ 5,000 | |
| OTD 4.13.d.3 | Hydro-testing Alternative Program - Phase 3 | 2013 | open | $ 8,658 | | $ 5,000 | $ 3,658 | |
| OTD 4.14.a | Fitting and Component Catalogue for IVP | 2014 | open | $ 5,000 | | $ 5,000 | | |
| OTD 4.14.c | Surface Indentation for Material Characterization Correlation of Surface Properties Based on Vintage | 2014 | open | $ 58,301 | | $ 30,000 | $ 28,301 | |
| OTD 4.e | Inspection Platforms for Unpiggable Pipelines (NYSEARCH) | | | $ 303,963 | | | | |
| OTD 5.06.e | Portable Propane Air Residential Temporary Gas Supply | 2006 | open | $ 90,062 | $ 14,851 | | | |
| OTD 5.07.f | Automated Meter Shut-Off Device (AMS) | 2007 | | $ 47,596 | | | | |
| OTD 5.07.p | 5.07.p (GTI) GPS Consortium | 2007 | open | $ 15,000 | | | | |
| OTD 5.08.a.2 | 5.08.a.2 Development of Automated Welding Unit for Installing Laterals – Phase 2 (GTI) | 2008 | open | $ 42,500 | $ 20,000 | $ 22,500 | | |
| OTD 5.08.d.3 | 5.08.d.3 Tool for External Classification of Pipe Contents, Phase 3 | 2008 | open | $ 1,000 | | $ 1,000 | | |
| OTD 5.8e | Gas Material Traceability | 2008 | 2012 | $ 77,008 | $ 4,020 | | | $ 72,988 |
| OTD 5.08.e.b (b) | 5.08.e.2ab Enhanced Material Tracking and Traceability-Development of Standardized Protocols/Identifiers for Meters, Regulators, and Transmission Pipelines, Phase 2 (TEJ) | 2008 | open | $ 6,749 | | $ 5,000 | $ 1,749 | |
| OTD 5.08.e.a (a ) | 5.08.e.a (a )Enhanced Material Tracking and Traceability Development of Standardized Protocols Identifiers For Meters and Regulators | 2008 | open | $ 5,000 | | | | |
| OTD 5.08.e.b (b) | 5.08.e.b (b) Enhanced Material Tracking and Traceability Development of Standardized Protocols Identifiers For Transmission Pipeline | 2008 | open | $ 30,916 | $ 7,916 | | | $ 30,916 |
| OTD 5.08.k Refund | 5.08.k Refund | | | | $ (287) | | | |
| OTD 5.08.l Refund | 5.08.l Refund | | | | $ (271) | | | |
| OTD 5.9c | Mitigating Elec. Interference on Cathodic Protection Systems | 2009 | 2012 | $ 80,522 | | | | $ 80,522 |
| OTD 5.09.f | CP Monitor Prototype Modification and Field Trials Phase 2 | 2009 | 2015 | $ 46,739 | $ 15,326 | $ 6,413 | | $ 25,000 |
| OTD 5.09.f Refund | 5.09.f Refund | | | | | | $ (546) | |
| OTD 5.09.h | 5.09.h North American Manufacturer Outreach | | | $ 1,893 | | | | $ 1,893 |
| OTD 5.9j | Gas Distribution Model | 2009 | 2012 | $ 103,600 | | | | $ 103,600 |
| OTD 5.9k | Low Impact Marking Study | 2009 | 2012 | $ 50,261 | | | | $ 50,261 |
| OTD 5.10.d.2 | 5.10.d.2 Remote Field QA/QC Phase 2 | 2010 | open | $ 73,450 | | $ 40,000 | $ 33,450 | |
| OTD 5.10.f Refund | 5.10.f Refund | | | $ (21,616) | $ (21,616) | | | |
| OTD 5.10.f | Cold Assisted Pipe Splitting (CAPS), Phase 1 | 2010 | 2012 | $ 46,615 | | | | $ 46,615 |
| OTD 5.10.g | Indoor Air Quality and Safety Issues | 2010 | open | $ 25,000 | | | | $ 25,000 |
| OTD 5.11.a | Dewatering Systems for Mains | 2011 | 2013 | $ 66,927 | | | $ 2,000 | $ 66,927 |
| 5.11.a Refund | 5.11.a Refund | | | | | | $ (229) | |
| OTD 5.11.m | Intelligent Utility Installation Process | 2011 | 2014 | $ 278,297 | $ 191,000 | $ 18,344 | | $ 68,953 |
| OTD 5.11.n | Quality Control Procedure for High Protential Anodes | 2011 | 2013 | $ 44,929 | $ 4,045 | | | $ 40,884 |
| OTD 5.11.n.2 | 5.11.n.2 Quality Control Procedure for High Potential Anodes – Phase 2 | 2011 | 2015 | $ 20,000 | $ 20,000 | | | |
| OTD 5.12.b | Development of a Portable Flash Fire Suppression System (PFFSS) | 2012 | 2014 | $ 34,430 | $ 14,430 | | | $ 20,000 |
| OTD 5.12.b.2 | 5.12.b.2 Development of a Portable Flash Fire Suppression System (PFFSS) Phase 2 | 2012 | open | $ 10,000 | | $ 10,000 | | |
| OTD 5.12.g | Large Diameter Medium Pressure Inflatable Stoppers Evaluation of Kleiss System for the U.S. Natural Gas Industry | 2012 | 2014 | $ 20,000 | $ 8,007 | | | $ 20,000 |

| PROJECT NUMBER | PROJECT | START DATE | END DATE | TOTAL NGRID COMMITMENT | TOTAL SPEND 2013 | TOTAL SPEND 2014 | TOTAL SPEND 2015 | TOTAL NGRID SPEND Joe YEARS |
|---|---|---|---|---|---|---|---|---|
| OTD 5.12.n | Advanced Tools for Improved AC Corrosion Prevention and Mitigation | 2012 | 2013 | $ 70,000 | $ 35,000 | | | $ 35,000 |
| OTD 5.12.o | Guidelines for Cast-Iron (CI) Winter Operations | 2012 | 2013 | $ 108,000 | $ 48,000 | | | $ 60,000 |
| OTD 5.12.o.2 | Assessment of Frost Impact on Cast Iron Pipes Phase 2 | 2012 | 2015 | $ 37,410 | | $ 37,410 | | |
| OTD 5.12.p | NG Appliance Immersion Study | 2012 | 2015 | $ 104,606 | $ 104,606 | | | |
| 5.12.p refund | 5.12.p Refund | 2012 | | | | | $ (5,722) | |
| OTD 5.13.c | PE Pipe Splitting Technical Evaluations, Enhancements, and Standardization of Tool Kits | 2013 | open | $ 30,000 | $ 30,000 | | | |
| OTD 5.13.d.2 | Transmission Cut In Valve Phase 2 | 2013 | open | $ 50,000 | | $ 25,000 | | |
| OTD 5.13.f | Low Cost Collision Avoidance System | 2013 | open | $ 18,338 | $ 10,000 | $ 8,338 | | |
| OTD 5.13.g | Post Disaster Risk Assessment with LiDAR and GIS | 2013 | open | $ 50,000 | $ 25,000 | $ 25,000 | | |
| OTD 5.14.a | RFID Testing Program | 2014 | open | $ 25,277 | | $ 15,000 | $ 10,277 | |
| OTD 5.14.b refund | 5.14.b Refund | 2014 | | $ (829) | | | $ (829) | |
| OTD 5.14.b | Smart Leak Repair Form | 2014 | open | $ 18,500 | | $ 18,500 | | |
| OTD 5.14.c | Improving Cybersecurity for LDCs-Needs Identification Workshop | 2014 | open | $ 5,000 | | $ 5,000 | | |
| OTD 5.14.d | Tracking and Traceability for Transmission Pipe Materials | 2014 | open | $ 15,000 | | $ 15,000 | | |
| OTD 5.14.d.2a | Tracking and Treaceability for Transmission-Phase 2a Standards for MTR and Coating Reports, Rev | 2014 | open | $ 19,141 | | $ 10,000 | $ 9,141 | |
| OTD 5.14.d.2b | Tracking and Treaceability for Transmission-Phase 2b Data Collection Technology, Rev | 2014 | open | $ 23,725 | | $ 10,000 | $ 9,091 | |
| OTD 5.14.f | Battery and Electric Powered Tool Evaluation Phase 1 | 2014 | 2015 | $ 20,000 | | $ 20,000 | | |
| OTD 5.14.j | Residual Gas Removal Identify Technologies Limitations Best Practices | 2014 | open | $ 15,000 | | $ 15,000 | | |
| OTD 5.14.n | Construction Compliance Monitoring System | 2014 | open | $ 29,234 | | $ 15,000 | $ 14,234 | |
| OTD 5.14.p | Pipe Insertion Technologies - Develop Devices to Use with Jameson Directional Insertion Tool | 2014 | open | $ 1,663 | | $ 1,000 | $ 663 | |
| OTD 5.14.t | Methods to Detect Inserted Plastic in Steel Mains | 2014 | 2015 | $ 11,909 | | $ 11,298 | $ 611 | |
| OTD 5.14.t Refund | 5.14.t Refund | 2014 | | $ (27) | | | $ (27) | |
| OTD 5.14.u | Evaluation of New Geospatial Technologies | 2014 | 2015 | $ 5,125 | | $ 5,000 | $ 125 | |
| OTD 5.14.u Refund | 5.14.u Refund | 2014 | | $ (1,221) | | | $ (1,221) | |
| OTD 5.14.w | Testing Program for Valve with Water Sensor for Storm Hardening | 2014 | open | $ 21,625 | | $ 21,625 | | |
| OTD 5.14.x | Atmospheric Corrosion / Leak Survey Considerations | 2014 | 2014 | $ 35,000 | | $ 35,000 | | |
| OTD 5.15.b | Roadmap for Enterprise Decision Support System | 2015 | open | $ 2,778 | | | $ 2,500 | |
| OTD 5.16.b | Alternative Caps for PE Service Tees Fusible Caps | 2016 | open | $ 5,620 | | | | |
| OTD 5.16.c | Piercing Tool Redevelopment Enhancement to Remove "Mole" from Small Excavations (12mo) | 2016 | open | $ 22,150 | | | | |
| OTD 5.16.d | Stopping Off LP Mains with No Excavation | 2016 | open | $ 19,982 | | | | |
| OTD 5.16.f | Improved Safe Excavation Productivity for Locating Buried Utilities | 2016 | open | $ 5,274 | | | | |
| OTD 5.16.g | Enhancement of the Dynamic Cone Penetrometer (DCP) Compaction Device | 2016 | open | $ 53,033 | | | | |
| OTD 6.a | Sustaining Membership Program - GTI (discontinued) | 2003 | 2012 | $ 152,000 | | | | $ 152,000 |
| OTD 6.6.a | Keyhole Consortium - GTI | 2006 | 2012 | $ 100,000 | $ 20,000 | | $ 20,000 | $ 60,000 |
| OTD 6.08.a | (GTI) Carbon Management Information Center | 2008 | ongoing | $ 65,000 | | $ 25,000 | $ 25,000 | |
| OTD 6.11.a | PRCI Membership | 2011 | 2015 | $ 10,000 | | $ 10,000 | | |
| OTD 6.13.a | Quantitative Risk Assessment Methodology Protocol for LNG Facilities Siting (AGA) | 2013 | open | $ - | $ (10,000) | $ 10,000 | | |
| OTD 6.14.a | Quality Audit Program | 2014 | open | $ 40,000 | | $ 20,000 | $ 20,000 | |
| OTD 7.8.a | Pipeline Quality Biomethane: Guidance Document for Landfill and Water Treatment Conversion | 2008 | 2012 | $ 65,990 | | | | $ 65,990 |
| OTD 7.9.c | Assessing Acceptable Siloxane Concentrations in Boimethane | 2009 | 2012 | $ 52,972 | | | | $ 52,972 |
| OTD 7.9.d and 7.10.c | Improving Methane Emission Estimates for NG Distribution Companies, Phase 1 and 2 | 2009 | 2014 | $ 67,674 | | | | $ 67,674 |
| OTD 7.10a | Trace Constituents in Natural Gas | 2010 | 2013 | $ 78,205 | | | | $ 78,205 |
| OTD 7.10.b | Odor Fade (GTI) | 2010 | 2014 | $ 36,940 | | | | $ 36,940 |
| OTD 7.10.b Refund | 7.10.b Refund | 2010 | | $ (1,570) | | | $ (1,570) | |
| OTD 7.10.b.2 | Odor Fade Phase 2 (GTI) | 2010 | 2014 | $ - | | $ (10,000) | $ 10,000 | |
| OTD 7.10.c Refund | 7.10.c Refund | 2010 | | | | | $ (43) | |
| OTD 7.10.c.2 | Improving Methane Emission Estimates for NG Distribution Companies, Phase 2 | 2010 | 2014 | $ 67,674 | | | | $ 67,674 |
| OTD 7.10.c.3 | Improving Methane Emission Estimates Phase III - Cast Iron and Unprotected Steel Pipes | 2010 | 2014 | $ 99,839 | $ 50,000 | $ 49,839 | | |
| OTD 7.10.c.4 | Improving Methane Emission Estimates for Natural Gas Distribution Companies Phase IV | 2010 | 2014 | $ 6,880 | | $ 5,000 | $ 1,880 | |
| OTD 7.11.a | Gas Quality Resource Center | 2011 | 2013 | $ 65,000 | $ 20,000 | $ 20,000 | | $ 25,000 |
| OTD 7.11.a.2 | Gas Quality Resource Center | 2011 | 2013 | $ 20,000 | | | $ 20,000 | |
| OTD 7.11.b | Trace Constituents Sensors | 2011 | 2014 | $ 27,610 | | | | $ 27,610 |
| OTD 7.14.a | Next Generation Water Clean-up Technology Phase 1 | 2014 | open | $ 25,000 | | $ 25,000 | | |
| OTD 7.15.a | Real Time Gas Quality Sensor | 2015 | open | $ 4,981 | | | $ 2,500 | |
| OTD 7.15.b.2 | Remote Gas Sensing and Monitoring Phase 2 | 2015 | open | 3000 | | | | |
| OTD 7.16.a | Leak Repair Prioritization | 2016 | open | 20110 | | | | |
| OTD 7.16.b | Evaluate Gas Imaging Technologies for LDC Applications | 2016 | open | 30000 | | | | |
| OTD 7.16.c | Secure Communication for Networked Gas Sensors | 2016 | open | 21302 | | | | |
| OTD 8.16.a | Intelligent Field Data Collection Platforms | 2016 | open | 19956 | | | | |
| OTD 8.16.b | Remote QA/QC: Fusion Inspection and Reporting | 2016 | open | 39441 | | | | |
| OTD 9.16.a | Determining Data Quality Implication | 2016 | open | 56224 | | | | |
| OTD 9.16.b | Establishing Risk Tolerance | 2016 | open | 25358 | | | | |
| | | | | $ 6,229,580 | $ 838,371 | $ 834,690 | $ 802,024 | $ 2,520,240 |
| T759 | Ergonomic Study to Develop New Needle Bar | 2005 | 2012 | $ 29,889 | | $ 557 | | $ 25,366 |
| T763 | Rock Impingement | 2007 | 2011 | $ 19,250 | | | | $ 21,100 |
| T764 | Auto Gas Lamp Evaluation | 2009 | 2012 | $ 27,500 | | $ 10,443 | | $ 10,314 |

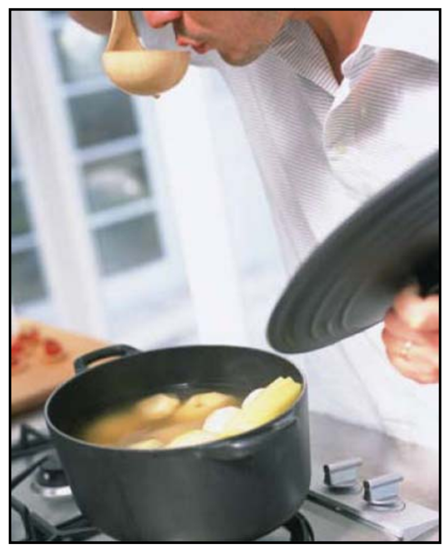
gti

the Energy to Lead

**TOPICAL REPORT**

GTI PROJECT NUMBER 20733

# National Grid Foodservice Market Assessment



**Report Issued:**
March, 2010

**Prepared For:**
National Grid

**GTI Technical Contact:**
Dr. Frank Johnson
Senior Engineer
End Use Solutions
847-768-0670
Fax: 847-768-0501
frank.johnson@gastechnology.org

**Gas Technology Institute**

1700 S. Mount Prospect Rd.
Des Plaines, Illinois 60018
www.gastechnology.org

## Disclaimer

*This information was prepared by Gas Technology Institute ("GTI") for National Grid.*

*Neither GTI, the members of GTI, National Grid, nor any person acting on behalf of any of them:*

*a. Makes any warranty or representation, express or implied with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights. Inasmuch as this project is experimental in nature, the technical information, results, or conclusions cannot be predicted. Conclusions and analysis of results by GTI represent GTI's opinion based on inferences from measurements and empirical relationships, which inferences and assumptions are not infallible, and with respect to which competent specialists may differ.*

*b. Assumes any liability with respect to the use of, or for any and all damages resulting from the use of, any information, apparatus, method, or process disclosed in this report; any other use of, or reliance on, this report by any third party is at the third party's sole risk.*

## TABLE OF CONTENTS

EXECUTIVE SUMMARY .......... 1
FOOD SERVICE INDUSTRY MARKET CHARACTERIZATION .......... 3
Product Drivers .......... 8
ENERGY USE AND NATURAL GAS V. ELECTRIC POSITIONING .......... 11
ENERGY EFFICIENCY PROGRAMS AND ENERGY STAR .......... 17
GAS INDUSTRY RD&D AND COMMERCIALIZATION .......... 22
Natural gas R&D .......... 22
Commercialization .......... 26
COMMERCIAL FOODSERVICE MARKET CHANNELS .......... 28
Commercial Foodservice Trade Associations .......... 28
National Restaurant Association .......... 28
The North American Association of Food Equipment Manufacturers (NAFEM) .......... 28
Foodservice Equipment Sales and Service Channels .......... 29
Market Channel Participant Interviews .......... 29
Phone Survey .......... 29
CONCLUSIONS .......... 32
REFERENCES .......... 34
APPENDIX A: MARKET SURVEY RESULTS .......... A-1
APPENDIX B: NATIONAL RESTAURANT ASSOCIATION DATA SHEETS .......... B-1
APPENDIX C: COMMERCIAL FOODSERVICE PUBLICATIONS .......... C-1

## LIST OF FIGURES

Figure 1: Foodservice Market Segmentation ........ 3
Figure 2: Commercial Sector Energy Intensity (DOE-EIA 2003 CBECS) ........ 5
Figure 3: Commercial Food Service Equipment Sales by Category (2006, $millions) ........ 8
Figure 4: Commercial Food Service Site Energy Use – Electric and Natural Gas ........ 12
Figure 5: Commercial Food Service Source Energy Use – Electric and Natural Gas ........ 13
Figure 6: Consumer Perceptions of Environmental Friendliness ........ 15
Figure 7: Product Development and Commercialization Process ........ 23
Figure 8: Piedmont Natural Gas Test Kitchen Profile (Source: GFEN, Spring 2009) ........ 27

## LIST OF TABLES

Table 1: Selected State Foodservice Data (2009) ........ 3
Table 2: 2010 Restaurant Sales and Segmentation ($Billions) ........ 4
Table 3: Restaurant Annual Sales Data (% of restaurants) ........ 5
Table 4: Top Seven Challenges for Foodservice Operators in 2008 ........ 6
Table 5: Commercial Foodservice Product Sales (2006, Source: Fryett) ........ 7
Table 6: Typical Restaurant Cost Stack ........ 11
Table 7: Restaurant Energy & Utility Costs by Restaurant Type (% of revenue) ........ 11
Table 8: Energy Costs By Sales Volume and Energy Costs Percent of Sales ........ 12
Table 9: National Electric and Gas Site Energy Use for Commercial Food Service ........ 13
Table 10: Natural Gas and Electric Strengths and Weaknesses ........ 14
Table 11: Comparison of Energy Costs in New York and Massachusetts ........ 14
Table 12: Restaurant Energy Cost and Consumption Comparisons in New York City and Boston ........ 15
Table 13: Natural Gas and Electric Opportunities and Threats ........ 16
Table 14: NRA Sustainability Survey – Planned Actions ........ 17
Table 15: Energy Efficiency Funding Comparison ........ 18
Table 16: CEE Qualifying Commercial Foodservice Products (2010) ........ 20
Table 17: Energy Star Availability Ratings for Commercial Food Service Equipment ........ 20
Table 18: Example UTD-Supported Commercial Foodservice Products ........ 23
Table 19: Supply Channel Actors ........ 29

# National Grid Foodservice Market Assessment

## Executive Summary

The commercial and institutional food service sector represents an important – **and growing** – market for the natural gas industry. According to the National Restaurant Association (NRA), there are approximately 525,000 commercial food service establishments nationwide with annual sales of $580 billion. Remarkably, nearly one in ten workers in the U.S. is a restaurant employee. The NRA indicates total U.S. commercial foodservice employment is 11.2 million – a substantial figure that is projected to grow to 14 million by 2020 (25 percent growth).

There are approximately 37,400 restaurants in New York with gross sales of $27.8 billion and over 672,000 employees. In Massachusetts, there are over 14,000 restaurants with annual sales of $11.8 billion and 304,000 employees. Rhode Island has nearly 2,700 restaurants with $1.8 billion in sales while New Hampshire has over 2,800 restaurants with annual sales of $2.1 billion. Together, this totals nearly 57,000 establishments with annual sales in excess of $43 billion. Using a nominal value of 3.4 percent of sales, commercial food service annual utility cost (electricity, natural gas, water, etc) exceed $1.4 billion in these four states and approach $20 billion nationally.

According to Energy Information Agency (EIA) survey data, commercial foodservice customers have 2.2 times the energy intensity (Btu/ft$^2$) of the average commercial customer. Audits conducted by Southern California Gas and Piedmont Gas found that natural gas sales to commercial foodservice customers account for 12 percent of the volume of gas sold, but comprise a healthy 19 percent of their profits.

In terms of new equipment, the estimated annual sales of new commercial foodservice equipment totaled about $1.2 billion in 2006. Of this, about 69 percent was natural gas-based products – indicating a strong market position for natural gas relative to electricity. The report provides further analysis of sales by product category and, an important consideration, the limited availability of Energy Star-rated natural gas products.

While a significant and growing market, there are continual threats and opportunities to assess within the commercial food service market segment. This project was undertaken to generate insights on the current gas foodservice market in National Grid's Northeastern United States market territory, with findings intended to guide a course of action for future RD&D and marketing initiatives within the foodservice arena. In addition to market and technology insights from GTI's experience and literature review, interviews were conducted with six foodservice consulting firms and equipment dealers within National Grid territories.

From this, the following observations, trends, opportunities, and threats are identified for the natural gas industry in the commercial foodservice marketplace:

- Natural gas market share is currently strong and holding against electric market share. New electric products; perceptions of electric as clean, simple, and reliable; and growing electric energy efficiency programs represent potential threats. There is also a market perception that electric equipment is more advanced or higher end than gas equipment, posing a significant threat.

- Natural gas is perceived as more cost-effective by users, with current electric-to-natural gas price ratios of 4.5:1 or higher. A typical restaurant is paying over twice as much annually for electricity than natural gas – underscoring the perception of natural gas as being cost effective.
- Rising labor, food, and energy costs are motivating foodservice providers to seek new and innovative equipment designs that could save operating costs through productivity improvements and speedier delivery.
- **Labor issues are a dominant factor in this sector** – major issues are obtaining and retaining quality workers, labor costs, and productivity. Increased labor turnover motivates foodservice providers to seek methods or equipment to improve the working environment for employees in terms of comfort, ease of equipment usage, and cleaning.
- Key purchase factors for new equipment include price, efficiency (operating costs), after-sales support, and productivity improvement. Equipment obsolescence and deterioration is typically the main reason to buy new equipment. With older gas equipment lasting for many years, added effort is required to convince users to purchase new equipment. Getting information to users about the cost and energy saving associated with new equipment is needed along with meaningful incentives from energy efficiency programs.
- There is a paucity of Energy Star recognized standards and, subsequently, natural gas products in the commercial foodservice sector. This can impact the ability to use utility energy efficiency program funds to incentivize the shift to higher-efficiency equipment.
- More investment is needed to develop advanced, energy efficient natural gas appliances that would satisfy current or future Energy Star labeling requirements.
- Trends toward healthier and/or more environmentally responsible eating habits can influence the market, but the economic benefits/effects are not fully understood by the industry.
- The industry is concerned about lower emissions standards (including $NO_x$ and particulates) – especially where such requirements have been imposed on residential appliances.
- Ventilation advancements represent an opportunity to increase energy efficiency and kitchen comfort and indoor air quality for workers. Improvements include demand ventilation systems.
- The green movement is a threat to natural gas. Consumer surveys show that electric is perceived as being more green, possibly due to the site-based efficiency claims. There is an opportunity to position new gas equipment as green through consumer education - identifying the financial, source energy, and environmental benefits.

## Food Service Industry Market Characterization

The food service industry is a growing and diverse segment of the commercial market. Figure 1 shows the major segments of this estimated $580 billion industry, including "eating places" (i.e., various types of restaurants), vending & recreation, non-commercial (i.e., institutional), managed services, lodging, as well as bars & taverns.

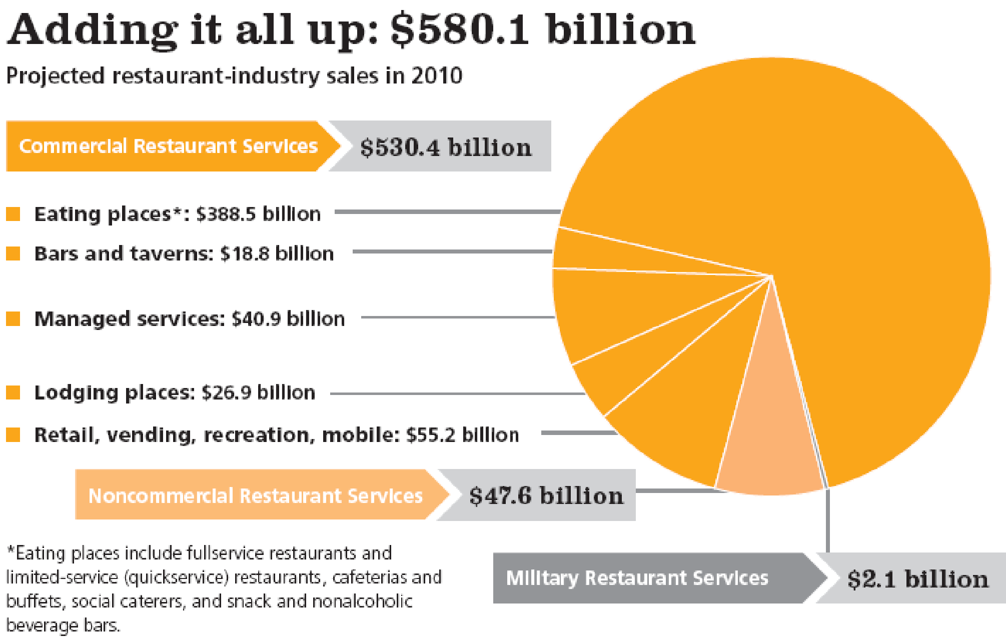



**Figure 1: Foodservice Market Segmentation**

(Source: NRA 2010 Restaurant Industry Forecast)

There are approximately 525,000 foodservice establishments across the country. State-level characteristics on four key states – New York, Massachusetts, Rhode Island, and New Hampshire – are shown in Table 1, with additional state profile data from the National Restaurant Association included in the appendix to this report. These four states include 56,900 commercial foodservice locations with annual sales in excess of $43 billion.

**Table 1: Selected State Foodservice Data (2009)**

| Sales Volume | Foodservice Establishments | Annual Sales ($Million) | Employment |
|---|---|---|---|
| **New York** | 37,400 | $27,800 | 672,000 |
| **Massachusetts** | 14,000 | $11,800 | 304,000 |
| **New Hampshire** | 2,800 | $2,100 | 61,200 |
| **Rhode Island** | 2,700 | $1,800 | 51,900 |

Source: National Restaurant Association

The foodservice market can be further broken down into major and niche segments (Table 2). Eating places are dominated by full-service restaurants – around $184 billion -- and limited-service (or quick-service) restaurants at over $165 billion. Together, these two groupings comprise 60 percent of the foodservice market. Beyond this are a number of smaller market niches, including institutions such as hospitals, schools, and universities.

**Table 2: 2010 Restaurant Sales and Segmentation ($Billions)**

| GROUP I COMMERCIAL RESTAURANT SERVICES | 2010 Sales | Growth? |
|---|---|---|
| EATING PLACES | | |
| Full-service restaurants | $184.176 | |
| Limited-service (quick-service) restaurants | $164.837 | ☑ |
| Cafeterias, grill-buffets and buffets | $7.671 | |
| Social caterers | $7.090 | ☑ |
| Snack and nonalcoholic beverage bars | $24.736 | |
| TOTAL EATING PLACES | **$388.510** | |
| Bars and taverns | $18.844 | |
| TOTAL EATING-AND-DRINKING PLACES | **$407.354** | |
| MANAGED SERVICES | | |
| Manufacturing and commercial offices | $9.218 | |
| Hospitals and nursing homes | $5.053 | ☑ |
| Colleges and universities | $13.649 | ☑ |
| Primary and secondary schools | $5.863 | ☑ |
| In-transit restaurant services (airlines) | $2.061 | |
| Recreation and sports centers | $5.025 | ☑ |
| TOTAL MANAGED SERVICES | **$40.869** | |
| Lodging Places | $26.943 | ☑ |
| Retail-host restaurants | $30.936 | ☑ |
| Recreation and sports | $12.518 | |
| Mobile caterers | $0.635 | |
| Vending and Non-store retailers | $11.097 | |
| TOTAL — GROUP I | **$530.352** | |
| GROUP II NONCOMMERCIAL RESTAURANT SERVICES | | |
| Employee restaurant services | $0.426 | |
| Public and parochial elementary, secondary schools | $6.144 | |
| Colleges and universities | $6.083 | |
| Transportation | $1.830 | ☑ |
| Hospitals | $15.225 | ☑ |
| Nursing homes, homes for orphans, disabled | $7.145 | ☑ |
| Clubs, sporting, recreational camps, community centers | $10.694 | |
| TOTAL — GROUP II | **$47.547** | |
| GROUP III MILITARY RESTAURANT SERVICES | $2.161 | ☑ |
| GRAND TOTAL | **$580.060** | |

Source: NRA 2010 Restaurant Industry Forecast

Schools, universities, hospitals are addressed using either in-house foodservice (non-commercial) and by "managed services" such as foodservice contractors. For example, the total university segment includes a non-commercial component of over $6.1 billion and a managed services component of about $13.6 billion (which is growing faster than the non-commercial segment). Managed service providers could be an attractive point for targeted marketing by National Grid.

Restaurants have a wide level of variability in their size and operations. Table 3 shows a breakdown of annual sales volumes based on average check cost. More than half of restaurants do more than $1 million annually in sales, with nearly one quarter being greater than $2 million. Not surprisingly, sales volume tends upward with higher average check businesses.

**Table 3: Restaurant Annual Sales Data (% of restaurants)**

| Sales Volume | Average Check <$15 | Average Check $15-25 | Average Check >$25 |
|---|---|---|---|
| **<$500K** | 19.3% | 9.6% | 12.3% |
| **$500K-$1000K** | 25.5% | 30.7% | 15.8% |
| **$1000-$2000K** | 31.7% | 33.3% | 31.0% |
| **>$2000K** | 23.5% | 26.4% | 40.9% |

Source: NRA and Deloitte, Restaurant Industry Operations Report (2006/2007 Edition)

Most restaurants are either owned by a private corporation (around 60-65 percent), sole proprietorship, or partnership (the latter two each being about 15-20 percent of the market). This ownership structure is true of those restaurants which are tied to a major public corporation. For example, an estimated 85 percent of McDonald's restaurants are owned and operated by franchisees or private joint ventures.

The food service industry is attractive because, on a per square foot basis, it uses much more energy than most other commercial buildings (Figure 2). Food service establishments use 2.2 times the energy per square foot of the typical commercial building (258 versus 116 kBtu/ft$^2$) and have the highest energy intensity in the commercial building sector.

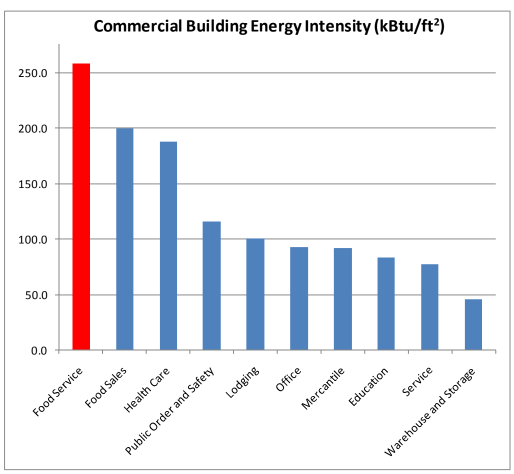



**Figure 2: Commercial Sector Energy Intensity (DOE-EIA 2003 CBECS)**

As evidenced by the relative energy intensity of foodservice establishments, energy is cited as one of several key factors of concern to food service operators. The following table shows results from the National Restaurant Association survey on key challenges perceived by full-service restaurant operators. Energy typically falls in the range of the top 5-6 areas of concern – and varies somewhat depending on the type of restaurant.

### Table 4: Top Seven Challenges for Foodservice Operators in 2008

| | Tableservice Segment | | |
|---|---|---|---|
| | Family Dining | Casual Dining | Fine Dining |
| Recruiting and retaining employees | 17% | 23% | 14% |
| Building and maintaining sales volume | 12 | 11 | 22 |
| The economy | 13 | 13 | 17 |
| Competition | 17 | 6 | 13 |
| Labor costs | 11 | 10 | 10 |
| Gas and energy costs | 11 | 8 | 5 |
| Food costs | 7 | 10 | 3 |

Source: National Restaurant Association, 2007 Tableservice Operator Survey

The National Restaurant Association estimates that 49 percent of consumer spending on food is expended in the foodservice sector (the balance being food bought in grocery stores and consumed at home). This compares to only 25 percent of the consumer spending in 1955. Forty-four percent of consumers say that restaurants are an essential part of their lifestyle, with over 40 percent saying they are more productive eating at restaurants or using take-out or delivery foodservice.

This long-term demographic shift, where consumers are increasingly spending their food dollars in restaurants, presents an opportunity and a threat for the natural gas industry. With less food prepared at the home, there is a threat to natural gas sales to the residential sector and potential for displacement with electro-technologies in the home (e.g., microwaves and radiant or inductive heating). However, if a strong position for natural gas can be retained in restaurants, the net effect should be minimal.

The lifestyle elements of food and eating are evident. Sixty-five percent of consumers say their favorite restaurant foods provide flavor and taste sensations they cannot easily duplicate at home. One element to consider, however, is the growing popularity of at-home cooking shows on television featuring a plethora of celebrity chefs – and a dedicated cable station, The Food Network – along with growing enrollment in culinary schools (which includes those pursuing a career as well as for personal enjoyment and development).

> "At the Culinary Institute of America in Hyde Park, N.Y., administrators increased their five-day, $2,095 "Basic Training" boot camp to 14 classes a year, up from 10 three years ago. The Whole Foods in the Soho neighborhood of New York City saw enrollment in the store's cooking classes increase 46% between 2009 and 2008, says a company spokeswoman."
> **Source: Wall Street Journal, Cutting Costs at Culinary School (Aug, 12, 2009)**

Tying natural gas into the lifestyle elements of culinary arts is an important branding consideration for the natural gas industry. As will be highlighted, natural gas has certain positive branding factors, but can face strong competition from newer electro-technologies that may be perceived as cleaner, more high tech, cleaner, greener, or safer. Tapping into culinary arts schools or collaborating with celebrity chefs to expose them to the latest natural gas commercial foodservice products could be an effective marketing approach.

Generally, natural gas has a strong position in the commercial foodservice segment. Table 5 and Figure 3 provide a snapshot view of natural gas and electric product sales. In several product categories – for example, ranges, convection ovens, and conveyor ovens – natural gas is the clear market leader. Leading electric product categories include: fryers, convection ovens, combi-ovens, and free-standing steamers. There are two categories where electric products have over 50 percent market share – counter-top steamers and combi-ovens. The rightmost column highlights product categories that are currently being addressed by UTD or SMP funded R&D efforts.

**Table 5: Commercial Foodservice Product Sales (2006, Source: Fryett)**

| Equipment Category | Total Sales ($MM) | Gas Sales ($MM) | Gas Share (%) | Electric Sales ($MM) | UTD/SMP/ Projects |
|---|---|---|---|---|---|
| Underfired Broilers | $9.8 | $9.8 | 100% | $- | |
| Pizza / Deck Ovens | $18.0 | $18.0 | 100% | $- | ☑ |
| Wok Ranges | $30.0 | $30.0 | 100% | $- | ☑ |
| Steamers - Pressure | $9.0 | $8.0 | 89% | $1.0 | |
| Charbroilers | $17.4 | $15.0 | 86% | $2.4 | |
| Ranges | $175.6 | **$146.5** | 83% | $29.1 | ☑ |
| Conveyor Broilers | $35.0 | $29.0 | 83% | $6.0 | |
| Conventional Ovens | $15.0 | $12.0 | 80% | $3.0 | |
| Conveyer Ovens | $93.9 | **$72.5** | 77% | $21.4 | ☑ |
| Rotisserie Ovens | $34.4 | $26.5 | 77% | $7.9 | |
| Griddles | $46.5 | $35.0 | 75% | $11.5 | |
| Pressure Fryers | $61.9 | $46.5 | 75% | $15.4 | |
| Fryers | $247.2 | **$175.0** | 71% | **$72.2** | ☑ |
| Over-fired Broilers | $36.8 | $24.1 | 65% | $12.7 | ☑ |
| Convection Ovens | $135.9 | **$77.4** | 57% | **$58.5** | ☑ |
| Steamers - Free-Standing | $68.0 | $38.0 | 56% | **$30.0** | |
| Tilting Skillets | $46.3 | $24.0 | 52% | $22.3 | |
| Combi Ovens | $100.0 | $46.0 | 46% | **$54.0** | |
| Steamers - Counter-Top | $39.5 | $9.9 | 25% | $29.6 | |
| **Total** | **$1,220.2** | **$843.2** | | **$377.0** | |
| **% of Total** | | **69.1%** | | **30.9%** | |

Fryers are a key market retention product for the natural gas industry due to the size of the market. While holding a 71 percent market share in 2006, this segment is threatened by electric products – especially with the recent shift to low oil volume fryers. This segment represents the highest dollar volume sales category for electric products. Also, for low oil volume fryers, electric units were developed and field tested one year before gas-fired models because of the extra development time required to design gas-fired burners. This situation places natural gas models of popular natural gas foodservice equipment at risk in terms of timing of commercial introduction or – in the most extreme cases – may be dropped from the product line-up if manufacturers do not see the benefit/cost of investing in a gas offering.

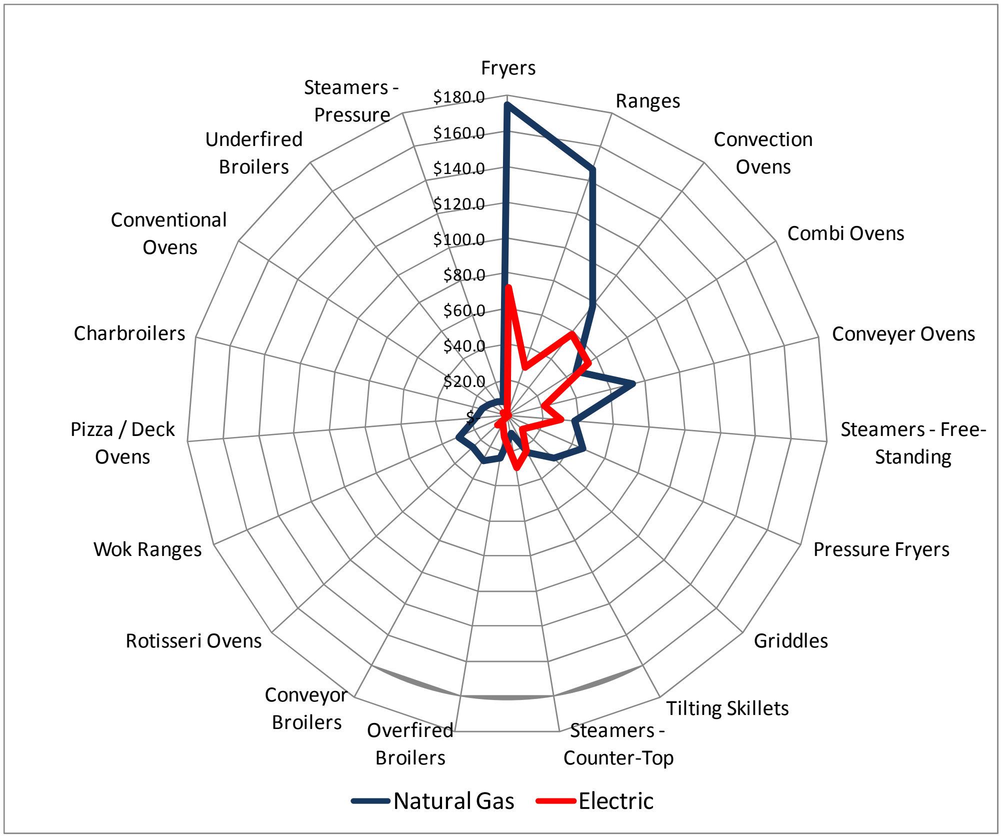



**Figure 3: Commercial Food Service Equipment Sales by Category (2006, $millions)**

## Product Drivers

Historically, the demand for new or healthy food products has driven the foodservice industry to develop new and innovative technologies and equipment. An example is what could be called the "Boston Market" effect during the early 1990's. The popularity of roasted chicken grew tremendously with the initial Boston Market restaurants, leading several other restaurants – including existing chains – to add roasted chicken to their menus. This also led several manufacturers to develop rotisserie ovens for cooking chicken. Another example is the rapid increase in bagel preparation equipment that was spawned by the increasing popularity of bagels several years ago.

A current driver in the foodservice industry is the removing or banning of trans-fat oils by several restaurant chains or metropolitan areas. Trans-fats, present in many deep-frying oils, are linked to unhealthy levels of cholesterol levels -- a fact that has received considerable media exposure. For this reason, partially hydrogenated oils and trans-fat oils are the subject of growing scrutiny from public health officials and health-conscious consumers. By mid 2008, cities such as New York and others passed legislation to ban or tightly control the use of trans-fat oils in any public restaurant. Restaurant chains including McDonald's, Arbys and KFC have either discussed or are eliminating trans-fat oil from their menu items. The main issue with using trans-fat free oils is not availability; they are widely available, but cost more and have a different taste. In response to this, restaurants looked to the foodservice industry and manufacturers for solutions. One result was the development of low oil volume fryers by manufacturers including Frymaster, Pitco and Henny Penny. Low oil volume fryers address the increased cost of the non trans-fat oils by using less oil than standard fryers, 30 to 35 pounds of oil compared to over 50 pounds. The savings is realized by throwing away less oil during each oil change. Oil savings are also realized by improved filtering methods in some of the low oil volume fryers that increase the useful life of the oil.

Rethermalization is an area of potential market change. The concept behind rethermalizing is to use either vendor-prepared or commissary-made food products in place of "from scratch" cooking. In addition to helping restaurants address high demand periods, this can result in labor savings, energy savings, improved consistency, and potentially improved food safety.

In this process, large batch cooking is employed to make a product (e.g., soup) that is quickly chilled and placed into multiple vacuum-sealed bags of food. This is also referred to as the *sous vide* process. Vacuum sealing helps to keep out harmful pathogens while retaining flavor and aroma.

The rethermalization process at the restaurant involves reheating the product – typically with lower temperatures and considerably less time than would be required by cooking from scratch. As noted earlier, labor is a major cost and operations issue for restaurants. Using rethermlized food can reduce restaurant labor costs and – to some extent – the quality of labor needed (compared to cooking from scratch).

> "From the standpoint of equipment, in some cases we may be headed for the **fireless kitchen** without pots or pans. This also would reduce, or in some cases even eliminate, exhaust requirements of many professional kitchens."
> **Source: "Rethermalize it," Nation's Restaurant News, Oct. 8, 2007.**

Rethermalizing is an area that could represent a threat or opportunity for the natural gas industry. A shift towards a "fireless" kitchen – one that mainly uses electricity for reheating pre-cooked products – is clearly a potential threat.

Ventilation is both an area of opportunity and concern for the restaurant operator and the natural gas industry. Employee turnover is very high in the restaurant industry; in some segments, the turnover rate is 200 percent. This puts additional costs on the restaurant through training and absenteeism costs.

By making the kitchen a more comfortable workplace through advanced ventilation practices and safer cooler equipment surfaces, employee turnover rates may be reduced. Ventilation issues also impact energy use (heating, cooling, fan power, etc) and indoor air quality in the kitchen environment. There are also fire safety consideration with ventilation systems and cleaning of grease to prevent fires.

Kitchen ventilation is an opportunity for improved comfort and energy savings. In most kitchens, exhaust fans will run at a constant speed throughout the day. This can impact space conditioning loads along with fan energy requirements. Opportunities for improvement include using demand ventilation approaches that can modulate fan speed depending on work conditions.

New emission standards have driven the development of new appliances in the residential/commercial markets at different times in the past few decades. Lower emissions requirements in California on residential water heaters led to the development of new combustion systems for all water heaters currently sold in the state. Establishing $NO_x$ emission levels on residential furnaces by the South Coast Air Quality Management District led to the development of new furnace designs and combustion systems. While new emissions legislation is usually more focused on residential appliances, new $NO_x$ emission standards are being considered for commercial cooking equipment in California. Agencies in California are also proposing new limits on the particulate emissions from charbroilers. Particulate emissions and grease build-up in ventilation systems is a serious issue for restaurants. GTI is currently working with the gas industry and manufacturers to explore options to address these environmental and restaurant workplace issues.

## Energy Use and Natural Gas v. Electric Positioning

Table 6 provides a breakdown of typical costs and pre-tax profits in the restaurant business. The dominant cost factors are food and beverage, followed by salaries and benefits. Labor-related issues – controlling labor costs, employee retention, increasing productivity – are key concerns for restaurant operators (as noted in Table 4). The other item of note is that most restaurants have relatively modest income before taxes – around 4 percent. Reducing costs even one percent can translate into a 20-30 percent relative increase in profits.

**Table 6: Typical Restaurant Cost Stack**

| | |
|---|---|
| Food & Beverage | 32% |
| Salaries & Benefits | 34% |
| Occupancy | 7% |
| General & Administrative | 3% |
| Other | 20% |
| Income Before Taxes | 4% |
| Total: | 100% |

Source: NRA and Deloitte, Restaurant Industry Operations Report (2006/2007 Edition)

Generally, restaurants are a tight margin business with many competitors, as evidenced by the substantial number of outlets across the U.S. (525,000). Restaurants typically go through dynamic cycles of birth and death for a variety of reasons. Statistics indicate that one in four restaurants fail in the first year, with nearly 60 percent failing within three years.

The “other” category in Table 6 includes energy and other “utility” costs such as water. The importance of energy and other utility costs will vary depending on the restaurant type and sales volume. Table 7 illustrates the relative importance of utility costs depending on the restaurant type (using average check size as a differentiator). The relative impact of energy costs generally increases as the average check size goes down.

**Table 7: Restaurant Energy & Utility Costs by Restaurant Type (% of revenue)**

| | Average Check <$15 | Average Check $15-25 | Average Check >$25 |
|---|---|---|---|
| Lower Quartile | 2.7% | 2.5% | 1.9% |
| Median | 3.7% | 3.4% | 2.7% |
| Upper Quartile | 4.9% | 4.5% | 3.8% |

Source: NRA and Deloitte, Restaurant Industry Operations Report (2006/2007 Edition)

Table 8 provides an estimate of annual energy costs for an example restaurant as a function of annual sales and the percent of total sales allocated for energy and related utility costs. Using a typical restaurant sale volume of $1-1.5 million annually and energy costs of 3.4 percent of sales, annual energy costs for a nominal restaurant is in the range of $34-50,000. This value will likely be in the range of $50,000-$100,000 for higher sales volume stores.

**Table 8: Energy Costs By Sales Volume and Energy Costs Percent of Sales**

| Energy Cost % Sales ➔<br>Annual Sales ⬇ | 2.5% | 3.0% | 3.5% | 4.0% | 4.5% |
|---|---|---|---|---|---|
| **$500,000** | $12,500 | $15,000 | $17,500 | $20,000 | $22,500 |
| **$1,000,000** | $25,000 | $30,000 | $35,000 | $40,000 | $45,000 |
| **$1,500,000** | $37,500 | $45,000 | $52,500 | $60,000 | $67,500 |
| **$2,500,000** | $62,500 | $75,000 | $87,500 | $100,000 | $112,500 |

As noted, commercial food service establishments are attractive because they use considerably more energy (per square foot) than other commercial buildings and tend to contribute more to natural gas profits. The higher energy intensity is due to their process activities such as food storage (e.g., refrigeration), food preparation (e.g., cooking), and sanitation (e.g., cleaning dinnerware).

Figure 4 and Table 9 show DOE-EIA estimates of site electric and natural gas use in all foodservice buildings in the U.S. (based on the 2003 Commercial Buildings Energy Consumption Survey). Electricity and natural gas are the primary energy options used in the commercial food service sector, with electricity being about 70 percent of total energy costs. Equivalent electric use is about 217 trillion Btu (63 billion kWh) and 203 trillion Btu for natural gas.

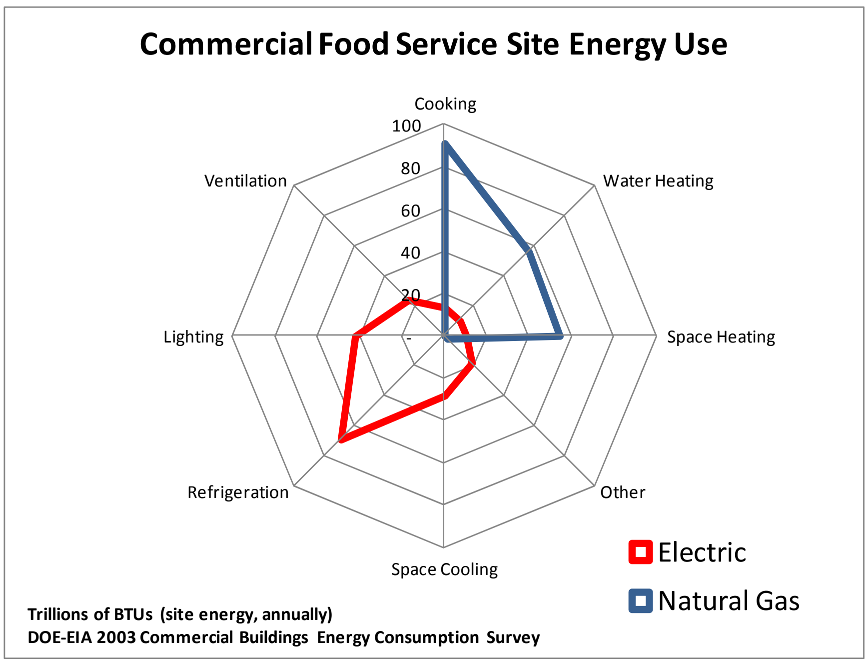



**Figure 4: Commercial Food Service Site Energy Use – Electric and Natural Gas**

The use of each of these two energy choices is highly differentiated, with most electricity used for refrigeration, space conditioning, lighting and ventilation. Natural gas is predominantly used for cooking, water heating, and space heating – holding over 80 percent share across the market. Retaining this market position against electric technologies should be a primary consideration for the natural gas industry.

**Table 9: National Electric and Gas Site Energy Use for Commercial Food Service**

| | Electric | Natural Gas | % Gas |
|---|---|---|---|
| Cooking | 13.6 | 91.0 | 87% |
| Water Heating | 10.2 | 56.0 | 85% |
| Space Heating | 10.2 | 54.0 | 84% |
| Other | 18.1 | 2.0 | N/A |
| Space Cooling | 28.2 | - | N/A |
| Refrigeration | 69.5 | - | N/A |
| Lighting | 42.4 | - | N/A |
| Ventilation | 24.3 | - | N/A |

Source: DOE-EIA 2003 Commercial Buildings Energy Consumption Survey (Trillion Btu)

There is a substantial amount of energy consumed to produce and deliver electricity. The total source to site energy lost is often more than twice the amount of electric energy used onsite. DOE-EIA data indicate that total energy consumption for electricity in commercial foodservice is about 650 trillion on a complete source to use basis (compared to about 215 trillion Btu on a site-only basis). Figure 5 illustrates the substantial differences in total source energy use compared to a site-only basis. For example, refrigeration loads use slightly less energy on a site basis, but are more than two times more in energy consumption on a source basis.

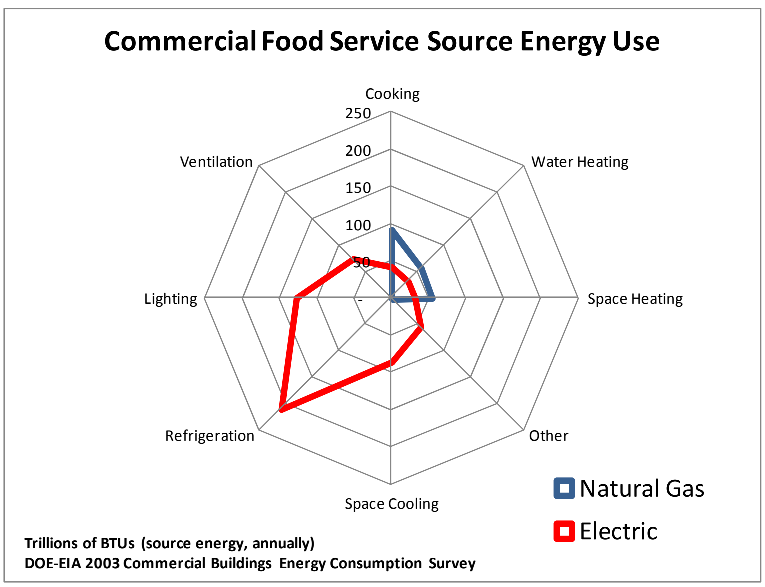



**Figure 5: Commercial Food Service Source Energy Use – Electric and Natural Gas**

The substantial differences in site versus source energy values can be an important factor when companies look at “green building” issues such as LEED compliance. Unfortunately, there has been a reluctance in some of these codes to recognize total source energy as a more complete and responsible measurement of national energy use.

Natural gas and electricity -- and the industries that represent them – have perceived strengths and weaknesses. The following table highlights some of these considerations.

**Table 10: Natural Gas and Electric Strengths and Weaknesses**

| | Strengths | Weaknesses |
|---|---|---|
| **Natural Gas** | • Perceived as lowest life-cycle and operating cost options for end users<br>• High energy rates with rapid response to changes in burner setting<br>• High delivered energy density compared to electric.<br>• Source energy and carbon emission advantages over electricity | • Less technologically advanced (e.g., manual controls, pilot lights)<br>• Perception in some cases as being less safe than electric products<br>• Manufacturers lack gas expertise or motivation to invest in state-of-the-art gas technology (e.g., indifferent on gas vs electric)<br>• Perceived limited gas industry marketing focus in this segment<br>• Lack of gas combustion engineers and burner design experts. Old designs tend to be reused |
| **Electric** | • Seen as cleaner, more technologically advanced<br>• Perceived as safer than natural gas<br>• Products are viewed as more reliable<br>• Typically lower first cost equipment<br>• Many 'green' building codes based upon site rather than total source energy | • Higher electric operating costs (energy and power demand)<br>• Utility pressure to manage peak demand, control costs, ensure reliability<br>• Typically higher source energy and emission factors (on a full-fuel-cycle basis)<br>• Limited availability in some locations to add amperage or install higher voltage outlets needed for resistance heating |

Operating costs are an important factor in the commercial food service sector. Survey data indicates that users perceive natural gas as a better value in terms of annual energy costs. The following table compares typical commercial natural gas and electricity prices in New York and Boston for commercial customers (Source: DOE-EIA, Oct. 2009 data).

**Table 11: Comparison of Energy Costs in New York and Massachusetts**

| | Natural Gas | Electric | Electric/Gas Ratio |
|---|---|---|---|
| **New York** | \$10.46/mcf<br>(\$10.25/MMBtu) | \$0.1568/kWh<br>(\$45.93/MMBtu) | 4.5:1 |
| **Massachusetts** | \$11.38/mcf<br>(\$11.16/MMBtu) | \$0.1912/kWh<br>(\$56.00/MMBtu) | 5.0:1 |

Using information from GTI's Building Energy Analyzer, the following table breaks down annual energy characteristics and energy costs for a typical 5,000 sq. ft. national chain casual full-service restaurant. This highlights the energy value provided by natural gas relative to electricity. Commercial food service establishments are paying monthly bills for electricity that are more than double their natural gas bills. This disparity likely helps underscore the consumer perceptions of natural gas being a better value – or, conversely, they are paying too much for electricity.

**Table 12: Restaurant Energy Cost and Consumption Comparisons in New York City and Boston**

| | Natural Gas | Electric | Electric/Gas Energy Ratio | Electric/Gas $ Sales Ratio |
|---|---|---|---|---|
| **New York, NY** | Site Energy<br>3,087 MMBtu<br>Source Energy<br>3,358 MMBtu<br>Cost: $31,640 | Site Energy<br>427,000 kWh; 89 kW<br>Source Energy<br>4,239 MMBtu<br>Cost: $66,950 | 0.47:1<br>(site)<br>1.26:1 (source) | 2.1:1 |
| **Boston, MA** | Site Energy<br>3,238 MMBtu<br>Source Energy<br>3,552 MMBtu<br>Cost: $36,140 | Site Energy<br>420,000 kWh; 87 kW<br>Source Energy<br>4,383 MMBtu<br>Cost: $80,300 | 0.44:1<br>(site)<br>1.23:1 (source) | 2.2:1 |

Note: Source emission factor of 2.91 for NY electricity, 3.06 for MA electricity, 1.088 for natural gas (Source: GTI)

The Northeast market may see further absolute and relative improvement in natural gas prices and electric/gas price ratios due to the substantial new natural gas supplies being developed in the Marcellus Shale region in Pennsylvania, New York. **The combined impact of expanding supplies coupled with market proximity (i.e., reduced transmission costs) is likely to further enhance the competitive position of natural gas in this market sector**.

As noted, there can be substantial differences between natural gas and electricity from an environmental perspective depending on whether you compare site or source (total) emissions. This is a relevant factor to highlight with respect to consumer awareness of energy, environmental, and sustainability concerns. Surveys indicate that consumers perceive electricity as being “more green” than natural gas (Figure 6) – even though natural gas emits lower greenhouse gases than electricity on a total energy basis.

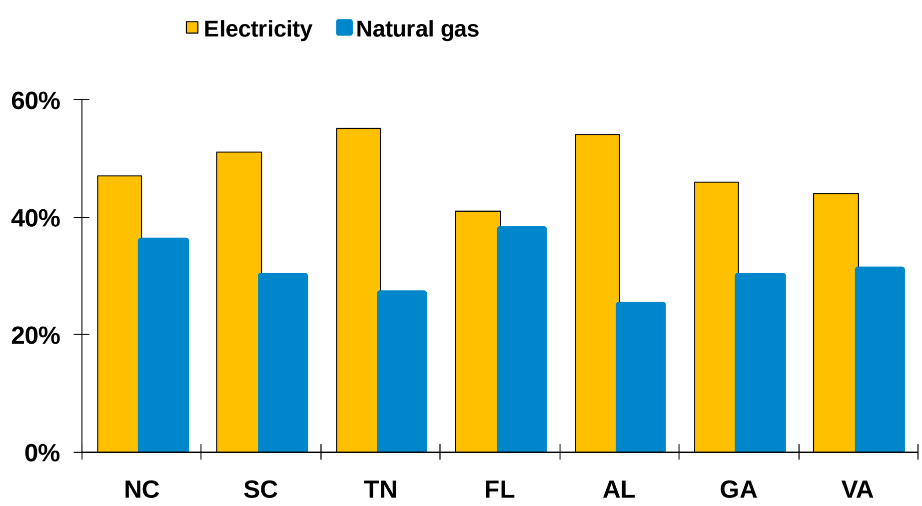



**Figure 6: Consumer Perceptions of Environmental Friendliness**

(Source: Council for Responsible Energy, 2007 data)

The natural gas industry is striving to elevate the source-to-site (or full fuel cycle) energy and environmental benefits of natural gas compared to electricity. Conveying this message to various stakeholders – individual consumers, businesses, and policymakers – is important. Decision makers in the commercial foodservice industry can also include architects, consulting engineers, and others – particularly those who are positioned in areas associated with "green buildings" (e.g., LEED-certified personnel).

There are market factors – opportunities and threats in the competitive marketplace -- that can influence the relative strengths and weaknesses of natural gas and electric now and in the future. The following is a summary of some of these factors that may impact natural gas and electric products and the customer's willingness to continue using or when purchasing new commercial food service products.

**Table 13: Natural Gas and Electric Opportunities and Threats**

| | Opportunities | Threats |
|---|---|---|
| Natural Gas | • Developing state-of the-art natural gas products (e.g., pilotless ignition, new sensors and controls,<br>• Smart technology that enhances control and communications<br>• Features that increase productivity, product quality<br>• Expanding the number of products recognized as Energy Star compliant<br>• Utility marketing, outreach and incentive programs (e.g., test kitchens, live cooking demonstrations, incentives for high-efficiency products)<br>• Marketing outdoor cooking and outdoor seating with gas heating to restaurants<br>• Potential improved positioning of natural gas prices relative to electricity<br>• Enhancing customer and policymaker awareness of source energy and environmental benefits | • Lower number of Energy Star appliances compared to electric<br>• Reduced opportunity for customers to benefit from energy efficiency incentives (and potential switching to electric)<br>• Larger and/or more aggressive electric utility marketing and incentive programs (7-10:1 greater energy efficiency funding)<br>• Reduced level of skill and expertise among small to medium manufacturers – particularly with respect to natural gas technology<br>• Tightening emission standards (e.g., NOx, particulates)<br>• Higher cost and complexity of ventilation and interior piping systems<br>• Bias in certain Green Building Codes towards site energy and "clean" electric |
| Electric | • Rethermalizing and similar trends that could reduce kitchen energy intensity and potentially favor all-electric kitchens<br>• Advanced cooking techniques such as induction cooking<br>• Smart technology that enhances controls and communications Leveraging green building codes that favor site energy | • Increasing electricity prices due to increasing cost of new power plants and added environmental costs to reduce carbon emissions<br>• Concerns over peak electric demand and electricity supply reliability<br>• Use of source energy in place of site energy for green building codes and energy efficiency metrics |

## Energy Efficiency Programs and Energy Star

Energy efficiency and sustainability are key concepts that resonate with restaurant and food service operators. Their tight operating margins provide an incentive to reduce fixed and variable energy costs. The following table from the NRA 2010 Restaurant Industry Forecast outlines steps taken in 2009 and plans for 2010 relative to energy savings and other resource conservation investments. These data indicate a higher inclination towards electricity savings steps (e.g., lights, air conditioning, refrigeration) followed by investments in energy-saving kitchen equipment. Water savings are generally lower priority resource conservation steps.

**Table 14: NRA Sustainability Survey – Planned Actions**

**Sustainability steps**

*Proportion of restaurant operators, by type of operation, who took the following energy-saving actions in 2009 or who plan to in 2010*

| | Family dining | | Casual dining | | Fine dining | | Quickservice | |
|---|---|---|---|---|---|---|---|---|
| | Did in 2009 | Plan to in 2010 | Did in 2009 | Plan to in 2010 | Did in 2009 | Plan to in 2010 | Did in 2009 | Plan to in 2010 |
| Purchased energy-saving light fixtures | 69% | 41% | 66% | 46% | 52% | 38% | 43% | 32% |
| Purchased energy-saving kitchen equipment | 45% | 34% | 41% | 34% | 28% | 32% | 34% | 31% |
| Purchased energy-saving refrigeration, air conditioning or heating systems | 50% | 32% | 40% | 28% | 34% | 27% | 32% | 30% |
| Installed water-saving equipment and/or fixtures | 27% | 26% | 27% | 23% | 27% | 24% | 23% | 23% |

The somewhat greater leaning toward electric savings may reflect the reality that annual electricity costs are likely to be twice as high as natural gas costs – that is, electricity provides greater opportunity for savings.

Other factors to consider are:

- The availability of Energy Star and other high-efficiency equipment
- The availability of rebates, tax credits, and other incentives that may enhance the buying decision process for the consumer

For example, electric and natural gas energy efficiency programs have grown considerably in recent years. These programs can provide meaningful incentives for the purchase of new high-efficiency equipment. Historically, this funding has primarily been directed at electricity consumers, with a more recent trend of funding for natural gas.

According to the Consortium for Energy Efficiency, in 2009 approximately $4.4 billion million was invested in electric energy efficiency and $930 million in natural gas energy efficiency programs across the US. The following table breaks down state-level natural gas and electric energy efficiency program funds (including demand response) directed at the commercial and industrial sector in 2009 by CEE.

**Table 15: Energy Efficiency Funding Comparison (Source: CEE, 2009 data)**

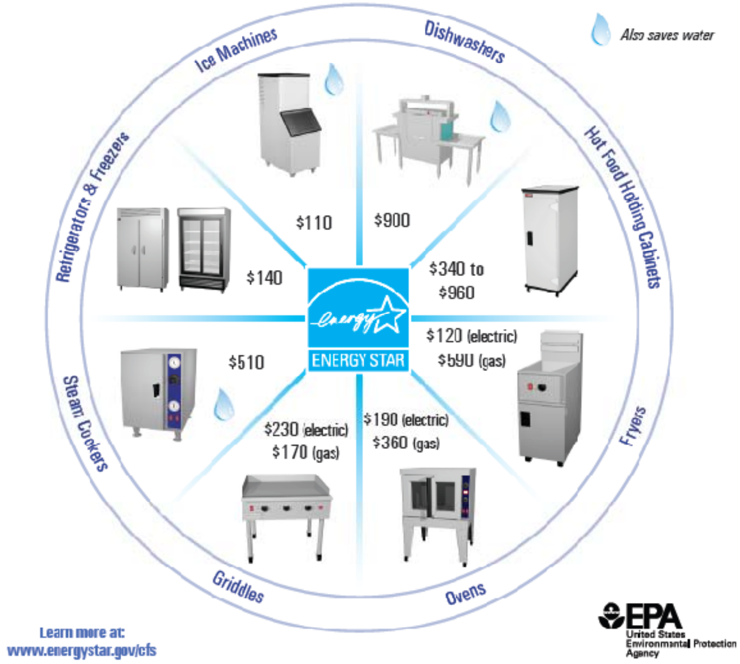
| | Natural Gas | Electric | Electric/Gas Ratio |
|---|---|---|---|
| **U.S. Total** | $930.0 million | $4,400.0 million | 4.7:1 |
| **New York** | $42.9 million | $393.2 million | **9.2:1** |
| **Massachusetts** | $32.5 million | $176.1 million | **5.4:1** |
| **New Hampshire** | $3.0 million | $16.3 million | 5.4:1 |
| **Rhode Island** | $7.6 million | $30.7 million | 4.0:1 |

Substantially greater funds are potentially available to commercial food service establishments for electric energy efficiency incentives and rebates compared to natural gas (by a factor of 4-9:1). Notably, the energy efficiency funding ratio is considerably higher than the national average in New York – that is, greater funds are available to incentivize the purchase of high-efficiency electric equipment. This underscores the potential threat to the natural gas industry of consumers switching to electric technologies based on the incentives provided by energy efficiency program funding.

A complementary issue is the availability of products that can qualify for energy efficiency funding. Energy Star is an international standard for energy efficient consumer products. It was first created as a United States government program by the Clinton Administration in 1992, but Australia, Canada, Japan, New Zealand, Taiwan and the European Union have also adopted the program. Devices carrying the Energy Star logo, such as computer products and peripherals, kitchen appliances, buildings and other products, generally use 20%–30% less energy than required by federal standards. There is considerable online information that can be found at www.energystar.gov – including product availability and other helpful information from consumers.

Initiated as a voluntary labeling program designed to identify and promote energy efficient products, Energy Star began with labels for computer products. In 1995 the program was significantly expanded, introducing labels for residential heating and cooling systems and new homes. As of 2006, more than 40,000 Energy Star products are available in a wide range of items including major appliances, office equipment, lighting, home electronics, and more. In addition, the label can also be found on new homes and commercial and industrial buildings. In 2006, about 12 percent of new housing in the United States was labeled Energy Star. The EPA estimates that it saved about $14 billion in energy costs in 2006 alone. The Energy Star program has helped spread the use of LED traffic lights, efficient fluorescent lighting, power management systems for office equipment, and low standby energy use.

There are eight types of commercial food service (CFS) appliances that can earn EPA's Energy Star. Qualified equipment models use less energy and less water than conventional CFS models. The following images from www.energystar.gov/cfs shows the potential annual savings of using Energy Star qualified compared to conventional appliances.




Energy Star appliances require sufficient information and usage data to determine the baseline energy consumption – a necessary pre-condition to establish an Energy Star performance level. There are limited categories for Energy Star products suitable to the commercial foodservice sector because the data either does not exist or has not been compiled into a useful set to establish Energy Star guidelines.

Current drivers within the foodservice industry are pushing the need to establish new categories of Energy Star appliances. Because of increasing energy and water utility costs and interest in being more sustainable, operators in the commercial foodservice industry are expressing increased interest in appliances and systems that are more energy efficient to replace older, less efficient units. Recent market surveys conducted by both GTI and the National Restaurant Association have shown a greater interest on the part of operators to invest in energy-efficient equipment. GTI surveys have shown that consumers within the past two years are more willing to spend extra on the first cost of new appliances if the units are significantly more efficient or Energy Star rated. Manufacturers also have expressed to GTI that concerns over energy efficiency and the environment have become major drivers in the foodservice industry compared to two years ago.

There is an ongoing challenge facing the natural gas industry to ensure there is a broad array of Energy Star-approved natural gas appliances available. Many utility energy efficiency programs use Energy Star as a product qualifying step for energy efficiency funds. Unfortunately, due to a variety of factors, there are numerous product categories in the commercial food service sector where there are no Energy Star-approved products available – either because the products do not exist or because there are no approved standards for that product category. Table 16 lists the current Consortium for Energy Efficiency "qualifying product" list. Only two categories tie with natural gas equipment – fryers and steamers; all product categories tie into electricity use. The lack of approved energy efficient product standards can stymie or inhibit:

- The development of new, high-efficiency equipment by manufacturers
- The ability of natural gas energy efficiency to incentivize the purchase of new high-efficiency natural gas equipment

**Table 16: CEE Qualifying Commercial Foodservice Products (2010)**

| | | |
|---|---|---|
| Dishwashers | **Fryers** | Ice machines |
| Hot food holding cabinets | **Steamers** | Refrigerators & freezers |
| Pre-rinse sprayers | | |

Table 17 outlines the major commercial food service products with GTI-developed rating criteria on Energy Star status. In nine equipment categories there is an impediment due to the lack of any current standard or standard development process underway. In three categories, a standard is in development. In total, twelve of the nineteen equipment categories (63 percent) of commercial foodservice products are lacking in a qualified Energy Star standard.

**Table 17: Energy Star Availability Ratings for Commercial Food Service Equipment**

| Equipment Category | Energy Star Status* |
|---|---|
| Underfired Broilers/Charbroilers | 1 |
| Pizza / Deck Ovens | 2 |
| Wok Ranges | 1 |
| Steamers - Pressure | 4 |
| Ranges | 1 |
| Conveyor Broilers | 1 |
| Conventional Ovens | 1 |
| Conveyer Ovens | 2 |
| Rotisserie Ovens | 1 |
| Griddles | 4 |
| Pressure Fryers | 1 |
| Fryers | 5 |
| Over-fired Broilers | 1 |
| Convection Ovens | 4.5 |
| Steamers - Free-Standing | 4 |
| Tilting Skillets | 1 |
| Combi Ovens | 2 |
| Steamers - Counter-Top | 3 |
| Warewashers | 3 |

* Energy Star Status Rating Key

5 = Standard Issued - Robust Qualified Gas Equipment

4 = Standard Issued - Some Qualified Gas Equipment

3 = Standard Issued - Electric Equipment Dominates

2 = Standard In Process

1 = No Standard

Taken together, these data on state-level energy efficiency programs, availability of industry recognized "qualified products" by CEE, and a substantial deficiency in Energy Star-approved standards and qualified equipment underscores the need for natural gas industry attention. Specifically:

- In selected Northeast states, such as New York and Massachusetts, there is a need to evaluate the relative availability of natural gas energy efficiency funds relative to those for electric in the commercial sector.
- A concerted natural gas industry effort is required to:
    - Substantially enhance the availability of Energy Star standards for various commercial food service equipment.
    - Expand efforts with CEE and other organizations to document and support an expanded list of energy efficiency commercial foodservice products.
    - Substantially expand the number of qualified Energy Star and CEE-recognized natural gas commercial food service products that are developed and available to consumers.

## Gas Industry RD&D and Commercialization

Based on these results, GTI sees the following as fertile areas in the foodservice industry for National Grid's territory:

Area 1. **Development of higher efficiency and Energy Star-compliant natural gas appliances, coupled with support of new energy efficiency standards and protocols**
Benefits: Energy savings, lower emissions and gas appliance positioning with the "green" and sustainability movement. Increased availability of "qualified products" for natural gas energy efficiency program incentives. Avoiding market erosion to electric equipment.

Area 2. **Improved space conditioning and ventilation in the work area for a healthier work environment**
Benefits: Improved workplace comfort, lower employee turnover, and energy cost savings.

Area 3. **Development and marketing of equipment that is easier to operate and maintain**
Benefits: Improved productivity, improved product quality, and lower energy costs for restaurant and commercial foodservice operators. Avoiding market erosion to electric equipment.

Area 4. **Expanded marketing and outreach programs: Test Kitchens and Live Cooking Demonstrations, increased use of rebates and incentives for natural gas energy efficient products**
Benefits: Greater customer and trade ally recognition of the availability and benefits of new natural gas products.

When assessing the needs, opportunities, and threats within the commercial food service sector, it is important to explore the spectrum of the product development and commercialization stages.

Figure 7 outlines an example of the steps required in the product development and commercialization process.

### Natural gas R&D

The natural gas industry has two primary collaborative R&D programs – the GTI Sustaining Membership Program (SMP) and Utilization Technology Development (UTD, an independent industry-driven non-profit RD&D organization). These organizations primarily span RD&D activities up to Stage 6, demonstration and deployment.

Leading towards commercialization, the roles of SMP and UTD are complemented by the Energy Solutions Center (ESC) as well as an expanding number of natural gas energy efficiency programs that support Stage 6, 7 and 8 efforts through marketing programs and outreach as well as incentives that help support new technology acceptance in the market. A part of the ESC includes the Gas Food Equipment Network, or GFEN. Utility energy efficiency programs also have a national organization called the Consortium for Energy Efficiency (CEE).

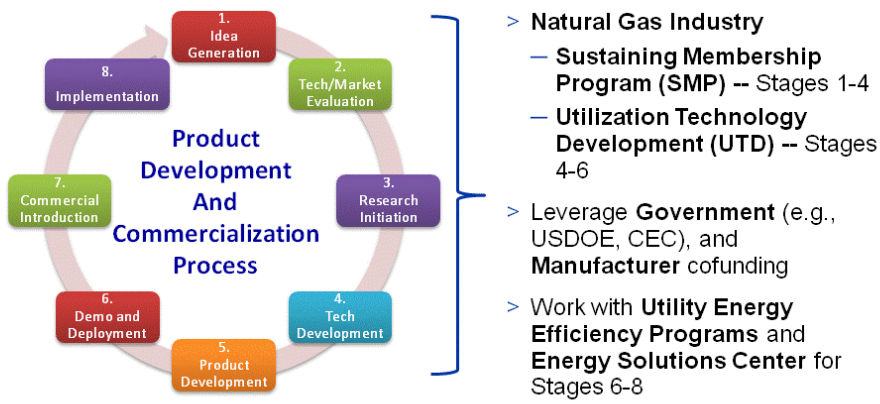



**Figure 7: Product Development and Commercialization Process**

For the reasons outlined in this report – notably, the energy intensity of commercial foodservice operations – GTI and UTD natural gas industry partners have maintained a focused concentration on product development for commercial foodservice customers. The research, development, and demonstration (RD&D) efforts of UTD has led to several successful commercial foodservice products (Table 18).

**Table 18: Example UTD-Supported Commercial Foodservice Products**

| | | |
|---|---|---|
|  | **Low-Oil-Volume Fryers**<br>A new commercial foodservice low-oil-volume fryer unit, marketed by Frymaster as Protector® fryers, increases energy efficiency while also extending cooking oil quality and life to provide significant customer savings. | **Contact: Linda Brugler**<br>Frymaster<br>318-866-2488<br>lbrugler@frymaster.com<br>www.frymaster.com |
|  | **Stellar Countertop Steamer**<br>This compact gas-fired countertop steamer for commercial food service offers enhanced cooking rates while providing users with added savings of energy and water consumption. The unit is the first gas-fired boilerless steamer with an ENERGY STAR rating. | **Contact: Market Forge Industries/Stellar Steam**<br>617-387-4100<br>866-698-3188<br>custserv@mfii.com<br>www.mfii.com<br>www.stellarsteam.com |
|  | **Avantec Combi-Oven**<br>The combination oven uses a patented technology for improving cooking performance, quality, and efficiency. Able to operate in various cooking modes, the oven provides enhanced uniformity when compared to similar-sized ovens. | **Contact: Dave Goble**<br>Avantec Food Service Equipment<br>800-322-4374<br>dave@twomarket.com<br>www.avantecequipment.com |

The UTD Foodservice Working Group is composed of representatives from UTD member gas utilities with expertise in the foodservice arena. The group holds regular conference calls to discuss issues and potential solutions for the foodservice industry and how the utilities can participate in this process. The development and maintenance of quality foodservice equipment is important to both the gas industry and the foodservice manufacturers.

During the past few meetings, several issues have been brought to the group for discussion. The biggest topic has been the need for more efficient gas-fired appliances to be introduced to the market. Specifically, utilities are looking for an expanded list of Energy Star eligible appliances that would qualify for rebates from the utilities. This expansion includes both increasing the number of efficient appliances in existing Energy Star categories and expanding the number of Energy Star categories to include more appliance types. Specific appliances discussed for investigation of improved energy efficiency include: convection ovens, conveyor ovens, and ranges. Specific energy efficiency issues for each appliance are discussed below:

- **Convection Ovens**
  Typical gas-fired full-sized convection ovens have heavy load efficiencies in the mid 30 percent range. The best gas-fired models that have been tested at the Foodservice Technology Center attain near 45 percent heavy load efficiency. The currently proposed standard for Energy Star rating will be 44 percent, meaning only a few models of existing convections ovens will receive an Energy Star Rating. Design elements that may contribute to the lower efficiency include: door gasket material, method of firing the burner (direct vs. indirect heating), construction seals and door design (split vs. one piece). There are an estimated 15,000 gas-fired convection ovens operating in National Grid Service territory, with an associated gas load of 9 million therms annually. Improving the stock efficiency of gas-fried convection has the potential to reduce the commercial gas load by 3 million therms per year. The associated carbon savings is 39 million pounds of $CO_2$ produced per year.
- **Conveyor Ovens**
  Over the past 30+ years, conveyor ovens have taken over the majority of baking pizzas in restaurants. Because of several factors in the design of conveyor ovens, the efficiencies tend to be low compared to other foodservice appliances, about 40 percent for large conveyor ovens and 20 percent for small ovens. A large majority of the larger ovens are gas; however, for the smaller ovens, there are more electric than gas models. More progress has been made to improve the efficiency of the larger ovens than the smaller ovens by improving stand-by losses in the ovens. However, other design issues tend to keep the efficiency of the smaller ovens lower than the large ovens. These include the open ends of the conveyor, cooking tunnel design/dimensions and air flow distribution. There are an estimated 3,000 gas-fired conveyor ovens operating in National Grid Service territory, with an associated gas load of 6.5 million therms annually. Improving the stock efficiency of gas-fried convection has the potential to reduce the commercial gas load by 2 million therms per year. The associated carbon savings is 26 million pounds of $CO_2$ produced per year.
- **Ranges**
  Commercial ranges are one of the most common appliances in the foodservice industry and 90

percent of ranges are gas fired, resulting in a significant gas load. Gas fired commercial ranges currently have very low efficiencies due to three main issues:

- Pilot lights – While most residential gas-fired ranges feature pilotless ignition, a very high percentage of commercial ranges have pilots. Some manufacturers have offered pilotless ignition, but the market has not embraced this feature.
- The ASTM water-boil efficiency is in the low 30 percent range.
- Some operators leave burners operating when there is no load in place on the burner.

Another issue is that there are new hood interlock rules from both the international mechanical code and the international fuel gas code that require gas to be shut off to cooking equipment when the kitchen hoods are not in operation. This forces the restaurant to either run a separate gas line for pilot operation or re-light their pilots every morning. The new hood interlock rules are forcing the industry to consider using ranges without pilots so they will not have to worry about relighting the pilot each morning. There are an estimated 21,000 gas-fired commercial range tops operating in the National Grid Service territory. These are broken into heavy-duty ranges, restaurant ranges and stock pot ranges. The estimated gas-load for the three subcategories of ranges is 20 million therms per year. Estimating 200 new ranges produced per year with 50 percent energy savings provides 1 hundred thousand therms of energy savings in the first full year of deployment alone.

The members also expressed interest in participating in the process of establishing Energy Star ratings and providing information to the customers on rebates and the advantages of using Energy Star appliances.

Another issue growing within the foodservice industry is the concept of “green” appliances and environmental benefits in term of carbon footprint of gas vs. electric. The group expressed the need to understand and define terms that apply to the “greenness” of an appliance and how information can be conveyed to the utilities and its customers.

The current RD&D process for commercial foodservice is reasonably robust, but could benefit from further investment. The following are R&D funded by UTD or SMP::

- Gas-fired wok
- Gas-fired rethermalizer
- Gas-fired conveyor oven
- Gas-fired convection oven
- Gas-fired commercial range
- Gas-fired warewasher

Beyond these readily identifiable products suited to the kitchen environment, there are several cross-cutting technology development initiatives that can benefit the commercial food service sector, such as:

- Early-stage cross-cutting technologies:

  - Advanced flat-panel radiant burner and controls (could be applied to various foodservice cooking devices)
  - Low $NO_x$ burners
- Hybrid tankless hot water technologies
- High-efficiency rooftop packaged gas heating units
- Desiccant-based dehumidification systems
- Commercial hybrid solar thermal/natural gas systems

One area of note is a UTD project that is addressing a growing trend in the foodservice industry: preparing certain food products in larger quantities at a centralized location and delivering those to restaurants for reconstituting or rethermalizing. The main driving factors for this are productivity and labor savings from centralized large-scale production, speedier in-restaurant preparation, and energy savings. Products like soups, gravies, vegetable side dishes and sauces have been shown to be prepared in this method and served in restaurants without any perceived sacrifice in flavor or texture. Data suggests that significant energy and labor savings can be realized by preparing these items in bulk.

### Commercialization

The Energy Solutions Center is a technology commercialization and market development organization representing energy utilities, municipal energy authorities, and equipment manufacturers and vendors. The mission of the Center is to accelerate the acceptance of and deployment of new energy-efficient, gas-fueled technologies that enhance the operations and productivity of commercial and industrial energy users, and improves comfort and reliability for residential energy users.

The ESC and its members identify, evaluate, and prioritize new market opportunities and then implement market development initiatives designed to move products from R&D success to broad market acceptance.

The Gas Foodservice Equipment Network (GFEN) is an international alliance of utilities, foodservice equipment manufacturers, gas industry associations and foodservice trade allies organized to be a source of gas solutions for the commercial foodservice segment. The objective of GFEN is to maintain and build natural gas load by ensuring that our commercial food service customers have an array of clean, efficient, cost-effective and high performance natural gas products from which to choose and are made aware of these products and their benefits.

There are a select number of utilities that have adopted targeted marketing efforts for the commercial foodservice sector using Test Kitchen facilities. This approach allows restaurant operators, cooks, equipment manufacturers and other stakeholders to test new products, learn about new energy efficient practices, and make side-by-side comparisons of competitive brands – including comparing natural gas and electric products.

Several utilities have invested in foodservice centers and test kitchens, including Southern California Gas, PG&E, Southwest Gas, Piedmont Natural Gas, Alabama Gas, and Centerpoint Energy, . Figure 8 shows a profile on Piedmont's test kitchen from a recent GFEN publication.

PIEDMONT NATURAL GAS
TECHNOLOGY CENTERS

Piedmont's Gas Technology Center in Charlotte has 6,000 square feet of space, two 10-foot sections of kitchen ventilation hood and five gas and electric connections. Both natural gas and electric cooking equipment can be compared in a real-world environment. A data acquisition system provides the capability to measure and calculate equipment performance, energy use and efficiency, and food production. In addition, there are large prep and cleanup areas with both condensing and high-efficiency commercial gas water heaters and a dishwasher with a gas booster heater.

When not used for equipment testing or demonstrations, the Centers have extensive audio/video capabilities and seating for 70 people which make them ideal for sales meetings, customer workshops, and ServSafe training sessions.

**Charlotte, NC · Spartanburg, SC**
**Sandra Minter · 704.731.4014**

**Figure 8: Piedmont Natural Gas Test Kitchen Profile (Source: GFEN, Spring 2009)**

The Consortium for Energy Efficiency (CEE), a nonprofit public benefits corporation, develops initiatives for its North American utility members to promote the manufacture and purchase of energy-efficient products and services. Their goal is to induce lasting structural and behavioral changes in the marketplace, resulting in the increased adoption of energy-efficient technologies. CEE members include utilities, statewide and regional market transformation administrators, environmental groups, research organizations and state energy offices in the U.S. and Canada. Also contributing to the collaborative process are CEE partners – manufacturers, retailers and government agencies. The U.S. Department of Energy and Environmental Protection Agency both provide support through active participation as well as funding.

# Commercial Foodservice Market Channels

## Commercial Foodservice Trade Associations

### National Restaurant Association

The National Restaurant Association represents more than 380,000 commercial food service businesses — from restaurants and suppliers to educators and non-profits. They produce annual reports and information products for their members as well as advocacy. They also network with a variety of state organizations, including:

**New York State Restaurant Association**
409 New Karner Rd
Albany, NY 12205-3883
Phone: (518) 452-4222
Web site: www.nysra.org

**Massachusetts Restaurant Association**
333 Turnpike Rd Ste 102
Southborough Technology Park
Southborough, MA 01772-1755
Phone: (508) 303-9905
Web site: www.marestaurantassoc.org

**New Hampshire Lodging & Restaurant Association**
PO Box 1175
Concord, NH 03302-1175
Phone: (603) 228-9585
Web site: www.nhlra.com

**Rhode Island Hospitality Association**
94 Sabra St
Cranston, RI 02910-1031
Phone: (401) 223-1120
Web site: www.rihospitality.org

The annual National Restaurant Association show is a venue to find the latest ideas, products and educational programs. Attendance can include over 75,000 industry professionals participating in over 60 free seminars.

The NRA also has period webinars to allow members to learn from industry experts and operators. This could be a possible communications channel for energy companies.

### The North American Association of Food Equipment Manufacturers (NAFEM)

NAFEM is a trade association of more than 625 foodservice equipment and supplier manufacturers that provide products for food preparation, cooking, storage and table service. NAFEM's biennial trade show attracts approximately 20,000 foodservice professionals and features more than 600 North American manufacturers.

## Foodservice Equipment Sales and Service Channels

Table 19 shows information from a USEPA document outlining supply channel actors for the commercial foodservice sector. This is a fairly typical multiple channel arrangement – with the added role of *design consultants* who would specialize in the commercial foodservice sector. This role is similar to that provided by architect and engineering firms, consulting engineers, etc.

**Table 19: Supply Channel Actors**

| |
|---|
| **Dealers:**<br>Dealers primarily sell to individual restaurants, which is often the most difficult market to reach. Smaller dealers may join buying groups so they can compete more effectively with larger dealers. Many dealers display their products in showrooms and tend to stock lower-priced, popular models that are usually not energy-efficient. A dealer's main objective is usually to sell the products they have on hand, and they are generally more interested in attracting customers with low prices rather than emphasizing the overall value of higher-end products (e.g., lifetime cost savings). Given that many manufacturers offer sales incentives to move lower-end models, dealer incentives can be an effective strategy to promote stocking and sales of energy-efficient equipment. |
| **Distributors:**<br>Distributors primarily supply bulk quantities of equipment to dealers and sell commodity equipment (e.g., ice machines, fryers) directly to end users. Since distributors usually supply dealers, developing a good working relationship with distributors helps funnel energy-efficient CFS products into dealer showrooms. In addition, some restaurant food distributors sell CFS equipment and should also receive program outreach. |
| **Manufacturers and Reps:**<br>CFS equipment manufacturers generally sell through product reps, although manufacturers may also sell directly to large end users such as national restaurant chains. Though all supply channels gravitate toward inexpensive, fast-moving pieces of equipment, a key value proposition for engaging reps is the up-sell potential of high-value, high-efficiency equipment. Sales of high-quality products earn reps a higher commission and generate long-term value for the customer, often leading to repeat business. |
| **Design Consultants:**<br>Design consultants assist in the planning and design of new or renovated commercial kitchens, typically working with large or chain-owned restaurants, hotels, universities, and hospitals. Conducting targeted outreach to design consultants helps to ensure that energy- and water-efficient CFS equipment is considered in these types of projects. Design consultants are typically focused on the overall design and aesthetics of the space and controlling project costs, and back-of-the-house equipment is often a low priority. In addition, they often have established relationships with buying groups and may receive incentives for selling lower-end equipment. Equipment quality and performance are key selling points for engaging design consultants. |

Source: USEPA Energy Star publication. Energy Star for Commercial Kitchens: Helping Customers Manage Costs, (June 30, 2009).

## Market Channel Participant Interviews

In order to gauge market conditions in National Grid's territory, GTI undertook targeted primary market research by talking to key market channel players in the Northeast commercial foodservice sector. An independent consultant was deployed to conduct phone interviews with foodservice consultants and dealers that operated in the National Grid Service territory.

### Phone Survey

GTI worked with Mr. Richard Topping of RFTopping Consultants to organize and conduct the telephone interviews. This encompassed two major Foodservice Consultant firms (Colburn & Guyette and Clevenger Foster LaVallee) and four foodservice equipment dealers/design houses (Kittredge, Trimark, Perkins and May Foodservice). As a practical matter, there are similarities between these two types of organizations but the consultants tend to work on bigger jobs and may be less brand-biased. The results of the interviews appear quite consistent across all six firms.

The most positive outcome from the survey is that participants felt that natural gas is firmly entrenched in the Northeast and that situation seems to be holding steady. No one sees any serious movement to electric equipment at this time.

The overall status of gas foodservice equipment in National Grid's service territory is good. Generally, responses show that gas provided good value and was a "green fuel." The relatively high electric rates in this area may be a contributor in this area. Several items that stood out as potential areas for improvement are highlighted below:

1. There were strong indications that neither the gas nor the electric utilities were involved in a significant role in the decision process for these marketers selling equipment. It is clear that all of the survey participants would welcome more utility involvement.
2. Venting of gas equipment was identified as an issue for five of the six companies.
3. Several of the respondents stated that electric appliances are perceived by some to generally be safer and more technologically advanced than gas-fired appliances.
4. All six responded that gas-fired booster water heaters face issues with being installed including venting, reliability, cost and efficiency.
5. According to three of surveyed sources, gas-fired warewashers face a disadvantage compared to electric because they require venting[1] (note: electric warewashers also require venting for the steam and steam hoods can also be used to vent flue products).
6. Three respondents expressed the need for pilotless ignition, especially on ranges, to address new hood interlock rules that require gas to be shut off to appliances when the kitchen hoods are not turned on. This forces the restaurant to either run a separate gas line for the pilots or re-light their pilots after each time the hoods are turned off.

Fuel cost is a major issue and natural gas has the advantage relative to electricity. Also, natural gas has a solid history and reputation. Electric is only preferred when deemed absolutely necessary, usually due to the lack of suitable gas service or ventilation issues (kiosks).

Interviewees were spread across the New York and Massachusetts areas. The detailed responses from the participants are included in tabular form in an appendix to this report.

The overall conclusion from this market survey effort is that, generally speaking, natural gas holds a good position in National Grid territory. Dealers and consultants feel that gas is the preferred fuel except when venting issues arise.

Several areas are candidates for some improvement if resources allow:

1. This issue arose when the dealers tried to support a gas booster heater program. The gas booster was not integral to the warewasher and required a separate vent. Since replacement sales are a significant component of the market for these appliances, venting is a big issue. GTI has been working with Jackson MSC to develop a warewasher with integral booster heater that vents through the body of the dish machine and should overcome the venting issue.

- Foodservice appliance manufacturers are relatively small in size and lack resources in engineering. They often need support in their gas designs, both for new product development and for troubleshooting existing designs.
- The surveyed dealer/consultant group did not receive information and support from the utilities that might help them promote gas equipment sales. This is probably a result of the loss of gas utility commercial marketing that has come about in the last few years.
- Energy efficiency and “greenness” are of extreme importance now. Appliances which can bear the Energy Star label are good sellers. At this time there are only a few appliance categories for foodservice where there is energy star. The community is working to expand this list over the next few years.

## Conclusions

The commercial and institutional food service sector represents an important – **and growing** -- market for the natural gas industry. According to the National Restaurant Association (NRA), there are approximately 525,000 commercial food service establishments nationwide with annual sales of $580 billion.

State-level characteristics on four key states – New York, Massachusetts, Rhode Island, and New Hampshire – indicate a market size of 56,900 commercial foodservice locations with annual sales in excess of $43 billion. Using a nominal value of 3.4 percent of sales, annual utility costs (electricity, natural gas, water, etc) exceeds $1.4 billion in these four states (and approaches $20 billion nationally).

According to Energy Information Agency (EIA) survey data, commercial foodservice customers have 2.2 times the energy intensity (Btu/$ft^2$) of the average commercial customer. Audits conducted by Southern California Gas and Piedmont Gas found that natural gas sales to commercial foodservice customers account for 12 percent of the volume of gas sold, but comprised a healthy 19 percent of their profits.

In terms of new equipment, the estimated annual sales of new commercial foodservice equipment totaled about $1.2 billion in 2006. Of this, about 69 percent was natural gas-based products – indicating a strong market position for natural gas relative to electricity. The report provides further analysis of sales by product category and, an important consideration, the availability of Energy Star-rated products.

While a significant and growing market, there are continual threats and opportunities to assess within the commercial food service market segment, including:

- Natural gas market share is currently strong and holding against electric market share. New electric products; perceptions of electric as clean, simple, and reliable; and growing electric energy efficiency programs represent potential threats. There is also a market perception that electric equipment is more advanced or higher end than gas equipment.
- Natural gas is perceived as more cost-effective by users, with current electric-to-natural gas price ratios of 4.5:1 or higher. A typical restaurant is paying over twice as much annually for electricity than natural gas – underscoring the perception of natural gas as being cost effective.
- Rising labor, food, and energy costs are motivating foodservice providers to seek new and innovative equipment designs that could save operating costs through productivity improvements and speedier delivery.
- **Labor issues are a dominanting factor in this sector** – the major issues are obtaining and retaining quality workers, labor costs, and productivity. Increased labor turnover motivates foodservice providers to seek methods or equipment to improve the working environment for employees in terms of comfort, ease of equipment usage, and cleaning.
- Key purchase factors for new equipment include price, efficiency (operating costs), after-sales support, and productivity improvement. Equipment obsolescence and deterioration is typically the main reason to buy new equipment. One of the problems with old gas equipment is that is lasts for many years and restaurants do not tend to replace equipment until is total breaks down

instead of updating to new equipment. Getting information to users about the cost and energy saving associated with new equipment is lacking.

- Trends toward healthier and/or more environmentally responsible eating habits can influence the market, but the economic benefits/effects are not fully understood by the industry.
- The industry is concerned about lower emissions standards (including $NO_x$ and particulates) – especially where such requirements have been imposed on residential appliances.
- The green movement is a threat to natural gas. Consumer surveys show that electric is perceived as being more green, possibly due to the site-based efficiency claims. There is an opportunity to position the new gas equipment as green through consumer education - identifying the financial and environmental benefits.

## References

Czachorski, M. and Leslie, N., “Source Energy and Emission Factors for Building Energy Consumption,” Gas Technology Institute for American Gas Foundation, Nov. 2009.

Energy Information Agency, “2003 Commercial Buildings Energy Consumption Survey,” www.eia.doe.gov.

Environmental Protection Agency, Energy Star www.energystar.gov.

Frable, F., “Rethermalize it,” Nation’s Restaurant News, Oct. 8, 2007.

Fryett, D.K., “So, What’s Going On Out There In The Food Service Industry That We Need To Know About,” Final Report, Gas Food Equipment Network (2008).

Gas Food Equipment Network, “Cooking Up Greener Solutions, Spring 2009 Newsletter.

Melink, S., “Kitchen Hoods Using Demand Ventilation,” ASHRAE Journal, Dec. 2003.

National Restaurant Association, “2010 Restaurant Industry Forecast,” (2010).

National Restaurant Association and Deloitte, “Restaurant Industry Operations Report (2006/2007 Edition).

Nevius, M., Eldridge, R., and Krouk, J., “The State of the Efficiency Program Industry Budgets, Expenditures, and Impacts 2009,” Consortium for Energy Efficiency, March 5, 2010.

USEPA, “Energy Star for Commercial Kitchens: Helping Customers Manage Costs,” Energy Star publication (June 30, 2009).

van Straten, G. and Brown, S., “Keeping Cooks in the Kitchen: Solving the Makeup Air Dilemma,” ASHRAE Journal, June 2003.

# Appendix A: Market Survey Results

| Key Issues | Issue / Question | Colburn & Guyette response | Clevenger Foster LaVallee response | Trimark response | Kittredge response | Perkins response | May Food Service response |
|---|---|---|---|---|---|---|---|
| | **What type of business is this?** | Colleges, healthcare facilities, institutions. C&G do not design many restaurants; dealers have a foothold and do designs for free to sell equipment. | CFL does big commercial and institutional jobs; also does more chain and restaurant work than typical consultants. | Largest dealer in US; also Trimark conducts engineering for restaurants and hotels. | Full service dealer of commercial kitchen equipment including engineering and sales | Dealer and design firm for restaurants, health care, institutions, etc. | Equipment distributor and design firm for food & beverage operations, institutions, etc. |
| | **What product lines do they have (we only care about cooking and warewashing equipment)?** | C&G does the research and specs equipment for clients by brand and model. They use gas wherever possible (high market share). Gas is more efficient and quicker (higher food output) | N/A | Large selection of equipment and brands | Offer products of most major manufacturers | Perkins specs equipment for their clients. | Full line of commercial foodservice equipment |
| | **Profile sales of gas vs. electric equipment** | | | | | | |
| | What are the actual sales of gas equipment / Actual numbers | N/A | N/A | N/A | N/A | | |
| | Share of market/sales of gas vs. electric | Sees no change in share; still predominantly gas in their market. | Sees no significant change in market share between gas and electric | Predominantly gas in the Northeast | Gas is predominant. | | |
| | Is this share ratio changing, and if so, why? | No | No | No. Electric energy cost is high which limits sales of electric equipment. Also, most chefs prefer gas because of better control and higher output. | No | No change seen; equipment is almost always gas. | No change seen in market share |
| | **Why gas share is what it is** | | | | | | |
| | Who specs fuel type and what are the key criteria (availability, cost, ventilation, reliability, etc.) | C&G uses gas wherever possible. They use electric with recirculating ventilation systems by necessity in limited applications. | CFL specs equipment (make and model) in consultation with the owner. CFL gets information from trade shows, equipment reps, AutoQuotes, etc. Usually specifies gas whenever gas is available. In situations without venting, electric is used. | Trimark works with their clients to spec the optimum equipment; also sells equipment to projects where the design is done by A&E firms and Consultants. | Replacement equipment nearly always utilizes the same fuel; utility changeover is very expensive and a hassle for an operating facility. Gas is usually specified when available; viewed as cheaper. | Perkins specs gas almost exclusively. Small markets are developing for unique electric equipment such as induction cooktops. However, induction currently is offered only in one or two station countertop units, no induction ranges are currently sold in the US (some may be coming from Europe). | May does the site design and specs the equipment by fuel type, make, model, etc. Gas is used almost exclusively in the Northeast except for very limited applications of electric equipment. |
| | What are the respective roles of consultants, dealers, manufacturers, utilities, etc.? | Big jobs use consultants; usually brought in by the A&E firm responsible for the project. Some projects like nursing homes use dealers but this may be changing as well. | Consultants typically are brought in by architects and A&E firms on large jobs (80 – 90% of their business). Dealers tend to do restaurant work in return for the equipment business. However, CFL also markets to the chains and restaurants; they do more of this work than most consultants. | Trimark, because of its size, has test kitchens where customers can prepare their food products with different types of equipment to determine what is best for their needs. | Consultants are hired by A&E's and architects for big jobs. Project subcontractors may include Kittredge who bids on supplying suites of equipment. Restaurants use Kittredge and its showrooms to purchase equipment. Kittredge does engineering for restaurants and offers a rebate on purchased equipment. | | Customers rely on May for recommendations on equipment. |
| ! | What is the level of participation of utilities, gas and electric. Is one doing a better job? | Utilities (gas or electric) aren't really involved; would be helpful if they were. C&G gets its information from manufacturers and trade journals | Utilities (gas or electric) provide no assistance to CFL. They could use help, especially in the area of codes and standards. Codes are becoming more varied across the country and restrictive. CFL could use one consistent set of up-to-date data. One specific problem area mentioned was requirements for flex connectors. | Rebates for Energy Star (currently up to $1000 for a fryer) help with the sale of high efficiency equipment. Bob believes the West Coast utilities still support the sale of gas with test kitchens and information; the East Coast utilities never did much and now do less. | GasNetworks does a good job of offering and advertising rebates in New England. The electric utilities have been much slower to offer rebates. However, it is like "pulling teeth" to get any assistance from utilities. | Utilities currently are providing $1000 rebates for high efficiency fryers. | Utilities really are no help at all. May is very disappointed that utilities are not more active in providing assistance and information on programs such as rebates. |
| | Is the current energy situation affecting share? | No | No. The fuel choice decision is based on the availability of gas; not energy cost. | No, electric cost is still higher than gas. | People are forgetting about energy and worrying about the economy | No, fuel cost drives the business and gas remains cheaper than electricity. | No |
| | Is the current world economic crisis impacting sales? | Not yet, but it appears there is a slowdown coming on new construction. | Yes, the current recession is slowing building projects. | Absolutely, the chains are experiencing a significant downturn. Franchisees cannot secure financing. | Yes | Across the board. | Yes, definitely. |
| | What is perception of gas equipment (vs. electric) / Cost | Electric equipment is higher cost | Gas equipment is more expensive in some equipment categories; less expensive in others. | Gas equipment is perceived as less costly, although in reality it is not always so. Electronics have added cost. | Gas is viewed as less expensive. | Gas | Gas equipment costs less. |

| Key Issues | Issue / Question | Colburn & Guyette response | Clevenger Foster LaVallee response | Trimark response | Kittredge response | Perkins response | May Food Service response |
|---|---|---|---|---|---|---|---|
| | What is perception of gas equipment (vs. electric) / Reliability | On par with the newer products; electric used to be less reliable | Better in some categories (ranges) and worse in others (kettles, combi-ovens and braising pans). However, the gas equipment manufacturers have done a good job improving equipment reliability | Even | Gas viewed as more reliable | Gas | Gas equipment is more reliable. |
| | What is perception of gas equipment (vs. electric) / Cook Quality | Gas is better | Depends on the application; electric braising was better but gas has improved. Some chefs prefer electric in specialized applications (griddle range and induction) so there is some small penetration of dual fuel kitchens | Gas is better | Gas is viewed as better overall. Some segments, such as bakers, prefer electric deck and convection ovens for better baked product quality. | Gas | Gas is better. |
| | What is perception of gas equipment (vs. electric) / Efficiency | Gas is higher | No perceived difference. | Gasis viewed as higher but because of energy cost. | Dan believes electric products are more efficient at getting the energy to the food but admits most of his customers only are concerned with energy cost which is lower for gas. | Gas | Gas is more efficient. |
| | What is perception of gas equipment (vs. electric) / Output | Gas is better | Same or greater for gas. | Even | Gas is better | Gas | Gas is higher |
| ! | What is perception of gas equipment (vs. electric) / Other issues including Venting | Electric is used if ventless systems are required | Venting is a major issue. For example, it prevents the use of gas booster heaters for warewashing in many applications. Without adequate venting, electric equipment is specified to prevent any potential problems. | Gas requires more ventilation and this is an issue. To expand, some facilities will add electric equipment to the current suite of gas products to eliminate the need to add more hood space. | Venting is a growing issue for all types and applications. Code officials and fire inspectors are requiring similar venting regardless of fuel type. Hoods are expensive. Even table top cooktops (bottled gas or induction) now need ventilation. Electric ignition is required in Massachusetts (though subject to fire inspector interpretation) | There is virtually no call for electric equipment other than small products (toasters) and induction cooktops which is desired by some sophisticated chefs. | Ventilation is not really an issue for the vast majority of applications since cooking requires venting regardless of fuel type. |
| ! | For costumers that prefer electric, why? | Can avoid ventilation cost. Also, certain applications use specialized cooking equipment (induction). New microwave/convection ovens are ventless and cook well; they fill a niche. | Regulations, safety (important in schools), desire for induction. Electric speed ovens (TurboChef) are impinging on gas in settings such as Dunkin Donuts for sandwich preparation. 20 years ago, a gas grill and hood would have been used. Codes and regulations could accelerate this trend – a potential dark cloud for gas. | Electric technology has improved more than gas lately. Speed-cook ovens and induction ranges are impressive and have potential to grow electric market share. | See above; also some churches like electric because of safety. | Applications where gas is not available or ventilation may be an issue. | Kiosk applications may require electric equipment where venting is an issue. |
| | Is there a significant trend in fuel choice by segment? | No | No. | No | No | No | No |
| | Who do users rely on for information before buying equipment | In this segment, on the consultants who rely on manufacturers and trade journals | Consultants and dealers. | Dealers and manufacturers reps. Reps have taken up the slack from utilities and now are much more sophisticated with test kitchens, data, etc. | N/A | | Dealers and designers. Some operators rely on this advice and really do not get involved. Others, like chains, are very much involved in the purchase decision. |
| | **What can be done to grow gas share** | | | | | | |
| | What would cause the decision of gas vs. electric to change in the future | N/A | See above. | N/A | If users start to accept (believe) the efficiency benefit of electric and the fact that electric equipment can be cheaper to operate in some circumstances. | | Large increase in gas cost. |

| Key Issues | Issue / Question | Colburn & Guyette response | Clevenger Foster LaVallee response | Trimark response | Kittredge response | Perkins response | May Food Service response |
|---|---|---|---|---|---|---|---|
| ! | What can manufacturers/utilities do to influence that decision | N/A | Utilities or a national association (AGA, GTI, etc.) could help by providing a national data base on codes and regulations. Foster mentioned a particular problem in New York City where ConEd, the gas supplier, has decided to maintain low pressure service in high rise buildings. This requires a $50K compressor system for food service applications costing $100K, not a cost effective solution. Therefore, electric is being used. Also, the new electronic controls monitor gas pressure and shut the equipment down if the pressure drops below specs. Older equipment used to keep operating at lower output. | N/A | N/A | | |
| ! | Are there opportunities for gas in steamers and warewashing equipment? | C&G uses steamer and kettle combinations that utilize gas-fired boilers. Countertop steamers are electric and have the advantage or being more portable. C&G never specs gas for warewashing equipment; gas-fired boosters are hard to get approved. This is a growth opportunity for gas. | CFL sees an opportunity for large steam generators that can function under a hood and provide steam to several appliances (kettles, booster heater, etc.). Currently, plant steam is used but there is a trend to decentralize steam plants in buildings such as hospitals. Gas booster heaters aren't being widely used because they are hard to vent and restricted by codes. | There are problems with gas boilers in the Northeast because of high iron content in the water. Gas booster heaters for warewashing really are not popular because of the need for venting and the perception that electric is easier to locate, cheaper, and more reliable. | Ventilation and cost restricts the use of gas boosters for warewashing. Dan didn't see any promising additional opportunities for gas boosters or steam generators. | There is an opportunity for gas booster heaters if they can be made more reliable and venting can be more easily accomplished. Electric boosters require very heavy electric service (80 - 100 Amp, 3 Phase). | There are opportunities for booster heaters if gas equipment becomes more reliable, less expensive and more efficient. |
| | Is the Green movement good or bad for gas? | There is a perception that gas is greener. | Good for gas. | Not sure. | Good for gas; as a result, gas companies are aggressively marketing rebates | Not fuel specific; more the desire for higher efficiency. | Don't know. |
| ! | What design improvements are needed for gas equipment (Efficiency, Cleanability, Performance, Price, etc.) | There is a need for electronic ignition in all gas equipment. The new ventilation systems turn off the gas supply when they are shut down. Electronic ignition is now required in some areas (Massachusetts) | The gas industry has done a good job overall with equipment. An additional needed design improvement is auto-shutdown for gas ranges. Currently ranges in many applications are turned on and left on. Also see above suggestion on steam generators | N/A | N/A | Pilotless ignition is being required by some codes. Electronic ignition systems have never been reliable in gas food service equipment; need improvement. | None come to mind. |

# Appendix B: National Restaurant Association Data Sheets

NATIONAL RESTAURANT ASSOCIATION®

**2010**
**Restaurant Industry**

# Pocket Factbook

**2010 Industry Sales Projection** **$580 billion**

| | 2010 Sales (billion $) |
|---|---|
| **Commercial** | $ 530.4 |
| Eating places | 388.5 |
| Bars and taverns | 18.8 |
| Managed services | 40.9 |
| Lodging place restaurants | 26.9 |
| Retail, vending, recreation, mobile | 55.2 |
| **Other** | $ 49.7 |

## Restaurants
### An Essential Part of Daily Life

- Restaurants will provide more than 70 billion meal and snack occasions in 2010.
- On a typical day in America in 2010, more than 130 million people will be foodservice patrons.
- 44% of adults say restaurants are an essential part of their lifestyles.
- 65% of adults say their favorite restaurant foods provide flavor and taste sensations that can't easily be duplicated in their home kitchens.

## Restaurants
### Small Businesses with a Large Impact on our Nation's Economy

- Restaurant-industry sales are forecast to advance 2.5% in 2010 and equal 4% of the U.S. gross domestic product.
- The overall economic impact of the restaurant industry is expected to exceed $1.5 trillion in 2010.
- Every dollar spent by consumers in restaurants generates an additional $2.05 spent in the nation's economy.
- Each additional dollar spent in restaurants generates an additional $0.82 in household earnings throughout the economy.
- Every additional $1 million in restaurant sales generates 34 jobs for the economy.
- Eating-and-drinking places are mostly small businesses. Ninety-one percent have fewer than 50 employees.
- More than seven of 10 eating- and drinking-place establishments are single-unit operations.
- Average unit sales in 2007 were $866,000 at fullservice restaurants and $717,000 at quickservice restaurants.

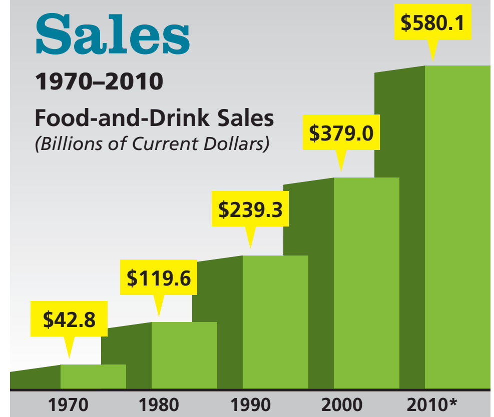
## Restaurants
### Cornerstone of Career Opportunities

- The restaurant industry employs about 12.7 million people, or 9% of the U.S. workforce.
- The restaurant industry is expected to add 1.3 million jobs over the next decade, with employment reaching 14 million by 2020.
- Nearly half of all adults have worked in the restaurant industry at some point in their lives, and more than one in four adults got their first job experience in a restaurant.
- Eating-and-drinking places are extremely labor-intensive — sales per full-time-equivalent nonsupervisory employee were $75,826 in 2008. That's much lower than most other industries.
- One-quarter of eating- and drinking-place firms are owned by women, 15% by Asians, 8% by Hispanics and 4% by African-Americans.
- Eating-and-drinking places employ more minority managers than any other industry.
- The number of foodservice managers is projected to increase 8% from 2010 to 2020.
- Fifty-eight percent of first-line supervisors/managers of food preparation and service workers in 2008 were women, 14% were of Hispanic origin and 14% were African-American.

## Restaurant Industry Share of the Food Dollar


## Total Restaurant Industry Employment


## Restaurant Sales
### 1970–2010
**Food-and-Drink Sales**
*(Billions of Current Dollars)*




* Projected

## Restaurants by the Numbers

- **$1.6 billion** Restaurant-industry sales on a typical day in 2010.
- **40** Percent of adults who agree that purchasing meals from restaurants and take-out and delivery places makes them more productive in their day-to-day life.
- **73** Percent of adults who say they try to eat healthier now at restaurants than they did two years ago.
- **57** Percent of adults who say they are likely to make a restaurant choice based on how much a restaurant supports charitable activities and the local community.
- **78** Percent of adults who say they would like to receive restaurant gift cards or certificates on gift occasions.
- **59** Percent of adults who say there are more restaurants they enjoy going to now than there were two years ago.
- **52** Percent of adults who say they would be more likely to patronize a restaurant if it offered a customer loyalty and reward program.
- **$2,698** Average household expenditure for food away from home in 2008.
- **29** Percent of adults who say purchasing take-out food is essential to the way they live.
- **54** Percent of adults who say they would be likely to use an option of delivery directly to their home or office if offered by a fullservice restaurant.
- **78** Percent of adults who agree that going out to a restaurant with family or friends gives them an opportunity to socialize and is a better way to make use of their leisure time than cooking and cleaning up.
- **63** Percent of adults who say the quality of restaurant meals is better than it was two years ago.
- **56** Percent of adults who say they are more likely to visit a restaurant that offers food grown or raised in an organic or environmentally friendly way.
- **70** Percent of adults who say they are more likely to visit a restaurant that offers locally produced food items.

www.restaurant.org/research

# New York

## Restaurant Industry at a Glance

**New York's restaurants are an increasingly important part of the state's economy.** Restaurants are a key driver of employment in New York, and their sales generate tremendous tax revenues for the state.

The contribution of New York's restaurants extends far beyond the jobs they create, the careers they build and the revenues they generate. America's restaurants today are leaders in nutrition and healthy living, sustainability and social responsibility, and entrepreneurship and business opportunities.

For more information visit www.restaurant.org.

## New York Restaurants by the Numbers

### LOCATIONS

In 2007, there were **37,354** eating-and-drinking places in New York.

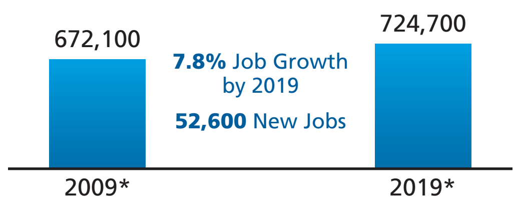
### STATE ECONOMY

Every $1 spent in New York's restaurants generates an additional **$.98 in sales** for New York's economy.

Each additional $1 million spent in New York's eating-and-drinking places generates an additional **23.4 jobs** in New York.

### JOBS

Restaurant and Foodservice **Employment**




Restaurant jobs represent **8 percent** of total employment in New York.

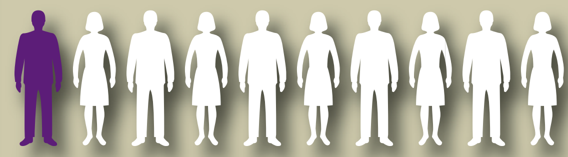
### SALES

In 2009, New York's restaurants will register **$27.8 billion** in sales.*

* projected

## America's Restaurants: By the Numbers

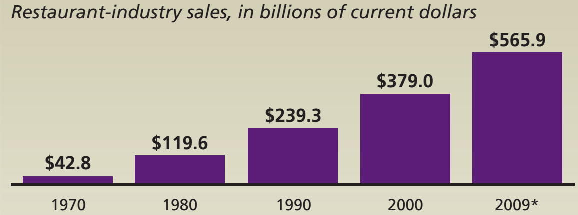
Almost **1 in 10** working Americans are restaurant employees



Restaurants' **share of the food dollar** is rising


Annual industry sales exceed a **half-trillion dollars**

*Restaurant-industry sales, in billions of current dollars*




* projected
**Source:** National Restaurant Association

## Did you know?

- **More than one out of four** American adults got their first job in a restaurant.
- **Nearly half of all Americans** have worked in a restaurant at some point in their working careers.
- America's eating-and-drinking places employ **more minority managers** than any other industry.

**Sources:** Figures are based on National Restaurant Association research and data from federal and state government agencies.

See www.restaurant.org/research/state for more information

National Restaurant Association
www.restaurant.org

New York State Restaurant Association
We serve you
www.nysra.org

# New York's Restaurants:
## Impact by Congressional District

| Cong. Dist. | U.S. Representative | Restaurant Establishments* | Restaurant Employees* |
|---|---|---|---|
| 1 | Timothy H. Bishop (D) | 1,350 | 17,431 |
| 2 | Steve Israel (D) | 1,225 | 15,812 |
| 3 | Peter King (R) | 1,357 | 17,513 |
| 4 | Carolyn McCarthy (D) | 1,436 | 18,534 |
| 5 | Gary L. Ackerman (D) | 973 | 12,560 |
| 6 | Gregory W. Meeks (D) | 476 | 6,151 |
| 7 | Joseph Crowley (D) | 919 | 11,866 |
| 8 | Jerrold Nadler (D) | 4,401 | 56,812 |
| 9 | Anthony Weiner (D) | 801 | 10,342 |
| 10 | Edolphus Towns (D) | 453 | 5,851 |
| 11 | Yvette D. Clarke (D) | 525 | 6,777 |
| 12 | Nydia Velazquez (D) | 975 | 12,587 |
| 13 | Michael E. McMahon (D) | 893 | 11,526 |
| 14 | Carolyn Maloney (D) | 2,559 | 33,039 |
| 15 | Charles B. Rangel (D) | 616 | 7,947 |
| 16 | Jose Serrano (D) | 446 | 5,756 |
| 17 | Eliot Engel (D) | 903 | 11,662 |
| 18 | Nita M. Lowey (D) | 1,465 | 18,915 |
| 19 | John J. Hall (D) | 1,129 | 14,574 |
| 20 | *Vacant Seat* | 1,352 | 17,459 |
| 21 | Paul Tonko (D) | 1,602 | 20,684 |
| 22 | Maurice D. Hinchey (D) | 1,722 | 22,235 |
| 23 | John M. McHugh (R) | 1,399 | 18,057 |
| 24 | Michael A. Arcuri (D) | 1,308 | 16,887 |
| 25 | Daniel B. Maffei (D) | 1,365 | 17,622 |
| 26 | Christopher John Lee (R) | 1,325 | 17,105 |
| 27 | Brian Higgins (D) | 1,651 | 21,310 |
| 28 | Louise McIntosh Slaughter (D) | 1,348 | 17,404 |
| 29 | Eric J. J. Massa (D) | 1,378 | 17,785 |
| | **TOTAL** | **37,354** | **482,200** |

***** Estimates are for eating-and-drinking place establishments and employees in 2007. "Eating-and-drinking places" is a Census designation that represents about three-fourths of all restaurant and foodservice employment.

**Source:** National Restaurant Association, based on data from the Bureau of Labor Statistics and U.S. Census Bureau.

NATIONAL RESTAURANT ASSOCIATION®
**www.restaurant.org**

NEW YORK STATE RESTAURANT ASSOCIATION
*We serve you*
**www.nysra.org**

NATIONAL RESTAURANT ASSOCIATION®

www.restaurant.org/research

# Massachusetts
## Restaurant Industry at a Glance

**Massachusetts's restaurants are an increasingly important part of the state's economy.** Restaurants are a key driver of employment in Massachusetts, and their sales generate tremendous tax revenues for the state.

The contribution of Massachusetts's restaurants extends far beyond the jobs they create, the careers they build and the revenues they generate. America's restaurants today are leaders in nutrition and healthy living, sustainability and social responsibility, and entrepreneurship and business opportunities.

For more information visit www.restaurant.org.

## Massachusetts Restaurants by the Numbers

### LOCATIONS

In 2007, there were **14,088** eating-and-drinking places in Massachusetts.

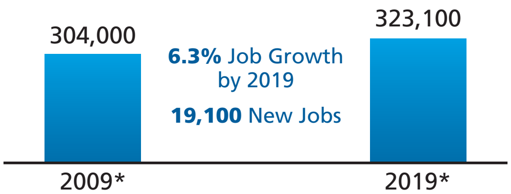
### STATE ECONOMY

Every $1 spent in Massachusetts's restaurants generates an additional **$1.02 in sales** for Massachusetts's economy.

Each additional $1 million spent in Massachusetts's eating-and-drinking places generates an additional **24.1 jobs** in Massachusetts.

### JOBS

Restaurant and Foodservice **Employment**




Restaurant jobs represent **9 percent** of total employment in Massachusetts.

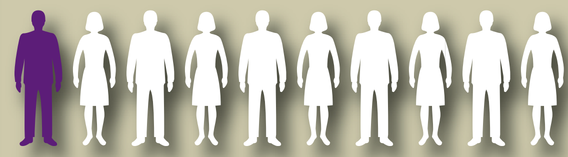
### SALES

In 2009, Massachusetts's restaurants will register **$11.8 billion** in sales.*

* projected

## America's Restaurants:
# By the Numbers

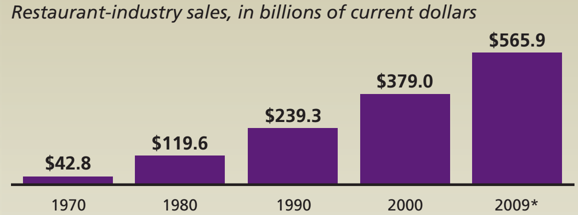
Almost **1 in 10** working Americans are restaurant employees



Restaurants' **share of the food dollar** is rising


Annual industry sales exceed a **half-trillion dollars**

*Restaurant-industry sales, in billions of current dollars*




* projected
**Source:** National Restaurant Association

## Did you know?

- **More than one out of four** American adults got their first job in a restaurant.
- **Nearly half of all Americans** have worked in a restaurant at some point in their working careers.
- America's eating-and-drinking places employ **more minority managers** than any other industry.

**Sources:** Figures are based on National Restaurant Association research and data from federal and state government agencies.

See www.restaurant.org/research/state for more information

NATIONAL RESTAURANT ASSOCIATION®

mra Massachusetts Restaurant Association

www.restaurant.org

www.marestaurantassoc.org

# Massachusetts's Restaurants:
## Impact by Congressional District

| Cong. Dist. | U.S. Representative | Restaurant Establishments* | Restaurant Employees* |
|---|---|---|---|
| 1 | John W. Olver (D) | 1,449 | 22,613 |
| 2 | Richard E. Neal (D) | 1,307 | 20,399 |
| 3 | James P. McGovern (D) | 1,483 | 23,132 |
| 4 | Barney Frank (D) | 943 | 14,706 |
| 5 | Niki Tsongas (D) | 1,211 | 18,893 |
| 6 | John F. Tierney (D) | 1,537 | 23,980 |
| 7 | Edward J. Markey (D) | 805 | 12,561 |
| 8 | Michael Capuano (D) | 1,926 | 30,053 |
| 9 | Stephen F. Lynch (D) | 1,521 | 23,738 |
| 10 | William Delahunt (D) | 1,905 | 29,724 |
| | **TOTAL** | **14,088** | **219,800** |

* Estimates are for eating-and-drinking place establishments and employees in 2007. "Eating-and-drinking places" is a Census designation that represents about three-fourths of all restaurant and foodservice employment.

**Source:** National Restaurant Association, based on data from the Bureau of Labor Statistics and U.S. Census Bureau.

NATIONAL RESTAURANT ASSOCIATION®

www.restaurant.org

MRA Massachusetts Restaurant Association

www.marestaurantassoc.org

NATIONAL RESTAURANT ASSOCIATION® | www.restaurant.org/research

# Rhode Island

## Restaurant Industry at a Glance

**Rhode Island's restaurants are an increasingly important part of the state's economy.** Restaurants are a key driver of employment in Rhode Island, and their sales generate tremendous tax revenues for the state.

The contribution of Rhode Island's restaurants extends far beyond the jobs they create, the careers they build and the revenues they generate. America's restaurants today are leaders in nutrition and healthy living, sustainability and social responsibility, and entrepreneurship and business opportunities.

For more information visit www.restaurant.org.

## Rhode Island Restaurants by the Numbers

### LOCATIONS

In 2007, there were **2,663** eating-and-drinking places in Rhode Island.

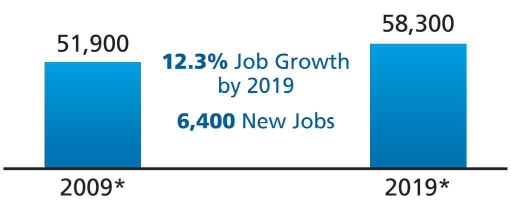
### STATE ECONOMY

Every $1 spent in Rhode Island's restaurants generates an additional **$.85 in sales** for Rhode Island's economy.

Each additional $1 million spent in Rhode Island's eating-and-drinking places generates an additional **24.7 jobs** in Rhode Island.

### JOBS

Restaurant and Foodservice **Employment**




Restaurant jobs represent **11 percent** of total employment in Rhode Island.

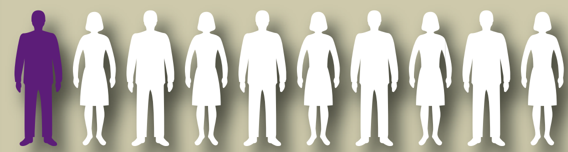
### SALES

In 2009, Rhode Island's restaurants will register **$1.8 billion** in sales.*

* projected

## America's Restaurants: By the Numbers

### Almost **1 in 10** working Americans are restaurant employees

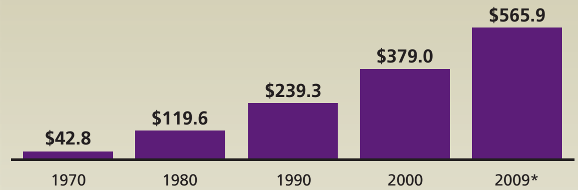


### Restaurants' **share of the food dollar** is rising

| 1955 | Present |
|---|---|
| 25% | 48.0% |

### Annual industry sales exceed a **half-trillion dollars**

*Restaurant-industry sales, in billions of current dollars*




* projected
**Source:** National Restaurant Association

## Did you know?

- **More than one out of four** American adults got their first job in a restaurant.
- **Nearly half of all Americans** have worked in a restaurant at some point in their working careers.
- America's eating-and-drinking places employ **more minority managers** than any other industry.

**Sources:** Figures are based on National Restaurant Association research and data from federal and state government agencies.

See www.restaurant.org/research/state for more information

NATIONAL RESTAURANT ASSOCIATION® | RI HOSPITALITY ASSOCIATION RI HOSPITALITY EDUCATION FOUNDATION Voice of Rhode Island's Lodging, Restaurant and Tourism Industry

www.restaurant.org | www.rihospitality.org

# Rhode Island's Restaurants:
## Impact by Congressional District

| Cong. Dist. | U.S. Representative | Restaurant Establishments* | Restaurant Employees* |
|---|---|---|---|
| 1 | Patrick J. Kennedy (D) | 1,259 | 18,535 |
| 2 | James R. Langevin (D) | 1,404 | 20,665 |
| | **TOTAL** | **2,663** | **39,200** |

***** Estimates are for eating-and-drinking place establishments and employees in 2007. "Eating-and-drinking places" is a Census designation that represents about three-fourths of all restaurant and foodservice employment.

**Source:** National Restaurant Association, based on data from the Bureau of Labor Statistics and U.S. Census Bureau.

NATIONAL RESTAURANT ASSOCIATION®
www.restaurant.org

RI HOSPITALITY ASSOCIATION
RI HOSPITALITY EDUCATION FOUNDATION
Voice of Rhode Island's Lodging, Restaurant and Tourism Industry
www.rihospitality.org

NATIONAL RESTAURANT ASSOCIATION® | www.restaurant.org/research

# New Hampshire

## Restaurant Industry at a Glance

**New Hampshire's restaurants are an increasingly important part of the state's economy.** Restaurants are a key driver of employment in New Hampshire, and their sales generate tremendous tax revenues for the state.

The contribution of New Hampshire's restaurants extends far beyond the jobs they create, the careers they build and the revenues they generate. America's restaurants today are leaders in nutrition and healthy living, sustainability and social responsibility, and entrepreneurship and business opportunities.

For more information visit www.restaurant.org.

## New Hampshire Restaurants by the Numbers

### LOCATIONS

In 2007, there were **2,824** eating-and-drinking places in New Hampshire.

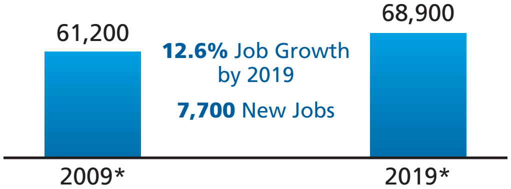
### STATE ECONOMY

Every $1 spent in New Hampshire's restaurants generates an additional **$.84 in sales** for New Hampshire's economy.

Each additional $1 million spent in New Hampshire's eating-and-drinking places generates an additional **22.9 jobs** in New Hampshire.

### JOBS

Restaurant and Foodservice **Employment**




Restaurant jobs represent **9 percent** of total employment in New Hampshire.

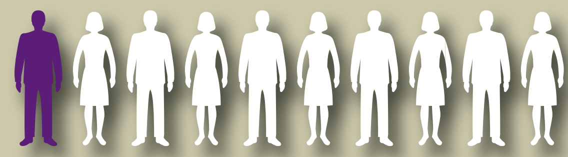
### SALES

In 2009, New Hampshire's restaurants will register **$2.1 billion** in sales.*

* projected

## America's Restaurants: By the Numbers

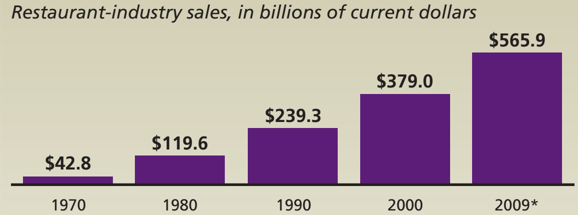
Almost **1 in 10** working Americans are restaurant employees



Restaurants' **share of the food dollar** is rising


Annual industry sales exceed a **half-trillion dollars**

*Restaurant-industry sales, in billions of current dollars*




* projected
**Source:** National Restaurant Association

## Did you know?

- **More than one out of four** American adults got their first job in a restaurant.
- **Nearly half of all Americans** have worked in a restaurant at some point in their working careers.
- America's eating-and-drinking places employ **more minority managers** than any other industry.

**Sources:** Figures are based on National Restaurant Association research and data from federal and state government agencies.

See www.restaurant.org/research/state for more information

NATIONAL RESTAURANT ASSOCIATION®
www.restaurant.org

NHLRA
NEW HAMPSHIRE LODGING & RESTAURANT ASSOCIATION
www.nhlra.com

# New Hampshire's Restaurants:
## Impact by Congressional District

| Cong. Dist. | U.S. Representative | Restaurant Establishments* | Restaurant Employees* |
|---|---|---|---|
| 1 | Carol Shea-Porter (D) | 1,528 | 23,973 |
| 2 | Paul W. Hodes (D) | 1,296 | 20,327 |
| | **TOTAL** | **2,824** | **44,300** |

***** Estimates are for eating-and-drinking place establishments and employees in 2007. "Eating-and-drinking places" is a Census designation that represents about three-fourths of all restaurant and foodservice employment.

**Source:** National Restaurant Association, based on data from the Bureau of Labor Statistics and U.S. Census Bureau.

NATIONAL RESTAURANT ASSOCIATION®
www.restaurant.org

NHLRA
NEW HAMPSHIRE LODGING & RESTAURANT ASSOCIATION
www.nhlra.com

# Appendix C: Commercial Foodservice Publications

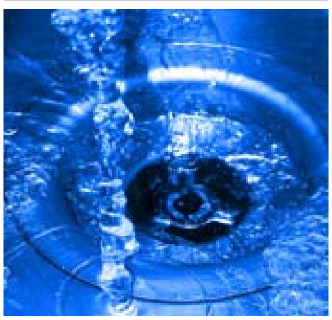
ENERGY STAR

# ENERGY STAR® Guide for Restaurants

## Putting Energy into Profit







EPA
United States
Environmental Protection
Agency

LEARN MORE AT energystar.gov

ENERGY STAR®, a U.S. Environmental Protection Agency program, helps us all save money and protect our environment through energy efficient products and practices. For more information, visit www.energystar.gov.

# Contents

| Contents | Page |
|---|---|
| Energy Efficiency and Your Restaurant | 1 |
| Cooking Appliances | 2 |
| Refrigeration Systems and Ice Machines | 4 |
| Lamps and Lighting Fixtures | 5 |
| Heating, Cooling and Ventilation | 6 |
| Water and Waste Management | 7 |
| Begin the Process, Learn More and Save! | 8 |

## IN PARTNERSHIP WITH

PG&E Food Service Technology Center is the industry leader in commercial kitchen energy efficiency and appliance-performance testing as well as a leading source of expertise in commercial kitchen ventilation and sustainable building design.

National Restaurant Association's Conserve initiative explores conservation efforts in restaurants around the nation and offers suggestions and resources to help operators reduce their costs and improve their environmental performance.

## ACKNOWLEDGEMENTS

This best-practices guide was created with the assistance of California's four investor-owned utilities (Southern California Gas Company, Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Edison). These energy suppliers are working together to provide comprehensive energy efficiency resources for California's food service industry, including, but not limited to, the following resources: rebates for cooking and refrigeration equipment, food service specific seminars and workshops, Web tools, energy audits, appliance testing, and energy education centers. The California energy-efficiency research and educational programs are funded by California ratepayers under the auspices of the California Public Utilities Commission and are administered by the four investor-owned utilities.

Southern California Gas Company
A Sempra Energy utility®
*www.socalgas.com/business*

PG&E®
*www.pge.com/fstc*

SDGE
A Sempra Energy utility®
*www.sdge.com/foodservice*

SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company
*www.sce.com/CTAC*

*Disclaimer: all energy, water, and monetary savings listed in this document are based upon average savings for end users and are provided for educational purposes only. Actual energy savings might vary based on use and other factors.*

## FIVE EASY STEPS TO SAVE ENERGY AND WATER

**1** *Install compact fluorescent lamps* (CFLs) in your walk-in refrigerators and kitchen ventilation hoods (and throughout your restaurant where appropriate).

**2** *Install a high-efficiency pre-rinse spray valve* in your dishroom and save hundreds of dollars a year!

**3** *Fix water leaks immediately*—especially hot water leaks: wasted water, sewer, and water heating costs can add up to hundreds of dollars a year.

**4** *Perform walk-in refrigerator maintenance:* check and replace door gaskets; clean evaporator and condenser coils; check refrigerant charge.

**5** *Replace worn-out cooking and refrigeration equipment* with ENERGY STAR qualified models!

Get additional easy to implement tips at: http://conserve.restaurant.org

Energy efficiency is a sound business practice that improves profitability, reduces greenhouse gas emissions, and conserves resources. This guide is designed to help your restaurant save energy and water, protect our Earth, and boost your bottom line.

## ENERGY EFFICIENCY AND YOUR RESTAURANT

Restaurants use about 2.5 times more energy per square foot than other commercial buildings.

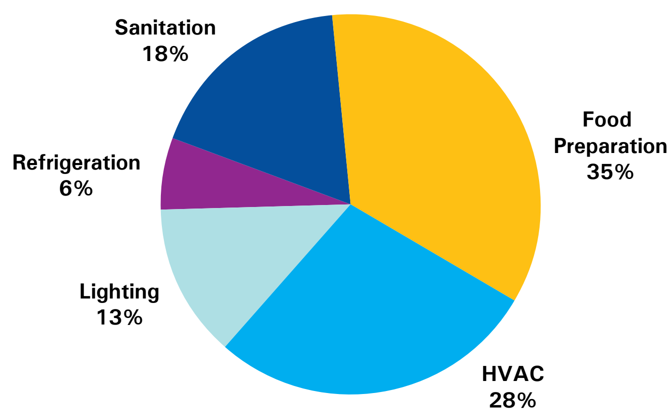
Energy costs have been increasing at a rate of 6 to 8 percent per year. Investing in energy efficiency is the best way to protect your business against rising energy prices.

Most commercial kitchen appliances are energy intensive. For instance, a typical electric deep fat fryer uses more than 11,000 kilowatt-hours (kWh) of energy per year which could cost you more than $1,100 in electricity.

You can reduce your restaurant's energy consumption by following the **Cost Saving Tips** outlined below and throughout this guide:

- Buy ENERGY STAR qualified appliances. If you're in the market for new equipment, think in terms of life-cycle costs, which include purchase price, annual energy costs, and other long-term costs associated with the equipment. High-efficiency appliances could cost more upfront, but significantly lower utility bills can make up for the price difference. Be sure to ask your dealer or kitchen designer to supply you with ENERGY STAR qualified equipment.
- Cut idle time. If you leave your equipment ON when it is not performing useful work, it costs you money. Implement a startup/shutdown plan to make sure you are using only the equipment that you need, when you need it.
- Maintain and repair. Leaky walk-in refrigerator gaskets, freezer doors that do not shut, cooking appliances that have lost their knobs—all these "energy leaks" add up to money wasted each month. Don't let everyday wear and tear drive up your energy bills.

**Example of the Average Energy Consumption in a Full-service Restaurant**
(British Thermal Units [Btu])




- Cook wisely. Ovens tend to be more efficient than rotisseries; griddles tend to be more efficient than broilers. Examine your cooking methods and menu; find ways to rely on your more energy-efficient appliances to cook for your customers.
- Recalibrate to stay efficient. The performance of your kitchen equipment changes over time. Thermostats and control systems can fail, fall out of calibration, or simply become readjusted. Take the time to do a regular thermostat check on your appliances, refrigeration, dish machines, and hot water heaters and reset them to the correct operating temperature.

## COOKING APPLIANCES

When replacing old appliances or buying new ones, look beyond the sticker price. Buying and installing equipment that has earned the ENERGY STAR could trim hundreds of dollars from your annual utility bills. In order to realize the most savings from your ENERGY STAR qualified equipment you must train your staff to use energy wisely by following good operating practices such as those in the **Cost-Saving Tips** that follow.

### Steamers

Steam cookers provide an effective way to batch-cook food but generating steam is an energy-intensive process. ENERGY STAR qualified steamers have a sealed cooking cavity that consumes a fraction of the energy and water required by traditional open systems. In many cases the dollar savings are so great that it makes sense to replace an existing steamer with an ENERGY STAR qualified one.

**Cost-Saving Tips**

- Look for the ENERGY STAR
- Close the door
- Use the timer
- Cut idle time
- Maintain & repair

Good practices can save:

$250 to $350 in annual energy costs for a traditional, electric, open-system steamer by eliminating an hour of idle time per day.

Buy an ENERGY STAR qualified connectionless steamer and save:

- $680 for water and sewer costs annually
- $510 for electricity annually (electric steamer), or
- $390 for gas annually (gas steamer)

Equating to an average $1,190 total savings for an electric steamer or $1,070 total savings for a gas steamer (some restaurants with high commercial sewer costs can save hundreds of dollars more annually)

### Fryers

Energy-efficient fryers that have earned the ENERGY STAR offer shorter cook times, faster temperature recovery times, and ultimately higher pound-per-hour production rates through advanced burner and heat exchanger designs. Some models also offer an insulated fry pot, which reduces standby losses, giving the fryer a lower idle energy rate.

**Cost-Saving Tips**

- Look for the ENERGY STAR
- Cut idle time & turn off back-up fryers when possible
- Recalibrate

Good practices can save:

$250 annually for a gas fryer by cutting four hours of idle time per day.

Buy an ENERGY STAR qualified fryer and save:

- $120 for electricity annually (electric fryer), or
- $590 for gas annually (gas fryer)

### Convection Ovens

Convection ovens are the industry standard due to faster cook-times produced by increased hot air movement inside the oven cavity. In addition, convection ovens are now eligible for ENERGY STAR qualification.

**Cost-Saving Tips**

- Look for the ENERGY STAR
- Cut idle time & turn off back-up ovens when possible
- Fully load the oven when cooking
- Replace seals & tighten hinges

Buy an ENERGY STAR qualified convection oven and save:

- $190 for electricity annually (electric oven), or
- $360 for gas annually (gas oven)

## Griddles

Griddles are a versatile piece of equipment and a workhorse appliance found on most kitchen lines. Variations in efficiency, production capacity, and temperature uniformity make it important to choose wisely when shopping for a griddle. Many energy-efficient griddles can deliver both high production capacity and excellent temperature uniformity.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Cut idle time
- Recalibrate

**Good practices can save:**

$250 annually from a gas griddle by cutting three hours of idle time per day.

**Buy an ENERGY STAR qualified griddle and save:**

- $190 for electricity annually (electric griddle), or
- $175 for gas annually (gas griddle)

## Holding Cabinets

ENERGY STAR hot food holding cabinets typically feature improved insulation, so heat stays in the cabinet and out of the kitchen. An insulated ENERGY STAR holding cabinet uses about half the energy consumed by an uninsulated cabinet. Other available features that could potentially save energy include magnetic door gaskets, auto-door closers, and dutch doors.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Shut off overnight
- Use the timer
- Replace missing or worn out control knobs

**Good practices can save:**

$500 annually by turning off an uninsulated holding cabinet when the kitchen is closed.

**Buy an ENERGY STAR qualified holding cabinet and save:**

- $340 to $960 annually for electricity

## Combination Ovens

The combination oven is an extrememly versatile cooking platorm with the added bonus of a self-cleaning feature. Operating a combination oven in "steam" or "combination" mode typically uses more energy and water than operating in traditional convection mode. Use the oven's programming capabilities to properly control different cooking modes to maximize energy efficiency and cost savings. Do your homework when buying a combination oven: the most efficient models will use about half as much energy and water as the inefficient models.

**Good practices can save:**

$400 to $800 annually off an electric combination oven by cutting out two hours of idle time per day.

**If ENERGY STAR qualified models don't exist for the type of equipment you're looking for don't worry: you still have options. Ask distributors and manufacturers for energy use information, and check online for equipment reviews. The California commercial food service incentive program is also a third party resource because, like ENERGY STAR, appliances that qualify must meet designated efficiency standards. The list of qualifying appliances can be found at: www.fishnick.com/saveenergy/rebates.**

## Broilers

Broilers are true kitchen workhorses but their dependability and simplicity come at a price: searing heat requires a great deal of energy and broilers have simple, non-thermostatic controls. This combination can make the broiler the most energy intensive appliance in the kitchen. For example, one gas broiler can use more energy than six gas fryers. A new generation of broilers incorporates better radiant designs, allowing the broiler to get the job done while consuming about 25 percent less energy.

### Cost-Saving Tips

- Cut preheat time
- Turn off unneeded sections
- Reduce idle time
- Replace missing knobs

Good practices can save:

$600 annually by cutting out three hours of idle time per day.

## Ranges

The range top is one of the most widely used pieces of equipment in restaurant kitchens. Ranges are manually controlled and can be energy guzzlers depending on how you operate them. A potential alternative to traditional range tops are induction ranges; they are more expensive but offer very high efficiency, rapid heat up, precise controls, and low maintenance.

### Cost-Saving Tips

- Maintain and adjust burners
- Use a lid
- Cut idle time

# REFRIGERATION SYSTEMS AND ICE MACHINES

## Reach-In Refrigerators and Freezers

Compared to standard models, ENERGY STAR qualified commercial refrigerators and freezers can lead to energy savings of as much as 35 percent with a 1.3 year payback. Glass door refrigerators and freezers can now earn the ENERGY STAR too! Features that could potentially save energy include improved insulation and components such as high-efficiency compressors and motors.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Turn off door heaters when possible
- Clean coils
- Set defrost timers
- Replace worn gaskets

Buy ENERGY STAR qualified equipment and save:

- $200 for electricity annually (per solid door refrigerator)
- $140 for electricity annually (per solid door freezer)

## Walk-In Refrigerators

Walk-in refrigerators are extremely important to any successful restaurant. Improve this equipment's energy performance with a few inexpensive upgrades and good practices, such as:

- Swapping out incandescent light bulbs for low-temperature ENERGY STAR qualified compact fluorescent lamps (CFLs) can reduce the lamps' heat output by 75 percent! (Look for the lowest possible "minimum start temperature" on the CFL box, e.g., zero degrees Fahrenheit.)
- Adding strip curtains and automatic door closers to your walk-in refrigerator: *they are inexpensive and easy-to-install.* Strip curtains can cut outside air infiltration by about 75 percent!
- Installing electronically commutated motors (ECM) on the evaporator and condenser fans reduces fan energy consumption by approximately two-thirds.

### Cost-Saving Tips

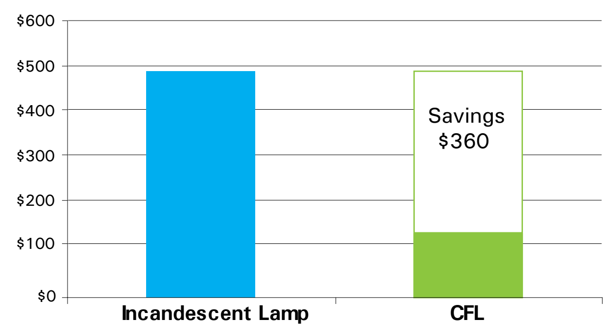
- Allow air circulation
- Insulate suction lines
- Check refrigerant charge
- Repair and realign doors
- Clean coils

## LAMPS AND LIGHTING FIXTURES

In a typical restaurant, lights are usually on for 16 to 20 hours a day. For many areas in your restaurant, high-efficiency ENERGY STAR CFLs and lighting fixtures are your ticket to savings.

- Install ENERGY STAR qualified fixtures and CFLs in your dining area and reduce energy consumption and heat output by 75 percent.
- Install occupancy sensors in closets, storage rooms, break rooms, restrooms, and even walk-in refrigerators. Look for sealed, low-temperature-specific sensors for refrigerated environments.
- If your restaurant features linear fluorescent lighting with T12 lamps and magnetic ballasts it is time to upgrade. Switch to more efficient T8 or T5 lamps with electronic ballasts. Electronic ballasts typically have faster on-times and do not hum or flicker. Look for utility incentives for lighting upgrades in your area.
- Swap your old Open/Closed and EXIT signs with LED technology for electricity savings up to 80 percent.
- Visit www.energystar.gov/lighting for more cost-saving information.

**Annual Savings After Replacing Eight Incandescent Lamps with Eight CFLs**




**CFL vs. Incandescent Light Bulbs**

If each of the 945,000 restaurants in the United States replaced only one incandescent light bulb with a CFL, more than 630 million pounds of $CO_2$ emissions could be avoided each year (the annual greenhouse gas emissions from more than 52,000 passenger vehicles*), and the restaurant industry could save about $42.5 million annually.

*Source: EPA Greenhouse Gas Equivalencies Calculator: www.epa.gov/cleanenergy/energy-resources/calculator.html

### Ice Machines

Commercial ice machines that earn the ENERGY STAR are on average 15 percent more energy efficient and 10 percent more water efficient than standard models.

- Cut down on your daytime electricity demand by installing a timer and shifting ice production to nighttime off-peak hours.
- Bigger ice machines are typically more efficient than smaller ones, yet the price difference is usually not very large. Choose wisely and you could get twice the ice capacity at half the energy cost per pound of ice.
- Avoid water-cooled ice machines because of their high water cost, which make them significantly more expensive to operate. *Note: water-cooled ice machines do not currently qualify for ENERGY STAR.*

#### Cost-Saving Tips

- Look for the ENERGY STAR
- Clean the coils
- Keep the lid closed
- Adjust the purge water timer

Buy an ENERGY STAR qualified ice machine and save:
- $120 for electricity annually

### Mercury and CFLs

**CFLs contain a very small amount of mercury sealed within the glass tubing (approximately 4 milligrams). By comparison, older thermometers contain about 500 milligrams of mercury an amount equal to the mercury in 125 CFLs. No mercury is released when the bulbs are intact (not broken) or in use. For more information about recycling and disposing of CFLs visit: www.energystar.gov/mercury.**

# HEATING, COOLING AND VENTILATION

Making smart decisions about your restaurant's heating, ventilating, and air conditioning (HVAC) system can have a big effect on your utility bills—and your customers' comfort.

## Heating and Cooling Systems

Heating and cooling systems account for a large portion of your restaurant's annual energy use. For many restaurants, heating and cooling is second only to food preparation in terms of annual energy consumption.

Energy use falls by 4 to 5 percent for every degree that you raise your cooling thermostat setpoint. Easing back on central cooling by only 3°F could trim air conditioning costs by 12 to 15 percent. Improve customer comfort by using an efficient ENERGY STAR qualified ceiling fan to compensate for the difference in air temperature. Ensure that your heating and cooling equipment is included in the start-up and shut down schedule to save even more.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Clean heat-transfer coils
- Replace air filters
- Consider an Energy Management System
- Repair broken duct work
- Recommission economizers

Don't forget about the restroom! ENERGY STAR qualified ventilating fans use 70 percent less energy than standard models.

### Buy ENERGY STAR qualified equipment and save:

- $1.70 per square foot over the life of the HVAC equipment ($4,250 for a 2,500 square foot restaurant; the same as $430 annually)
- $17 annually for electricity costs per ceiling fan
- $75 annually for electricity costs for ventilating fans that are run continuously

**According to the Consortium for Energy Efficiency (CEE), at least 25 percent of all rooftop HVAC units are oversized, resulting in increased energy costs and equipment wear. Properly sized equipment dramatically cuts energy costs, increases the life of the equipment, and reduces greenhouse gas emissions.**

## Kitchen Ventilation

An unbalanced or poorly designed kitchen exhaust system can allow heat and smoke to spill into your kitchen, spelling trouble both for your restaurant's air quality and for your utility bills. Spillage leads to a hot, uncomfortable working environment and higher energy bills for air-conditioned kitchens.

- Cut down on spillage by adding inexpensive side panels to hoods.
- Push each cooking appliance as far back against the wall as possible to maximize hood overhang and close the air gap between the appliance and the wall.
- Install a demand-based exhaust control. It uses sensors to monitor your cooking and varies the exhaust fan speed to match your ventilation needs. Demand ventilation controls could reduce your exhaust system costs by anywhere from 30 to 50 percent and can be installed on either new equipment or retrofitted to existing hoods.

### Learning More About Kitchen Ventilation

If you're getting ready to design a new kitchen or renovate an old one, check out "Improving Commercial Kitchen Ventilation System Performance," a two-part kitchen ventilation design guide written by the experts at PG&E FSTC and available at: www.fishnick.com/equipment/ckv/designguides.

## Windows

Applying a clear, heat rejecting window film will help cut your cooling costs while making your dining room more comfortable. Use only high quality window film installed by a qualified professional.

## Patio Heaters

The best approach to saving money with patio heaters is to cut back their use—both for hours of operation and for the number of patio heaters running at any given time. Patio heaters are radiant devices that heat up quickly so there is no reason to leave them running if a seating area is temporarily empty.

### Good practices can save:

$530 per heater annually by cutting three hours of use per day

# WATER AND WASTE MANAGEMENT

## Water Use

Using water more efficiently preserves water supplies, saves money, and protects the environment. By conserving hot water you trim not one but two bills: one for the water and sewer and another for the electricity or natural gas used to heat the water used in bathroom faucets, kitchen sinks, and dishwashers.

### Cost-Saving Tips

- Look for the ENERGY STAR and WaterSense label
- Add aerators
- Install WaterSense labeled toilets
- Repair leaks
- Reduce sink and tap usage

Similar to the ENERGY STAR, the WaterSense® label identifies water-efficient products and programs. WaterSense is a partnership program sponsored by EPA and additional information is available at: www.epa.gov/watersense.

look for WaterSense Meets EPA Criteria

### Good practices can save:

$1,000 annually by turning down dipper wells and making sure they are OFF when the kitchen is closed

$1,000 annually by fixing leaks in sinks, mop-stations, and dishmachines

### Look for WaterSense labeled equipment and use WaterSense irrigation partners to landscape your restaurant:

Bathroom faucets are 30 percent more water efficient

Landscaping with WaterSense irrigation partner could save you 15 percent compared to average watering bills

## High-Efficiency Pre-Rinse Spray Valves

A high-efficiency, or low-flow, pre-rinse spray valve is one of the most cost-effective energy saving devices available to the foodservice operator. And it is easy to install! Just unscrew your old spray valve and screw in your new, water-efficient one.

In addition to minimizing hot water consumption, you can reduce both your water-heating and sewer expenditures per month. How? Typical spray valves can release hot water at a rate of three to four gallons of water per minute (gpm), while common high-efficiency units spray only 1.6 gpm or less without sacrificing cleaning power!

### Buy a 1.6 gpm spray valve and save:

$300 to $350 annually for water, sewer, and natural gas costs annually (used one hour a day and compared to 3 gpm sprayer).

Additional information is available at: www.fishnick.com/equipment/sprayvalves.

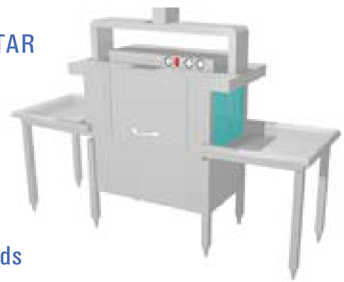
## Dishwashers

From an operational standpoint, dishwashers are one of the most expensive pieces of equipment in your kitchen. Commercial dishwashers that have earned the ENERGY STAR are on average 25 percent more energy and water efficient than standard models.

- Run fully loaded dish racks through the dish machine. Cutting wash cycles could save you hundreds of dollars annually.
- Pay attention to your dishwasher's pressure gauge—if it's showing pressure above 25 psi, there is a good chance you are using much more water than is necessary. Most dishwashers require only around 20 psi.
- If you have a conveyor-style dishwasher, make sure you are using it in auto mode, which saves electricity by running the conveyor motor only when needed.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Turn off at night
- Replace torn wash curtains
- Repair leaks
- Replace worn spray heads



Buy an ENERGY STAR qualified dishwasher and save:

- $975 for electricity annually
- $200 for water annually

## Waste Reduction Is Good Business

Waste reduction leads to increased operating efficiency and cost savings. Decreased solid waste generation reduces collection and disposal costs just as reducing electricity and water consumption reduces utility bills. Waste minimization also may reduce your purchasing costs for restaurant supplies.

Using recycling and composting bins, sustainable take-out containers, and "green" signage are all excellent ways to announce and to demonstrate to your customers your efforts to be more environmentally sustainable and aware.

For help identifying waste reduction opportunities please visit www.epa.gov/wastewise.

## BEGIN THE PROCESS, LEARN MORE AND SAVE!

The best first step is to perform an energy audit on your facility. Energy service providers (utilities), state energy offices, and private sector product and service providers can assist you in identifying a trained professional to conduct your audit. However, comprehensive, affordable energy audits are not available everywhere in the country for commercial food service businesses.

To help address the lack of energy audits in many communities, ENERGY STAR provides free online tools and information to achieve energy savings. ENERGY STAR's basic guidance for self-assessments is part of the Guidelines for Energy Management, "Step 2: Assess Performance," at: www.energystar.gov/guidelines.

In addition, ENERGY STAR's Portfolio Manager software is designed to help businesses "benchmark" and track energy use, costs, and greenhouse gas emissions. Portfolio Manager also offers the option to track water use and renewable energy credits—all in a password protected online file. Portfolio Manager users can track multiple facilities independently or aggregate all the business locations into one file. Your restaurant can generate a Statement of Energy Performance which includes a "weather-normalized" kBtu/ft$^2$ energy use intensity calculation, associated greenhouse gas emissions and a national average for similar building types. Access to the software and free online training in use of Portfolio Manager is available at: www.energystar.gov/benchmark.

Once you have identified the areas of potential energy savings, decide which energy efficiency upgrades you want to install and what practices to initiate. If your finances and operating schedule make it impractical to perform all the upgrades at once, you can take a staged approached and install them as time and money allow.

Remember, having your **restaurant manager** 100 percent on board is absolutely key to saving your restaurant money and protecting the environment! Your best-laid energy-saving plans are only as good as the staff that is implementing them!

## For more information, please consult the following online resources:

- ENERGY STAR Commercial Food Service: www.energystar.gov/cfs
- ENERGY STAR Restaurants: www.energystar.gov/restaurants
- ENERGY STAR Portfolio Manager: www.energystar.gov/benchmark
- PG&E Food Service Technology Center: www.fishnick.com
- National Restaurant Association Conserve: http://conserve.restaurant.org
- EPA WaterSense: www.epa.gov/watersense
- EPA WasteWise: www.epa.gov/wastewise

**Find Monetary Incentives**

ENERGY STAR CFS Incentive Finder: go to www.energystar.gov/cfs and click on “Special Offers” or go to www.energystar.gov/cfsrebate _ locator

December 2009

EPA 430-R-09-030

For more information visit www.energystar.gov.

Food Service Technology Center
*Promoting Energy Efficiency in Food Service*

conserve
solutions for sustainability

NATIONAL RESTAURANT ASSOCIATION®

energy
LEARN MORE AT energystar.gov

ENERGY STAR

# ENERGY STAR® FOR COMMERCIAL KITCHENS: HELPING CUSTOMERS MANAGE COSTS

Buildings with restaurants and other food service operations are very energy intensive, consuming roughly 2.5 times the energy per square foot as other commercial buildings, or close to 250,000 British thermal units (Btu) of energy per square foot.[1] Energy efficiency program administrators can help these customers rein in operating costs while also reducing energy use, peak demand, and water use by promoting ENERGY STAR qualified commercial food service (CFS) equipment and other best practices. Utility cost savings of 10 to 30 percent are achievable without sacrificing service, quality, style or comfort—all while making significant contributions to a cleaner environment.[2] The U.S. Environmental Protection Agency (EPA) is working with about 50 efficiency program administrators throughout the nation to integrate ENERGY STAR qualified CFS equipment into their program offerings. EPA is providing this fact sheet to introduce more program administrators to ENERGY STAR and the savings opportunities in commercial kitchens, as well as to share best practices for program design, implementation, and evaluation based on the experiences of recent CFS programs.

## DELIVERING SOLUTIONS IN COMMERCIAL KITCHENS

Promoting the installation of energy-efficient equipment in commercial kitchens is an important part of a comprehensive CFS program. It saves significant amounts of energy and offers meaningful financial benefits to the establishment. Utility costs are a major operating expense for the CFS industry, on the level of about one-half to almost parity with their profit margins—which, for a full service restaurant, is around 5 percent of sales.[3] Due to rising energy costs, CFS customers may be increasingly receptive to program administrator assistance for improving energy efficiency and reducing related utility bills. And the savings opportunities are significant: as much as 80 percent of the food service sector's $10 billion annual energy bill is expended on energy that does no useful work and a substantial portion of this waste is related to equipment inefficiencies.[4]

ENERGY STAR provides a comprehensive and cost-effective platform for promoting greater equipment efficiency and related best practices to CFS customers. ENERGY STAR currently identifies efficient products in eight product categories: hot food holding cabinets, solid door refrigerators and freezers, fryers, steam cookers, ice machines, commercial ovens, griddles, and dishwashers.

These energy-efficient products offer energy savings of 10 to 65 percent over standard models, depending upon the product category. Three of the product categories, commercial dishwashers, ice machines, and steam cookers, also offer water savings of up to 90 percent over standard models. Three CFS utility programs have earned ENERGY STAR awards for promoting these energy-saving products and are showing promising early returns. They include:

- California's four investor-owned utilities (IOUs)—Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), and San Diego Gas & Electric Company (SDG&E)—offer a coordinated statewide incentive program with strong early results, achieving annual electric savings of around 20.6 million kilowatt-hours (kWh) and annual natural gas savings of around 526,000 therms.[5]
- The Energy Trust of Oregon's (ETO) CFS program is achieving annual savings of nearly 1.2 million kWh and over 190,000 therms by partnering with dealers that sell CFS equipment directly to restaurants.[6]
- Wisconsin's Focus on Energy offers CFS customers a bonus incentive to encourage the purchase of multiple ENERGY STAR qualified products and is achieving annual electric savings of nearly 350,000 kWh and annual natural gas savings of nearly 22,000 therms.[7]

Outfitting an entire commercial kitchen with a suite of ENERGY STAR qualified equipment could save around 300 million Btus of energy and about $3,600 per year.

## PROGRAM DESIGN AND IMPLEMENTATION

A key factor in effective program design is understanding the market barriers to greater adoption of energy-efficient equipment and developing strategies to overcome these barriers. Common barriers in the CFS market include:

- ***Hard-to-reach market***—The CFS market is highly fragmented, both in terms of equipment supply channels and end use sectors.
- ***Lack of readily available supply***—CFS equipment suppliers typically compete on low prices and therefore stock only a limited supply of energy-efficient products. This barrier is compounded by customers who make short-term purchasing decisions due to the need to replace equipment quickly when it fails.
- ***Incremental costs***—ENERGY STAR qualified CFS equipment is generally more expensive than standard efficiency equipment and can cost significantly more than refurbished models sold in the used equipment market.
- ***Lack of knowledge***—Equipment suppliers and end users might not be aware of energy-efficient products, might have misperceptions about tradeoffs between energy efficiency and performance, or both.

The following sections describe the CFS equipment market in further detail and discuss program strategies for addressing the key barriers listed above.

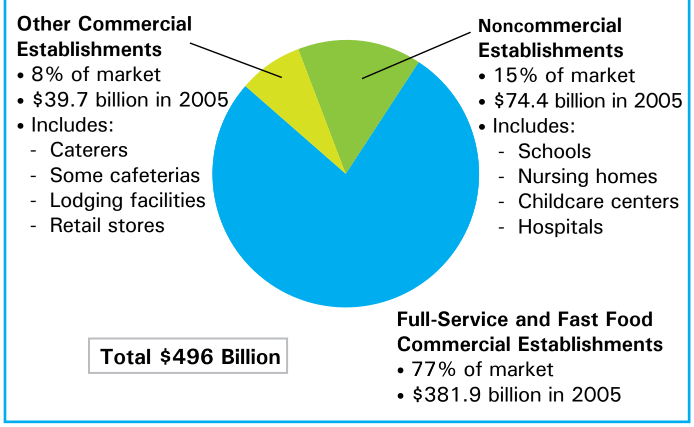
### Understanding and Engaging the CFS Market

Foodservice establishments include commercial and noncommercial entities, diverse business sectors, and account for approximately $500 billion in expenditures for food consumed away from the home (e.g., meals and snacks for on-premise or immediate consumption). Commercial establishments—including full service restaurants, fast food outlets, caterers, some cafeterias, lodging facilities, and retail stores—account for about 85 percent of this total with full-service restaurants and fast food restaurants representing the two largest industry segments, accounting for 77 percent of expenditures for food consumed away from the home. Noncommercial foodservice operators—those that prepare and serve food as an adjunct service in institutional settings (e.g., schools, nursing homes, childcare centers, and hospitals)—account for the remaining 15 percent.[8]

In addition to the diverse business sectors that comprise the foodservice industry, the CFS equipment market is complicated by multiple equipment distribution channels including:

- Dealers that primarily sell to individual restaurants.
- Distributors that primarily supply bulk quantities to equipment dealers and sell commodity equipment (e.g., ice machines, counter-top fryers) directly to end users.

**Breakdown of Consumer Expenditures for Food Consumed Away from Home in 2005**




Source: *Adapted from U.S. Department of Agriculture Economic Research Service, Briefing Room: Food Marketing System in the United States.*

- Manufacturers that sell through manufacturer representatives (reps) but may also sell directly to large end users such as national restaurant chains.
- Consultants that assist in either designing new or renovating existing commercial kitchens, typically working with restaurant chains, hotels, hospitals, and universities.

(Additional information on supply channel actors and strategies for influencing them can be found in the text box on page 3).

Due to the complexity of the CFS market and potential for widespread variability between service territories, program administrators should consider conducting a market assessment to: 1) understand the major sectors and primary distribution channels influencing the CFS equipment market in their territory, 2) develop estimates of likely program uptake for each sector

### ITW Food Equipment Group

2008 and 2009 ENERGY STAR Partner of the Year, ITW Food Equipment Group (ITW FEG)—the parent organization of independent companies such as Hobart, Stero, Vulcan, Traulsen, and Wittco—understands the importance of supporting customers in their drive to cut costs, use less water and consume less electricity, and has responded by offering 381 ENERGY STAR qualified CFS products.

> "ENERGY STAR plays an important role in helping foodservice operators and food retailers design a sustainable kitchen that's good for the environment and good for business in terms of efficiency, productivity and quality...Our partnership with ENERGY STAR enables us to emphasize the value of selecting equipment engineered for high efficiency and low water consumption."
>
> —*John McDonough, President of ITW FEG*

taking into account the uniqueness of each sector (e.g., while restaurants are often the largest segment, they are often the hardest segment to influence), and 3) establish program baseline conditions (e.g., what is the current market share for an efficient product, and what is the best estimate of market share over time absent a program). See related discussion under Measurement and Verification, page 7.

Another key best practice is to engage equipment suppliers and other key stakeholders, such as large and small restaurant customers and their trade associations, during program design. Engaging stakeholders early in the planning process can help program administrators better understand stakeholder business models and gauge receptivity to potential education, marketing, and incentive strategies.

Continuing this dialogue during program launch, particularly with supply-side market actors, is essential to ensuring that manufacturer reps, distributors, dealers, and businesses are familiar with program incentives, policies and procedures, and are able to effectively communicate the key benefits and features of qualified energy-efficient equipment to their customers. During these meetings, it is important to communicate both the mechanics of how the CFS program works and the business benefits of program participation.

An ENERGY STAR qualified commercial refrigerator can save a restaurant around $200 on energy costs per year. This may not seem like much until one considers the slim profit margins in the restaurant industry. If a restaurant operates with a profit margin of around 5 percent (the industry average), it will need to make roughly $4,000 in sales to earn $200 in profit.

## Improving Availability of ENERGY STAR® Qualified Equipment

In the retrofit market, purchasing often occurs when existing equipment fails, and the top priority is getting new equipment online quickly. Decisions on product selection and purchase are usually driven by product availability, price, and advice from the equipment supplier. Unfortunately, many suppliers do not stock or promote efficient equipment due to price premiums that range from 10 to 85 percent, depending on product category.

The following are important strategies for motivating suppliers to sell and stock ENERGY STAR qualified equipment:

**Make the business case—**It is important to educate suppliers on the value proposition for promoting ENERGY STAR qualified CFS equipment to their customers. While efficient equipment may have

## Supply Channel Actors

**Dealers**—Dealers primarily sell to individual restaurants, which is often the most difficult market to reach. Smaller dealers may join buying groups so they can compete more effectively with larger dealers. Many dealers display their products in showrooms and tend to stock lower-priced, popular models that are usually not energy-efficient. A dealer’s main objective is usually to sell the products they have on hand, and they are generally more interested in attracting customers with low prices rather than emphasizing the overall value of higher-end products (e.g., lifetime cost savings). Given that many manufacturers offer sales incentives to move lower-end models, dealer incentives can be an effective strategy to promote stocking and sales of energy-efficient equipment.

**Distributors**—Distributors primarily supply bulk quantities of equipment to dealers and sell commodity equipment (e.g., ice machines, fryers) directly to end users. Since distributors usually supply dealers, developing a good working relationship with distributors helps funnel energy-efficient CFS products into dealer showrooms. In addition, some restaurant food distributors sell CFS equipment and should also receive program outreach.

**Manufacturers and Reps**—CFS equipment manufacturers generally sell through product reps, although manufacturers may also sell directly to large end users such as national restaurant chains. Though all supply channels gravitate toward inexpensive, fast-moving pieces of equipment, a key value proposition for engaging reps is the up-sell potential of high-value, high-efficiency equipment. Sales of high-quality products earn reps a higher commission and generate long-term value for the customer, often leading to repeat business.

**Design Consultants**—Design consultants assist in the planning and design of new or renovated commercial kitchens, typically working with large or chain-owned restaurants, hotels, universities, and hospitals. Conducting targeted outreach to design consultants helps to ensure that energy- and water-efficient CFS equipment is considered in these types of projects. Design consultants are typically focused on the overall design and aesthetics of the space and controlling project costs, and back-of-the-house equipment is often a low priority. In addition, they often have established relationships with buying groups and may receive incentives for selling lower-end equipment. Equipment quality and performance are key selling points for engaging design consultants.

a higher first cost, it costs less to operate. With today's rising energy costs, efficient equipment will continue delivering dividends through lower utility bills for years to come. It is also important to highlight non-energy benefits of efficient products such as water savings, reduced noise, reduced waste heat, and other quality and performance features. Businesses that can effectively up-sell higher-end equipment can increase their bottom line.

**Sales incentives—**Upstream incentives, including salesperson incentives or "spiffs," can be effective at motivating equipment suppliers to promote the multiple benefits of energy-efficient products, rather than steering customers to low-cost products, which is the norm. Puget Sound Energy (PSE) offers a $30 "spiff" for each completed incentive application submitted by an equipment supplier; San Diego Gas & Electric Company (SDG&E) offers a $25 spiff.

### Program Highlight

**Puget Sound Energy's** $30 spiff rewards equipment suppliers for submitting completed incentive applications to the utility for processing on behalf of the customer. The supplier discounts the purchase price by the amount of PSE's customer rebate, so the customer receives an incentive at the point-of-purchase. Suppliers are reimbursed for the amount of the customer rebate, and get the $30 reward for their time and effort. This approach has led to higher turn-in rates for incentive applications, and fewer paperwork errors.

**Provide program information—**Providing easy access to up-to-date information about program offerings and procedures is essential to engaging and maintaining effective trade ally relationships. Initial kick-off workshops provide an opportunity to discuss the benefits of ENERGY STAR qualified CFS equipment and to inform participants of program requirements and incentive offerings. Conducting regular visits to trade ally showrooms/offices to discuss the program and distribute educational literature, point-of-purchase marketing materials, and incentive applications are also highly effective strategies for keeping trade allies informed. Other best practices include establishing a dedicated Web site and distributing electronic newsletters to keep equipment suppliers updated on program activities.

## Offering Customer Incentives to Overcome First-Cost Barriers

The incremental cost of some ENERGY STAR qualified equipment can be a significant barrier to purchasing products. In general, the incremental cost is highest for fryers and hot food holding cabinets; moderately high for commercial dishwashers, refrigerators and freezers, and ice machines; and lowest for steam cookers.

**Equipment rebates—**To overcome the significant barrier of incremental cost, the majority of CFS programs offer prescriptive rebates for the purchase of qualified equipment. Program administrators typically set incentive levels at 50 percent or less of the incremental cost of purchasing the ENERGY STAR qualified model versus a standard efficiency model. There is, however, no set formula for success when choosing equipment rebate levels, and CFS programs are achieving success with a range of levels. As of August 2008, the following incentive ranges were available from the online ENERGY STAR CFS equipment incentive finder tool.

**Table 1: Range of Incentives Offered by Program Sponsors (as of 5/09)***

| Product | Incentive Range |
|---|---|
| Fryers | $150–$1,000 |
| Hot food holding cabinets | $200–$500 |
| Refrigerators and freezers | $50–$500 |
| Steam cookers | $200–$1,500 |
| Ice machines | $50–$600 |
| Commercial dishwashers | $200–$2,000 |

Some programs, like Wisconsin's Focus on Energy, promote comprehensive kitchen efficiency upgrades by offering bonus incentives for the purchase of two or more pieces of qualified equipment. The customer is eligible for the usual per-unit equipment incentive, plus an additional $100 if they purchase two or more pieces of qualifying equipment, or $300 if they purchase three or more pieces of eligible equipment at a time. This strategy can be particularly effective when targeting commercial kitchen renovation and new construction opportunities.

The following are common best practices related to incentives:

- Tie incentive levels to ENERGY STAR specifications whenever possible to help customers easily identify products that qualify for rebates and to take advantage of the growing consumer awareness, market momentum, and supporting infrastructure provided by the program.
- Keep incentive application processes simple and straightforward.
- Maintain relatively consistent incentive levels from year to year, trending downward as market penetration increases.
- Ensure suppliers and buyers have easy access to a list of qualified models and related incentive levels. ENERGY STAR qualified product lists are available on each of the specific

* Note: *data include some programs offering incentives for equipment achieving higher efficiency levels than ENERGY STAR.*

product pages at *www.energystar.gov/cfs*. The California IOUs, which offer incentives for CFS equipment beyond ENERGY STAR qualified products, provide an online list of qualified equipment through PG&E's Food Service Technology Center (FSTC).

- Promote program and incentives through the online ENERGY STAR CFS equipment incentive finder tool (*www.energystar.gov/CFSrebate _ locator*).
- Educate customer call centers about program offerings, procedures, and where to direct customers for additional information.

**Audits—**Offering free or reduced-cost audits for commercial kitchen facilities is another form of incentive that can be useful for helping customers, particularly regional and national franchise chains, identify and correct operational inefficiencies, and for encouraging customers to take advantage of program rebate offerings when equipment purchases are needed. Customers are more likely to make smart decisions about CFS appliances if they have time to research options and secure the necessary capital to purchase new equipment. Many utilities offer audits to national restaurant chains as part of the menu of services they receive as managed accounts, and offer a higher level of support in helping such customers specify efficient equipment options for their facilities.

Audits can be offered for a nominal fee or at no cost to the customer. Some programs make a free audit contingent upon implementation of a minimum number of energy- and water-saving recommendations. Immediate energy savings benefits can be achieved by conducting direct installation of low-cost measures (e.g., high-efficiency pre-rinse spray valves, gaskets on refrigeration equipment, or compact fluorescent light bulbs).

### Program Highlight

To effectively serve the diverse set of CFS market participants, the programs sponsored by the **California IOUs** offer an array of services, including site audits, equipment testing, and new restaurant plan review, as well as regular energy efficiency seminars for food service professionals.

Audits help to develop the customer relationship, increasing the likelihood that the customer will take advantage of program offerings when it comes time to replace equipment or conduct comprehensive facility upgrades. To ensure that the program is viewed as a credible resource, it is critical that auditors be knowledgeable about the unique challenges and business realities of CFS operations, and deliver realistic recommendations. A recent evaluation of the PG&E's FSTC found that in order to deliver the most value to food service operators, audit reports should include detailed information on costs and savings associated with the recommended improvements.[9]

## Educating the Marketplace

Lack of knowledge about efficiency opportunities among end users and equipment suppliers, as well as misperceptions about tradeoffs between efficiency and performance, continue to inhibit greater adoption of energy-efficient equipment in the CFS market, despite improvements in this area since EPA introduced ENERGY STAR specifications for a variety of CFS products—as of May 2009, there are more than 98 ENERGY STAR CFS manufacturing partners and 2,600 qualified CFS products on the market.

The following strategies have been effective for getting information to end users to overcome these barriers:

**Target marketing—**Program information needs to be timely and relevant in order to motivate consumers to take action. For this reason, program administrators often develop targeted marketing strategies and messaging for each major market segment they are trying to reach—restaurants, hotels, schools, hospitals, etc.—taking into account business cycles and major industry events in timing promotions and outreach.

**Training and equipment demos—**Equipment suppliers may have little experience selling energy-efficient equipment, and they and their customers may be confused by different efficiency claims in the market or think energy efficiency comes with a tradeoff in productivity or product features. Equipment demonstrations and hands-on training can be particularly effective for persuading consumers that ENERGY STAR qualified CFS equipment comes with no tradeoffs in features or performance. Some programs have dedicated demonstration facilities for this purpose, while others work to assist suppliers in developing their own equipment demonstrations.

- PG&E's FSTC evaluation found that training seminars were a good way to build relationships with food service operators, leading to energy savings impacts over time.[10]
- New York State Energy Research and Development Authority's (NYSERDA) Small Commercial Kitchen Pilot successfully used cooperative marketing dollars to assist suppliers in developing their own equipment demonstrations (see text box on page 6).
- ETO gives an annual 45 minute sales training to CFS dealers to ensure sales staff understand the energy, monetary, and ancillary benefits of ENERGY STAR qualified CFS equipment.

**Cooperative marketing—**CFS programs create opportunities for cooperative advertising, showroom promotions and other collaborative marketing efforts with equipment suppliers. Programs often provide collateral marketing materials such as point-of-purchase banners, tags or stickers to identify rebate-eligible equipment, and informational flyers and brochures. Providing cooperative advertising funds is also an effective approach as it allows businesses the flexibility to market and advertise their ENERGY STAR qualified products in a way that is best aligned with their business model. For example, equipment suppliers that join

### Program Highlight

ETO developed a highly successful document modeled after CFS dealers' handbooks (folders with equipment specification and sell sheets) that dealers take with them on the road. The handbooks contain all the relevant information that a dealer would need to sell ENERGY STAR equipment, such as:

- What is energy efficiency
- What is ENERGY STAR
- List of incentives available in Oregon
- A territory map showing where incentives are available
- Qualified product lists
- Tables listing the energy, water, and monetary savings for energy-efficient equipment (e.g., fryers, ice machines, refrigerators)
- Ancillary benefits of ENERGY STAR equipment
- Incentive application forms

Alliant Energy's trade ally network can be reimbursed for up to 50 percent of the cost of cooperative advertising, subject to utility pre-approval and other minimum requirements. For CFS products that save energy and water—commercial dishwashers, ice machines, and steam cookers—a growing number of energy and water utilities are pursuing opportunities for cooperative marketing, joint program implementation, or both.

**Trade association outreach—**CFS programs can leverage existing trade association networks to raise awareness of program opportunities and boost participation by customers and suppliers. Program administrators should consider joining the local restaurant association and trade associations serving food service equipment suppliers, as well as state restaurant associations. Membership in these organizations will keep program managers abreast of developments in the industry and alert them to outreach opportunities available through trade shows, meetings, and monthly publications. Informational seminars, industry conferences, and well-crafted articles are excellent ways of reaching service decision-makers. At these events, program administrators can also conduct informational seminars and display information and materials to publicize CFS program offerings.

**Communications and outreach—**A robust communications plan utilizing multiple channels including newsletters, targeted mailings, personal contact, seminars, and electronic communications increases awareness of program opportunities. Personal contact (i.e., "face time") is extremely important for implementing a successful program. Energy efficiency is a new concept in the CFS market and supply channel actors often need additional support from utilities before stocking, promoting, and selling energy-efficient CFS equipment. Program administrators can contact ENERGY STAR for assistance in identifying trade allies and developing outreach materials.

### Program Highlights

1) **CenterPoint Energy** (MN) uses its Commercial Food Service Learning Center in Minnesota to provide hands-on education to trade allies about the benefits of high-efficiency equipment. CenterPoint is also a member of several food service trade associations and regularly attends the **Upper Midwest Restaurant Show.**

2) Distributor **Saratoga Restaurant Equipment Sales** (SRES) leveraged cooperative marketing opportunities through **NYSERDA's Small Commercial Kitchen Pilot** and increased sales of qualified equipment by 50 to 900%, depending on the product. Promotional efforts included a showroom event and equipment demonstration, hang tags on qualified equipment, and direct mail. SRES also streamlined the application process by filling out rebate paperwork on the customer's behalf.

3) As part of their program outreach activities, the four **California IOUs** attend the annual **Western Food Service and Hospitality Expo** in Los Angeles. The show is a great way for California program sponsors to engage with trade allies and to reach their key audience: restaurants.

## Motivating Behavior Change and Continuous Energy Performance Improvement

In addition to purchasing energy and water efficient equipment, there are a number of operational best practices that program administrators can share with food service operators. The ENERGY STAR Restaurant Guide provides both short- and long-term recommendations for saving energy in commercial kitchens, equipment use and maintenance tips, and general energy savings tips, in addition to outlining the benefits of energy-efficient equipment installation. Program administrators can use this guide as part of education efforts with commercial kitchen customers to promote additional savings. EPA's Portfolio Manager tool can also be used to obtain a weather-normalized energy performance benchmarks for buildings, assisting food service operators in tracking their building's energy use and reducing it over time.

EPA also works cooperatively with the Consortium for Energy Efficiency (CEE) Commercial Kitchens Initiative. CEE is a nonprofit corporation whose membership includes utility, state, and nonprofit administrators of energy efficiency programming. The goal of the initiative is to define a high performance commercial kitchen package that CEE members can deliver to customers in targeted CFS sectors. A bundled whole-kitchen approach may be particularly appropriate for new construction or major renovation projects. For more information, please visit: *www.cee1.org/com/com-kit/com-kit-main.php3*

### Program Highlight

**PG&E** has developed a Food Service Edition of the Smart Business Rebate Booklet identifying over $6,000 in rebates for the food service industry. The booklet provides information on nearly two dozen ways that PG&E can help customers save energy in commercial kitchens. The booklet tells customers how to apply for rebates, how to access education and training through PG&E's Food Service Technology Center, and how to develop an energy management plan using PG&E's online tool, SmartEnergy AnalyzerTM.


## MEASUREMENT AND VERIFICATION

Measurement and verification (M&V) are central to the success of energy efficiency programs, and are used to assess the market during program design, monitor program performance during program implementation, validate program impacts, and justify continued investment in a program.

During the program planning and design phase it is important to establish a baseline and capture important data before it is lost.

### Baseline Assessment

During the program planning process, it is useful to develop a baseline market assessment of the energy savings potential from commercial kitchens. This baseline will allow program managers to set realistic savings goals and design programs that are well-suited for the target market. Understanding market potential and the market penetration of energy-efficient CFS equipment is well worth the effort, providing valuable insights into how the program should be delivered, and what incentive levels would be cost-effective and successful at moving the market.

Many program administrators quantify kWh savings potential by customer segment. Some market assessments employ a survey process to develop baseline assumptions. At a minimum, a market assessment will identify the number of independently owned and franchised restaurants, hospitality businesses, and large institutional users of CFS equipment (e.g., hospitals, schools, prisons) within the service territory, and provide general information on the baseline equipment installed in such facilities. Growth projections for key end-use sectors and annual run time for qualified equipment are also useful metrics to include.

### Program Tracking

Developing and maintaining a program tracking system is important for measuring program progress and tracking energy savings. Program administrators have found the following indicators useful in tracking program performance over time: energy savings (kWh and kW) from approved incentive applications; level of rebate activity by product type; level of rebate activity by customer type (restaurant, hospitality, etc.); trade ally participation; and program costs.

Incentive applications are an important source of information for collecting basic information not only to justify rebate payment, but also to inform future program impact evaluation. The following are commonly required inputs:

- Customer contact information
- Equipment cost
- Type of facility (restaurant, hotel, etc.)
- Number of qualified units installed
- Equipment type
- New installation or retrofit
- Manufacturer
- Proof of purchase (including serial number)
- Model number
- Trade ally contact information (if trade ally incentives are offered)

It is important to keep in mind the significant lag time between implementing a program and achieving program results. According to PG&E, CFS incentive programs take approximately 12 months to demonstrate changes in equipment stocking, selling, and purchasing behavior.

### Process and Impact Evaluation

CFS programs are typically subject to two types of evaluations: process evaluation and impact evaluation. Process evaluations review program design and implementation to assess what elements of the program are working well and identify opportunities for improvement. Impact evaluations estimate the energy and demand savings that directly result from a program. The Model Energy Efficiency Program Impact Evaluation Guide, a resource of the National Action Plan for Energy Efficiency, is a useful resource for learning more and is available at *www.epa.gov/cleanenergy/documents/evaluation _ guide.pdf*

## PROGRAM COST EFFECTIVENESS

ENERGY STAR qualified CFS equipment provides substantial savings opportunities for program administrators. While CFS programs can be operational within a two to four month period, given the diffuse nature of the distribution and purchasing patterns associated with this equipment, seeing significant progress in terms of program participation may take as long as one year.

Measure-level cost-effectiveness analysis, conducted during program planning, requires data on incremental measure cost, per-unit savings (kW, kWh, therms), annual hours of operation, and measure life. Program administrators typically base hours of operation assumptions on the type of facility where the equipment is installed (e.g., full service restaurant, quick service restaurant, hospital, school). As refrigeration measures are weather-sensitive,

**Figure 1: Example of Co-Branded Marketing Document**


ENERGY STAR supports development of co-branded marketing materials, like this flyer from **Wisconsin's Focus on Energy** highlighting the benefits of ENERGY STAR qualified equipment.

savings assumptions may vary based on the climate zone where the equipment is installed.

Measure-level data are available from a number of public sources, including the following:

- The Database for Energy-efficient Resources (DEER), maintained by the California Energy Commission and California Public Utilities Commission: *www.energy.ca.gov/deer*
- Program work papers filed by the California IOUs, available through the Energy Efficiency Groupware Application: *http://eega2006.cpuc.ca.gov*
- PG&E's FSTC Web site: *www.fishnick.com*
- NYSERDA also has a Deemed Savings Database, available by request

Table 2 presents program administrator cost (PAC) effectiveness results for three existing programs that provide incentives for ENERGY STAR qualified CFS equipment. These calculations only include the equipment incentive and administrative costs, but are estimated for the useful life of the equipment and discounted to net present value using 7 and 9 percent discount rates.

Program administrator costs are different, and usually lower than, total resource cost (TRC), which include the end users' marginal cost for purchasing energy-efficient equipment. For example, PG&E's PAC cost per kWh is estimated at $0.04 for both 7 and 9 percent discount rates; TRC is estimated

**Table 2: Estimated Program Cost Effectiveness for Three Utilities***

| | Pacific Gas & Electric Company[11] (PG&E) | Southern Minnesota Municipal Power Agency[12] (SMMPA) | Energy Trust of Oregon[13] (ETO) |
|---|---|---|---|
| Implementation Period (years) | 2.75 | 2.00 | 4.00 |
| Implementation Dates | 01/06 to 09/08 | 05/06 to 05/09 | 05/05 to 04/09 |
| Total Rebated Units | 3,026 | 60 | 4,757 |
| Gas | 858 | 7 | 2,601† |
| Electric | 2,168 | 53 | 2,156 |
| Total Therms Saved | 490,625 | 1,402 | 458,970 |
| Total KWh Saved | 13.3 million | 183,147 | 3.4 million |
| Levelized CCE - Natural Gas ($/Therm)° | $1.06 –1.18 | $1.54 – 1.70◊ | $0.44 – 0.47◊,† |
| Levelized CCE - Electricity ($/kWh)° | 0.04 | $0.01◊ | $0.10 – 0.11◊ |

* Levelized Cost of Conserved of Conserved Energy (CCE) estimates using the Program Administrator Cost Test (also known as the Utility Cost Test).

° Levelized CCE is presented using a range for discount rates of 7% and 9%.

◊ Administrative costs: for ETO and SMMPA an administrative cost of 11% was used in calculating CCE based on a published cap on administrative costs from the Oregon Public Utility Commission (www.energytrust.org/who/090323_Facts_EnergyTrust.pdf). PG&E data includes administrative costs supplied by the utility in program files and imbedded in measure level estimates.

† Includes 2,202 low-flow pre-rinse spray valves (PRSVs) provided free of charge to restaurants by ETO.

between $0.12 and $0.13 per kWh for the same discount rates (9 and 11 present respectively).11 The difference between these two estimates is the end users' added costs for purchasing the equipment. Utilities should analyze both PAC and TRC when deciding what types of equipment to incentivize.

## ENERGY STAR SUPPORT FOR CFS PROGRAMS

In order to take full advantage of the ENERGY STAR platform for CFS programs, program administrators sign an ENERGY STAR Partnership Agreement with the government. The ENERGY STAR Program has an established national network of program administrators, equipment manufacturers, and marketing support firms that can provide advice and technical assistance during program start-up and implementation. Examples of support and resources include:

- **Specifications**—ENERGY STAR specifications currently cover six CFS equipment types, with new product categories evaluated every year. Information on new specifications and revisions to existing specifications is available at *www.energystar.gov/productdevelopment*.

**Figure 2: Example of Co-Branded Incentive Booklet**


Be creative when publicizing your programs! Southern Minnesota Municipal Power Agency created the Food Service Equipment Rebate booklet to showcase the comprehensive incentive program they developed for their 18 Member utilities. The booklet includes information on the utility's CFS equipment rebates, emphasizes ENERGY STAR's role in CFS market transformation, and provides product- and market-specific information for end users.

The Food Service Equipment Rebate booklet is available at: *http://www.SaveEnergyInBloomingPrairie.com/Upload/FoodServiceBooklet.pdf*

- **Marketing tools and resources**—Downloadable logos, equipment-related information, and educational tools like the ENERGY STAR Guide for Restaurants allow program administrators to customize a variety of marketing and informational materials, while using high-quality ENERGY STAR graphics and language that effectively describes how ENERGY STAR works in commercial kitchens (see figure 1 and 2).
- **Training resources**—A variety of materials are available to support program training activities, including customizable train-the-trainer presentations and opportunities for online or in-person training conducted by PG&E's FSTC (minimum participation requirements apply).
- **Partner matchmaking**—ENERGY STAR facilitates contacts between energy efficiency program administrators and manufacturers, equipment suppliers, and restaurant associations to support program marketing and outreach.
- **Savings calculators**—Spreadsheet tools estimate lifecycle energy, water, and cost savings for each category of ENERGY STAR qualified CFS equipment and are available at *www.energystar.gov/cfs* by clicking on the relevant product page.
- **Manufacturer and product lists**—Regularly-updated lists of equipment models that have earned the ENERGY STAR support rebate verification activities and are available at *www.energystar.gov/cfs* by clicking on the relevant product page.
- **Best practices tools**—Spreadsheet tools for quick service restaurants and full service restaurants estimate lifecycle energy and cost savings from additional energy-efficient food service equipment categories not currently covered by ENERGY STAR, and are available at *www.energystar.gov/cfs*.
- **CFS Equipment Incentive Finder**—Online database of available rebates for qualified equipment is searchable by zip code or by product type and is available at *www.energystar.gov/CFSrebate _ locator*.
- **CFS Program Guide**—Regularly-updated publication informs food service equipment suppliers about cross-promotional opportunities available through efficiency programs.
- **CFS newsletter**—Bimonthly electronic publication is distributed to industry associations, equipment suppliers, and efficiency program administrators highlighting efforts to promote ENERGY STAR qualified CFS equipment.
- **Case studies**—Success stories highlight commercial kitchens saving energy and money by leveraging energy efficiency programs and purchasing ENERGY STAR qualified equipment.

## RESOURCES FOR ADDITIONAL INFORMATION

The following links are useful resources for energy efficiency program administrators that would like to learn more.

- ENERGY STAR for Commercial Food Service: *www.energystar.gov/cfs*

- ENERGY STAR for Restaurants: *www.energystar.gov/restaurants*
- ENERGY STAR Purchasing and Procurement with Product Savings Calculators: *www.energystar.gov/purchasing*
- ENERGY STAR Small Business Network: *www.energystar.gov/smallbiz*
- CEE Commercial Kitchens Initiative: *www.cee1.org/com/com-kit/com-kit-main.php3*
- PG&E's FSTC: *www.fishnick.com*
- GasNetworks: *www.gasnetworks.com/efficiency/pdf/Fryer_Rebate_Form_07_08.pdf*
- Green Restaurant Association: *www.dinegreen.com*
- National Restaurant Association: *www.restaurant.org*
- National Restaurant Association Conserve Initiative: *www.conserve.restaurant.org*
- North American Association of Food Equipment Manufacturers (NAFEM): *www.nafem.org*

## PROGRAMS PROMOTING ENERGY STAR QUALIFIED CFS EQUIPMENT

Selected efficiency programs offering rebates for ENERGY STAR qualified CFS equipment include:

- Avista Utilities: *www.avistautilities.com/business/rebates/washington_idaho/Pages/incentive_7.aspx*
- The Energy Trust of Oregon: *www.energytrust.org/buildingefficiency/restaurants.html*
- MidAmerican Energy: *www.midamericanenergy.com/kitchen*
- New York State (NYSERDA): *www.nyserda.org/Commercial_Industrial/CommercialKitchens/default.asp*
- Pacific Gas & Electric Company: *www.pge.com/mybusiness/energysavingsrebates/incentivesbyindustry/hospitality*
- Puget Sound Energy: *www.pse.com/solutions/forbusiness/pages/comRebates.aspx?tab=4&chapter=4*
- San Diego Gas & Electric Company: *www.sdge.com/foodservice*
- Southern California Edison: *www.sce.com/RebatesandSavings/SmallBusiness/ExpressEfficiency/FoodServiceEquipment*
- Southern Minnesota Municipal Power Agency (SMMPA): *www.smmpa.org/members.asp?utility=59&service=326*
- Wisconsin's Focus on Energy: *www.focusonenergy.com/foodserviceincentives*

## SOURCES

[1] Consortium for Energy Efficiency. Commercial Kitchens Fact Sheet. Available at: *www.cee1.org/resrc/facts/comkit-fx.pdf*

[2] PG&E Food Service Technology Center.

[3] National Restaurant Association (2008). 2007/2008 Restaurant Industry Operations Report, as cited in National Restaurant Association, 2008 Restaurant Industry Forecast.

[4] PG&E Food Service Technology Center.

[5] California Public Utilities Commission (CPUC) (2008). Energy Efficiency Groupware Application, 4th Quarter 2007 E3 Calculators. Available at: *http://eega2006.cpuc.ca.gov*

[6] Personal communication, Energy Trust of Oregon, July 9, 2008.

[7] Personal communication, Wisconsin's Focus on Energy, July 16, 2008.

[8] U.S. Department of Agriculture Economic Research Service. Briefing Room: Food Marketing System in the United States. Available at: *www.ers.usda.gov/Briefing/FoodMarketingSystem/foodservice.htm*

[9] PA Consulting Group (2008). Pacific Gas & Electric: Process Evaluation and Strategic Assessment of the Food Service Technology Center. Available at: *www.calmac.org/publications/PGE_FSTC_Eval_ _Report_-_Final_Feb_14_2008.pdf*

[10] PA Consulting Group (2008). Pacific Gas & Electric: Process Evaluation and Strategic Assessment of the Food Service Technology Center. Available at: *www.calmac.org/publications/PGE_FSTC_Eval_ _Report_-_Final_Feb_14_2008.pdf*

[11] Pacific Gas and Electric Company. E-mail communication and data sharing, January 2009.

[12] Southern Minnesota Municipal Power Agency. E-mail communication and data sharing, April 2009.

[13] Energy Trust of Oregon. E-mail communication and data sharing, April 2009.

ENERGY STAR®, a program sponsored by the U.S. EPA and DOE, helps us all save money and protect our environment through energy-efficient products and practices. Learn more. Visit www.energystar.gov.

Date of Request: April 11, 2016 DPS Request No. DPS-421 JL-4
Due Date: April 21, 2016 KEDNY/ KEDLI Req. No. BULI-438

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, James Lyons

TO: National Grid, Sean Mongan

SUBJECT: Research and Development Costs - KEDNY

Request:

Provide the following:

1. Using the table below, provide five (5) years of data (one table for each year, 2011-2015, showing the annual planned budget, program revenues (surcharges/base rates) collected from customers, actual program expenditures, and reconciled accrued program dollars for each of the three major R&D program areas (KEDNY Internal, NYSERDA, and Millennium). If the amount is $0 for any cell, please indicate the $0 amount and explain why the amount is zero.

2. For 2016, provide the same data as requested in question 1, showing the projected/estimated program expenditures, program revenues to be collected during 2016, actual program expenditures to-date, and accrued program dollars for each of the three major R&D program areas ((KEDNY Internal, NYSERDA, and Millennium).

| KEDNY Research and Development 2010 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | Program Budget | Revenues Collected | Actual Expenditures | Total Program Accruals |
| **Internal Programs** | | | | |
| **NYSERDA** | | | | |
| **Millennium** | | | | |
| **Total** | | | | |

3. To the extent that the Companies currently engage in internal research and development, identify how these projects differ from those end-use technologies that will be developed by Utilization Technology Development (UTD).

4. On p. 16, of your testimony for KEDNY, you show planned cost associated with UTD of $250,000 annually and identify flexibility for KEDNY to determine which projects they wish to support. Explain where the program dollars will come from that KEDNY plans to direct to projects that have the greatest potential to benefit its customers. For example, will these expenditures come from the $250,000 planned annual expenditures for this program or another source? If these expenditures will come from the $250,000, how much of these dollars will be under the control of KEDNY? If they will come from another source, explain where they originate from.

Response:

1. Please see below:

| KEDNY Research and Development 2011 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $128,170 | $0 | $128,170 | $0 |
| **NYSERDA** | $1,745,995 | $1,807,190 | $1,745,995 | $0 |
| **Millennium** | $1,282,501 | $1,232,890 | $1,282,501 | $49,611 |
| **Total** | $3,156,666 | $3,040,080 | $3,156,666 | $49,611 |

| KEDNY Research and Development 2012 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $81,561 | $0 | $81,561 | $0 |
| **NYSERDA** | $1,456,349 | $1,845,141 | $1,456,349 | $0 |
| **Millennium** | $1,184,936 | $1,164,547 | $1,184,936 | $20,389 |
| **Total** | $2,722,846 | $3,009,688 | $2,722,846 | $20,389 |

| KEDNY Research and Development 2013 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $105,592 | $0 | $105,592 | $0 |
| **NYSERDA** | $1,465,455 | $1,797,772 | $1,465,455 | $0 |
| **Millennium** | $687,730 | $1,875,017 | $687,730 | ($1,187,287) |
| **Total** | $2,258,777 | $3,672,789 | $2,258,777 | ($1,187,287) |

| KEDNY Research and Development 2014 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $187,805 | $0 | $187,805 | $0 |
| **NYSERDA** | $814,840 | $1,835,525 | $814,840 | $0 |
| **Millennium** | | $2,559,962 | $766,988 | ($1,792,974) |
| **Total** | $1,002,646 | $4,395,487 | $1,769,633 | ($1,792,974) |

| KEDNY Research and Development 2015 Revenues and Expenditures | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $78,944 | $0 | $78,944 | $0 |
| **NYSERDA** | $1,995,469 | $1,835,525 | $1,995,469 | $0 |
| **Millennium** | $1,010,897 | $799,032 | $1,010,897 | $211,865 |

| | | | | |
|---|---|---|---|---|
| **Total** | $3,085,311 | $2,634,557 | $3,085,311 | $211,865 |

Total Program Accruals are $0 for Internal Programs and NYSERDA as these are not subject to true-up

2. Please see below:

| **KEDNY Research and Development 2016 Revenues and Expenditures** | | | | |
|---|---|---|---|---|
| | **Program Budget** | **Revenues Collected** | **Actual Expenditures** | **Total Program Accruals** |
| **Internal Programs** | $64,122 | $0 | $64,122 | $0 |
| **NYSERDA** | $1,995,469 | $1,835,525 | $534,309 | $0 |
| **Millennium** | $1,422,351 | $0 | $820,785 | $820,785 |
| **Total** | $1,422,351 | $1,835,525 | $820,785 | $820,785 |

Total Program Accruals are $0 for Internal Programs and NYSERDA as these are not subject to true-up

3. Current internal R&D is focused on short term research (worked expected to be 24 months and less duration) and technology to improve gas distribution operations in the areas of safety, cost-effective operations, damage prevention, reliability and environmental performance. As such, this research almost exclusively supports the development of technologies for deployment on the Company's side of the meter (*e.g.*, threat risk model improvements, cured-in place liners technology transfer and trenchless service replacement prototype) not end-use utilization. National Grid's Three Year Research, Development, and Demonstration Report (Attachment 2) discusses these programs in more detail.

   The United Technology Development (UTD) program is focused on supporting the development of technologies for application on the customer side of the meter that utilize natural gas, including technologies to improve the energy performance of customers' buildings or processes with natural gas in terms of life-cycle costs, reliability and environmental performance. The technologies are of interest to National Grid because they support the expanded use of natural gas, including advanced residential applications, distributed generation, commercial HVAC applications such as thermal air conditioning, natural gas vehicles, commercial process such as foodservice, and renewable technologies. For example, there are more than 7,200 foodservice businesses in the KEDNY service area. Attachment 3 is a 2010 GTI assessment of the energy challenges and technology opportunities in the foodservice industry in areas served by National Grid.

4. The $250,000 to participate in the UTD program is proposed to be included in KEDNY's revenue requirement as an annual operating expense. This is the only funding for gas end-use R&D (other than the internal labor to manage National Grid's participation).

The UTD program is managed by the Gas Technology Institute (GTI). Each member company appoints a representative to the Board of Directors and a member of the technical program committee.

Individual project proposals are initially developed by the GTI staff based on their review of relevant technological opportunities and needs. In some cases, projects are conceived by the member companies. For each project identified, the members of the program committee allocate a portion of their company's dues to the projects of interest to their company. A member's funds can only be allocated by a member's vote. Projects that receive sufficient interest, by virtue of the total funding allocated, proceed and those that do not achieve the required minimum funding do not proceed and those funds are available for re-allocation. National Grid's representatives will be responsible for allocating funds to projects that have the greatest potential benefit to KEDNY's customers or for proposing projects if none are sufficiently relevant.

One of the benefits of the UTD program is the ability, on a project-by-project basis, to leverage the funds of other companies with similar customer benefits and also to leverage external funding from federal or state research programs, such as the US Department of Energy or NYSERDA. Co-funding is usually a requirement or a factor in scoring for DOE or NYSERDA funding and, by pooling funds, the UTD program makes it easier to achieve the minimum required co-funding.

| Name of Respondent: | Date of Reply: |
|---|---|
| Chris Cavanagh/Mary Holzmann | April 21, 2016 |

nationalgrid

**Tae Kim**
Associate Counsel
Legal Department

April 5, 2016

**VIA ELECTRONIC DELIVERY**
Honorable Kathleen H. Burgess, Secretary
New York State Public Service Commission
Three Empire State Plaza
Albany, NY 12223

**Re: Case No. 98-G-1304 - National Grid's Three Year Research, Development, and Demonstration Report**

Dear Secretary Burgess:

The Brooklyn Union Gas Company d/b/a National Grid NY, KeySpan Gas East Corporation d/b/a National Grid, and Niagara Mohawk Power Corporation d/b/a National Grid hereby submit for filing their Three Year Research, Development, and Demonstration Report.

Please direct any questions regarding the enclosed report to Mary Holzmann, Principal Engineer – Gas Research, Development & Deployment at (631) 770-3449 or mary.holzmann@nationalgrid.com.

Respectfully submitted,

*/s/ Tae Kim*
Tae Kim

Enc.

One Metrotech Center, Brooklyn, NY 11201
T: 929-324-4550 ■ F: 917-310-0132 ■ Tae.Kim@nationalgrid.com ■ www.nationalgrid.com

# National Grid

# Three Year RD&D Report

**Prepared for**

**New York State**
**Public Service Commission**

**Albany, NY**

**Prepared by**

**Mary Holzmann**
**Principal Engineer**
**Gas RD&D**

**April 2016**

**Introduction**

National Grid distributes natural gas to 2.5 million customers in Nassau and Suffolk Counties on Long Island and in Brooklyn, Staten Island and parts of Queens in New York City, and large portions of Upstate New York, including the cities of Albany and Syracuse. National Grid also distributes natural gas to 1.2 million customers in Massachusetts and Rhode Island.

In addition to its gas distribution business, National Grid owns and operates electric generation in Nassau and Suffolk Counties of New York State and also distributes electricity to customers in Upstate New York, Massachusetts and Rhode Island.

**Goals of the RD&D Program**

National Grid's Gas Research, Development & Demonstration (RD&D) program is designed to improve distribution operations. Targeted operations improvements involve enhanced public safety, cost reductions, improved worker safety, environmental and regulatory compliance. Within these broad areas, National Grid's ongoing research program focuses on the following technical categories:

- Damage Prevention. Technologies that allow the accurate detection of hard-to-find underground facilities such as plastic pipe with inoperable tracer wire, sewer laterals, or joints on cast iron systems. Technologies that warn of impending damage to underground gas facilities, or detect obstacles in the path of directional drilling machines
- Leak Location. Technologies that allow quicker, more accurate and less costly detection of leaks.
- Integrity Management. Various technologies to facilitate National Grid's compliance with the Pipeline Safety Improvement Act of 2002 and subsequent pipeline safety regulations which includes robotics, cased-pipe, material verification and integrity, improvements in asset tracking and traceability, TIMP and DIMP, crack detection, plastic pipe, and other risk and pipeline integrity management challenges.
- Live Maintenance and Repair. Live Repair technologies eliminate customer downtime by allowing repairs with gas mains in the live, operating condition.
- Trenchless Technology. Techniques that allow pipelines to be rehabilitated with minimal excavation.
- Gas Quality. The Company is engaged in various research projects to help prepare us for the expected changing picture in gas supply. The research is focused on the potential impacts that new supplies may have on our infrastructure and our customers.
- Environmental Technologies. New technologies that could be brought to bear on methane and advanced leak detection methods, residential methane sensors, manufactured gas plant (MGP) site remediation, monitoring, and other projects related to climate change.

- Infrastructure Support. Various projects targeted in improving infrastructure operations, corrosion control, construction and the tracking and traceability of underground assets.
- General Operations Improvement. Various projects targeted at improving operational safety, efficiency and/or worker ergonomics.
- Metallurgy, Welding, and Joining Process Improvements.

Projects active during the past three years within these categories, are described in the body of this report.

**Execution of the Program**

Most RD&D projects within these program areas are performed with a high degree of collaboration via the following research consortia:

**NYSEARCH**
NYSEARCH, whose members consist of 19 local distribution companies (LDCs) and one Pipeline Company in North America, is the research sub organization of the Northeast Gas Association (NGA). The NGA is a regional trade association focusing on education, training, research and development, operations planning and increased public awareness on natural gas in the Northeast US. NGA member companies collectively serve 9.5 million customers in eight states. NYSEARCH was originally created as a committee within the former New York Gas Group but has since become national in scope. In addition to the Northeast, NYSEARCH membership comes from the Middle Atlantic States, Mid-West and the West Coast and Canada. NYSEARCH focuses primarily on Operations projects. The NYSEARCH Staff of four project managers manage an active portfolio of projects within the program areas above. Member LDCs join projects at their discretion, commit funds according to their size, act as project advisors, and may host field demonstrations. For the NYSEARCH program, the Company's budget is set by first analyzing the projects that are approved. The project schedules are then established and a spending forecast is developed jointly with NYSEARCH. The company may contribute "in-kind" expenses towards a project in the form of field demonstrations and those costs are also considered. If a new project is still awaiting approval, a forecast is made of projected spending, again in conjunction with NYSEARCH.

**Operations Technology Development (OTD)**
OTD consists of 25 LDCs throughout North America and is an Illinois based not-for-profit (NFP) company administered by the Gas Technology Institute (GTI). GTI also performs project management services and researches about half the project portfolio. OTD focuses on operations projects. OTD Member LDCs join projects at their discretion, commit funds as they deem appropriate, act as project advisors, and may host field demonstrations. The OTD business model calls for an up-front pre-determined (based on company size) payment of annual dues each calendar year. For the OTD program the Company's annual dues are $750,000.  As projects are approved they are funded by the annual dues. Unused funds can be used to offset the following year's dues. The company exercised this option for 2012.

A sub-program within OTD, the Sustaining Membership Program (SMP) is a longer term GTI program focusing on basic science, which usually results in a proof of concept that which is further developed in the OTD program. National Grid terminated its participation in the SMP program effective January 2013.

In some cases, National Grid may choose to enter into development contracts with research providers jointly with other LDCs or by ourselves.

**NYSERDA**
The Company is currently assessed an annual amount of approximately $4.9 Million for the NY State Energy Research and Development Authority (NYSERDA). The assessed rate is based upon NYS Intrastate Revenue – (Sales for Resale and Transmission for Others). The Company has no say in which projects are funded through the NYSERDA program. However, the company monitors the various NYSERDA Project Opportunity Notices (PONS) and may elect to submit a proposal to NYSERDA for cofunding a Company RD&D project.

**Funding**

Part of National Grid's ongoing RD&D program is funded via the "Millennium" Fund and surcharge, authorized by the New York Public Service Commission's February 14, 2000 Order in Case 99-G-1369 (the "Millennium Order") to replace the mandatory FERC pipeline research surcharge. A maximum allowable collection rate of $0.0174/dekatherm on firm transportation and sales is the source of funding for the program. National Grid currently collects $0.0067/dekatherm from its KEDNY operations and $0.0000/dekatherm from its Long Island and Upstate Operations. The winter of 2014-15 was unusually cold with extended periods below freezing. This caused the collection rates, which are tied to dekatherm usage, above the current spending levels for a period of time. Additionally, a great deal of R&D focus has been on residential methane detectors which is not being funded through Millennium but is being funded via company funds through the Long Island Settlement Agreement instead. So we have decreased the collection rates in KEDLI and NMPC in order to levelize balances with current R&D commitments. Since the last report, the changes in spending levels are in part due to National Grid Downstate has been funding the majority of the development of the Explorer 16/18 inch internal inspection robot for un-piggable pipelines in this range of larger diameter transmission piping. While this project benefits our Upstate territory, the larger share has been funded through the Downstate surcharge due to the larger inventory of 16 inch un-piggable pipe there. More recently, projects looking into the use of drones in gas operations will be of greater potential use in our Upstate NY area which will shift R&D investment dollars to Upstate as that work progresses.

Unlike the phased-out Federal Energy Regulatory Commission (FERC) surcharge, the Millennium fund is controlled by National Grid and spent on eligible projects via NYSEARCH, OTD, GTI or other research providers at National Grid's discretion. As specified in the Commission's Millennium Order, in order to qualify for Millennium funding a project must be medium to long term in nature (i.e., projects that are at least twenty-four months or more from becoming a commercially deployable product); 80% of Millennium funds must be spent on co-funded projects and cannot be directed to fund natural gas appliance research or supply/storage projects. The projected budget for the next three years averages $2.7 Million. The Company realizes a high degree of cofunding from other participating LDCs, and from the US Department of Transportation (DOT) Pipeline Safety Research Program. Because of this, the Company's leverage is about 7:1, meaning for every RD&D dollar we spend we realize seven dollars of overall RD&D funding.

National Grid maintains an internal budget to fund projects that do not meet the criteria set forth in the Millennium Order. The budget is $183,000 and typically funds short term "quick hit" RD&D efforts, association (NYSEARCH) dues, and patent protection fees.

Attachment 1 shows actual and projected spending for the Company's Gas RD&D program, Internal, External (NYSEARCH and OTD) and the NYSERDA Assessment.

**Program Management**

The management and administration of the operations program is by National Grid's Gas Materials and Standards, group within the Gas Engineering/Network Strategy organization. Subject matter experts throughout the company are used as needed when specific technical expertise is required on projects.

**Selection of Projects**

The Company uses four criteria to judge the merits of RD&D projects. The first is safety. Some projects are undertaken to enhance the safety of workers in the field, or the general public.

The second criterion is compliance with regulations. An excellent example of this is the transmission pipeline safety regulations. In the Pipeline Safety Improvement Act of 2002, Congress directed the US Department of Transportation to establish and promote a research partnership with industry to develop tools and techniques to improve pipeline safety. Ensuring the highest level of pipeline safety requires tools and techniques that have been developed over the last 10 years, such as the robotics program for internal inspection of unpiggable pipelines.

The third is increased knowledge about gas operations which can lead to increased efficiencies, material improvements and or better techniques for conducting daily operations.

The fourth criterion is financial benefit. The R&D budget is looked at based upon historical spending levels and is adjusted depending upon if there is an increase or decrease in current challenges being addressed and priorities that require research investment are funded. The Company may use a benefit/cost (B/C) ratio test to determine whether RD&D projects should be adopted into our operations. Benefits are the net savings in operational costs that are realized via implementation of new technology. Costs are the project costs to fund and implement the new technology. In some cases R&D studies can also lead to operational savings and the same B/C test applies. However, not all studies have a definitive cost benefit. Studies may lead to increased safety measures or process improvements.

Most projects have multiple benefits, for example, projects undertaken for worker safety can lower injuries and reduce sick time (thereby providing a financial benefit), and compliance with regulations can improve safety of the gas system and the public. A project with a marginal financial benefit may also be approved if it meets one or more of the other criteria.

**Benefits**

National Grid, in collaboration with other funders, has been involved with bringing the following products or increased knowledge to market over the past few years:

- Keyhole Tools and Methods
- Pipe Splitter
- PFT Chromatograph for Leak Detection
- No-Interrupt Service Transfer (NIST) Tee
- Cured in Place Liner Improvements
- Butt Fusion Repair Sleeve (BFRS)
- 4” and 6” Variable Length PE Repair Sleeve
- Remote Methane Leak Detector (RMLD)
- Studies on Plastic Pipe Performance
- A Full Suite of Live Internal Gas Main Video Inspection Devices
- NYSEARCH/Kiefner Interacting Threats Modeling Software
- Cased Pipe Integrity Assurance Model
- Explosion Proof Light Fixture
- Guidance Document on Biomethane
- Explorer Suite of Inspection Robots for the Inspection of Unpiggable Pipelines – Pipetel Technologies, Inc. EXP 6/8, EXP 10/14, EXP 16/18, EXP 20/26, EXP 30/36, Supporting Technologies and enhancements in detection capabilities
- Cased Pipe Annular Space Inspection Robot
- CISBOT
- Acoustic Pipe Locator
- Metallic Joint Locator

**<u>Active Project Discussion</u>**

**<u>Internal Budget – Non-Millennium – NYSEARCH Projects</u>**

Projects that do not meet the criteria set forth in the Millennium Order (i.e., medium to long term and no end use or appliance funding) are funded via National Grid's internal budget. Internal projects (also referred to as Non-Millennium or Traditional R&D) are research that is of short term duration (work that is expected to be completed in less than 2 years) or work that is appliance or storage related.

**T759 - Ergonomic Study to Develop and Test a New Design Needle Bar.** A needle bar is a manually operated tool used to make small diameter holes, called barholes, in paved or unpaved areas over gas mains to allow pinpointing of leaks. During a typical leak investigation as many as 15-25 such holes may be required. The repetitive up-down motion required when using the tool is often a source of soft tissue injury if the user fails to maintain an upright position when using the tool. An ergonomic needle bar with a ratcheting handle was developed. This tool allows the operator to remain in an upright position for the duration of time it takes to create a barhole. The drawback is that the tool is heavier. Field trials were conducted throughout the National Grid territory and the tool failed to gain universal user acceptance. However, these efforts have stimulated manufacturers to continue working independently working towards more ergonomic tool design. The benefit of this work is a reduction in soft tissue injuries.

**T763 - PE Rock Impingement Study.** A study was undertaken to determine whether the requirement for clean backfill around polyethylene (PE) pipe could be relaxed given the high resistance to slow crack growth demonstrated by modern PE materials. In many situations, a common practice is to truck in clean, screened backfill in lieu of using native materials, at an increased cost. Testing performed in Europe has demonstrated that modern PE materials have such superior resistance to point loadings that use of select backfill is no longer required. No such testing had been undertaken in the US so, through NYSEARCH, Jana Labs was commissioned to perform the tests. Medium density and high density PE pipe, which is representative of the PE pipe installed now at the Company, were subjected to extreme point loading to simulate contact with rocks which could be present in native backfill. (Test loadings were so severe that the indentation was visible at the interior pipe wall.) The sample pipes were then pressurized and hot tank tested (standard testing protocol – which compresses many years of testing into a relatively short time period). Tests have shown no harmful effects from extreme simulated rock impingement loading and the projected time-to-failure in normal operating conditions is well in excess of 100 years. This work is an excellent validation of the superior toughness of modern PE materials. Significant cost savings have already been experienced in the Company's New York City Operation.

**T764 - Auto Gas Lamp Field Evaluation.** Working through NYSEARCH, the Company undertook an evaluation of a gas lamp for street lighting that was equipped with an igniter and a photo sensor which would shut off during daylight hours and reignite in the evening. Independent testing confirmed that the lamp and igniter system performed well in lab testing and several lamps were deployed in funders' territory. The benefit of the project is a savings of natural gas during daylight hours, a corresponding reduction of CO2 emissions, and improved customer relations and satisfaction.

**T765 - Gas Interchangeability Study for Installed Residential Appliances.** The addition of new gas supplies (imported LNG, unconventional gas) is expected to accelerate, leading to wider ranges of natural gas compositions. While the industry is expanding supply sources, to date there has been no standardized approach for evaluating the impacts of varying gas compositions on in-service residential gas appliances. The benefits of such a study are to determine the extent to which potentially sensitive appliances exist and to identify which specific appliances are affected based on type, vintage, adjustment practices, and maintenance characteristics. With that information, better decisions can be made about whether adjustments are necessary to those appliances in order to successfully accommodate varying gas compositions. The project consists of two phases; in Phase I, over 2400 appliances were visited in the field and firing rate, percent excess air, CO and NOx formation were measured and flame quality was observed. In Phase II, lab testing was performed on selected appliances (about 20) subjecting them to a wide range of future expected gas compositions to determine their performance. This phase of the study yielded important information about how typical appliances will perform over a wide range of gas compositions and benefits the company by allowing it to more effectively negotiate future tariffs and plan for remedial actions for more sensitive appliance types. This work is nationally recognized. Project results have been shared with the American Gas Association (AGA) and key findings will be incorporated into the next revision of “Bulletin 36,” which addresses gas interchangeability concerns. Based on the results of this work an appliance assessment software tool is now available on the NYSEARCH website. NYSEARCH RANGE™ is one of the deliverables of the NYSEARCH Gas Interchangeability for Appliances project which studied and modeled how changing gas composition can impact the performance of in-service residential appliances. This risk assessment model is available to purchase for on-line use.

**T766 - Technology Transfer Improvements**. An ongoing study to investigate specific member lessons learned with successes and failures of technology transfer and to share procedures so that more companies can be successful with a process for cultivating company support and longevity in implementing new technology

**T768 - NYSEARCH/Kiefner Interactive Threats Project.** The project defined and prioritized interacting threats that impact pipeline integrity. A more robust treatment of interacting threats was incorporated in risk models. To ensure that the NYSEARCH/Kiefner Interacting Threats model stays current, PHMSA's annual incident and Kiefner's forensic failure databases are being checked and incorporated into annual software version upgrades.

**T769 – Test Program for Picarro Leak Surveyor**. In early 2012 the Company became aware of a new technology for leak survey manufactured and marketed by Picarro Corp. The technology is vehicle mounted laser based sensing of methane at sensitivity levels never achieved before by standard leak detection technology. Methane at 30 parts per billion (PPB) above background concentrations can be detected. Along with methane sensing, this vehicle based technology also records atmospheric conditions such as wind speed and direction, temperature, humidity and cloud cover. When methane is detected

the Picarro technology plots out an area that should be investigated and pinpointed. The area to be investigated is based on the methane concentration that was detected, and the atmospheric conditions, such as wind speed and direction. This gives operators a good idea from which direction the methane is coming.
Through the NYSEARCH consortium, the company and others wanted to do a side-by-side comparison of Picarro technology to existing distribution leak survey methods in use at the Company. A double blind test protocol was established and for two days the standard company leak survey procedure – which is a walking survey using Bascom Turner “Rover” leak detector – was run on the same days on the same streets as the Picarro mobile survey technology. Results of the comparative surveys for the Company and other project participants have been compiled. No report can be released due to legal agreements with Picarro. This project was completed in Nov. 2014.

**T-770 - Technology Transfer, Demonstration & Post Mortem Testing of Cast Iron & Steel Pipe Lined with Cured-in-place Pipe Liners. See details under Live Inspection, Maintenance and Repair section.**

**T-773 - Trenchless Replacement of Small Diameter Steel Gas Service Lines. See details under Trenchless Technology section.**

**T-774 - Impact of Gasoline/Oil on PE Pipe.** The objective of the project is to understand the impact of external contaminated soil conditions on the external surfaces of PE pipe and develop a practical engineering and operator’s guideline that provides specific instructions for evaluating in-service PE pipe exposed to contaminated soils.

**National Grid Study on Risks Associated With Natural Gas Appliances Immersed In Water.** Flooding and flood damage are not unusual events in the United States (U.S.). According to the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS) data, annual flooded property losses exceed $7.8 billion on average during the past thirty years. Major episodic events such as Hurricanes Katrina and Sandy can substantially raise losses and place substantial strain on natural gas and electric utility operations due to the extensive damage done to delivery infrastructure and customer equipment. This study was undertaken to help qualitatively assess the failure modes and potential risks associated with natural gas appliances immersed in water for extended periods. Survey questions were used to facilitate interaction with several natural gas furnace, boiler, and water heater manufacturers.

In general, funding for “internal projects” is used to pilot new products and technology—e.g. keyhole, live main insertion, leak sealants, or to perform short term studies. Any appliance related work would also be internally funded.

## Millennium Program

### NYSEARCH and OTD Projects

## Damage Prevention and Pipe Location

According to the US Department of Transportation (DOT), third party damage is the primary cause of pipeline incidents on LDC distribution systems, accounting for over one third of all reportable incidents. Repair costs due to Third Party Damage are estimated at $10 Million annually, and often result in loss of service to customers. National Grid is funding the following efforts:

**M2001-005 – Handheld Pipe Locator using Ground Penetrating Radar (GPR)**. GPR is high frequency electromagnetic radiation that has proven capabilities to detect underground features but no hand held GPR device existed. The goal of the project is to develop a user friendly GPR device that can be deployed by field crews when standard locating technology cannot precisely locate suspected underground facilities. A portable, light-weight free scanning plastic pipe locator for use by LDCs and construction crews to identify the lateral position of hard-to-find plastic pipe (can also locate other metallic pipe). The target application for this technology is plastic pipe with inoperable tracer wire. Such pipe cannot be located by standard “clip-on” locating technology. The product has been designed, developed and tested. NYSEARCH worked with Pipehawk LLC, a UK company, to develop the technology but attempts to commercialize it in 2006 were unsuccessful. Difficulties arose when attempting to transfer this product to a commercializer for engineering improvements (such as ergonomics) and preproduction testing. Another potential commercial partner, Sensors and Software, a recognized leader in both development and manufacture of GPR locating equipment, had been engaged to explore potential commercialization. This contractor is now assessing the feasibility and potential market for this technology. A successful device would provide company crews with the ability to quickly locate plastic pipe without tracer wire. After multiple attempts with a selected contractor who had interest in commercializing, no additional work or funding was promoted.

**M2002-011 PhIII - FFT Damage Prev Monitoring - Advances with Aura.** Damage Prevention and particularly proactive monitoring for third party intrusion near transmission and distribution pipelines is a high priority for many gas companies. Due to interest expressed by members in revisiting the FFT’s fiber optic intrusion detection system, and in particular its advanced system known as Aura™, NYSEARCH renewed this project (renewing the former FFT project that worked with the Secure Pipe product) to test this higher resolution distributed sensor product as it applies to two different test sites with different conditions; one at Woodbridge NJ in PSEG's territory and one in Ontario in Enbridge's territory. Tests and results are finalized. Final Reports for PSEG complete; final report for Enbridge work pending.

**M2002-018 - Proactive Infrasonic Sensor** This system consists of seismic sensors that can be installed near critical gas mains or other facilities and can sense activity near those facilities and send a warning to a control center or other company facility. The system is “trained” to distinguish benign threats (truck traffic, etc) from real threats. Comparable systems on the market now differ in one important distinction; they all require physical contact with the sensor, this system will detect activity as far away as 300 ft. Benefits of this project are reduced incidences of third party damage and associated repairs.

**M2007-007 Advanced Video Surveillance (A-Gas) System**. This project uses a video image approach to detect possible third party damage. Standard video cameras are trained on an area of concern and proprietary software is used to "learn" the scene so that normal activity can be discounted but abnormal activity alarmed. The A-Gas system is available for security applications. The research component of this project is to adapt the technology to the new concept of advanced warning to LDC operators of potential third party damage. In a second phase of the project we are working with the vendor to develop an environmentally hardened version of the camera/software system which can be mounted outdoors without any special environmental enclosures. The benefits of this project are reduced incidences of third party damage and associated repairs.

**M2008-001 – Advanced Development of PipeGuard™ – Proactive Pipeline Damage Prevention.** This system by Magal/Senstar is technically similar to the Proactive Infrasonic Sensor system but is a commercially available system that is used for security applications. The goal of this project is to adapt this security based technology for use in the natural gas industry to be utilized in an underground surveillance mode to detect occurrences at or near the surface to alert the operator of third party activity, presumably excavation, in the vicinity of the installed sensors. This project includes the evaluation of a geophone-based pipeline monitoring capability that will warn an LDC of impending damage to pipeline facilities. Following the initial technical feasibility assessment, through NYSEARCH, the Company is hosting a demonstration site on Long Island to test this technology adaptation. The target goal for detection alarms for backhoe, pneumatic piercing tools, and pavement breakers is 250 feet from the sensing units. This will provide total monitoring coverage of 1000 feet along the pipeline run when two sensing units are installed. It is expected that detection distances for shovels and manual post-hole digging tools will be significantly lessened. Benefits of this project are reduced incidences of third party damage and associated repairs through proactive monitoring in advance of actual work performed by a third party.

**M2011-005 – Fiber Sen System Development and Testing** In the last 10 years advanced damage prevention technologies using fiber optic cable have been marketed. Most of these technologies are suitable for extremely long lengths of transmission piping and one system even uses satellite transmission of data to a central monitoring site in Europe. Systems such as this do not meet the needs of the Company. Through NYSEARCH, the Company became aware of Fiber SenSys Inc., who is interested in developing a shorter version of existing technology which would be more applicable to the needs of distribution companies.

Fiber SenSys proposed to develop a fiber optic cable which can be installed parallel to an existing gas transmission main, or alternately the cable can be incorporated into a new main installation. The system functions by detecting vibrations in the soil around the pipeline. The vibrations alter the characteristics of the laser light in the cable and can be detected and alarmed. Requirements are that the system be able to detect presence of commonly used excavation equipment, while recognizing and filtering out other acoustic signals that would be generated by benign threats such as truck or rail traffic. The system must perform in all types of soil that can commonly be encountered in the Company's territory. A NYSEARCH member company has offered a test site where a prototype system can be installed and tested. The target cost of the system, depending on length monitored, would be as low as $3000 per mile. The benefit to the Company is enhanced damage prevention and potential avoidance of a major pipeline accident due to third party damage. This project expanded on lessons learned from a prior project related to proactive monitoring for third party damage using fiber optic sensors. The project developed a system for shorter runs of pipe based on the contractor's (Fiber Sensys's) system for longer runs of pipe. The 'short ranger' system was tested and evaluated for gas distribution applications and its technical and economic feasibility was studied.

**M2011-008 – BioBall Test Program.** A NYSEARCH member company has worked with a technology company to develop a simple technical approach to accurately locate sewer laterals. The technical approach is to simply wind a length of copper wire on to a biodegradable "spool" which can be flushed down a commode in a residence. The wire will unspool and standard locating equipment can be connected to it and the location of the sewer lateral can be determined. NYSEARCH member companies want to determine whether the idea is feasible and have funded a test program. The Company has conducted a week long field test program on this technology. Results were mixed; in many cases gaining access to the residence was problematic. In those cases access to the sewer lateral was through an outside cleanout. Where the bioball did deploy successfully, location of the lateral was determined within +/- 2 ft. Interest in this project is high because of a concern with "crossbores," in which pipe installed via directional drilling inadvertently punctures a sewer lateral. The situation may not be detected for years until the sewer line clogs and a plumber is called by the homeowner, with potentially disastrous results.
The benefit of this technology is accurate location of sewer laterals and subsequent avoidance of a crossbore.

**OTD 1.8.a - GPS-Based Excavation Encroachment Notification** This project focuses on linking Global Position System (GPS) technology with digging operations to provide a warning system to prevent excavation damages to underground facilities. The objective is to develop and demonstrate a system to ensure that excavation activities are occurring within a valid "One-Call Ticket" area (which authorizes excavation) and are not encroaching upon underground pipes and facilities. The Company and other project funders are partnering with Virginia Utility Protection Service (VUPS), a "one-call" center for utility locates, that has been conducting pilot programs to demonstrate the feasibility of using GPS-enabled cell phones (Phase 1) and GPS-enabled locators (Phase 2), and excavating equipment (Phase 3) to call in excavation projects, access information, and prevent unauthorized excavations. The benefits of this project are more accurate and smaller "white-line" (areas needing markout) areas, more accurate locating, and warnings to excavators if they are excavating in unmarked areas. All of this reduces the threat of third party damage. The company is participating in a follow on project to implement a similar pilot program in upstate NY.

**OTD 1.h and 1.10.c – Hand Held Acoustic Pipe Locator.** Plastic pipe without tracer wire remains a vexing problem for LDC locating crews because standard electromagnetic locating techniques will not detect plastic pipe. Ultrasonic waves are ideally suited for this application because they will travel well through solid mediums (soil) but are reflected off of voids, air pockets or lighter density materials. The acoustic locator has shown that it can reliably detect plastic pipe. A follow on to this project (described next) will target location of sewer laterals, an important issue lately as more LDCs are using directional drilling to install gas mains. Accurate location of our buried facilities is the main benefit of this project. Completed 2013.

**OTD 1.10.e – Enhancing Damage Prevention in New York.** The objective is to conduct a pilot project to demonstrate the procedures and technologies for implementing an electronic as-built process and radio frequency (RF) tag based asset locating system. The proposed technology will automate the as-built process by using new high-accuracy GPS technology and aerial photography to document the location of newly installed facilities. RF tags will be used to enhance the locating and mark-out process by providing field personnel with additional asset location information. Phase 3 will develop a prototype system that allows the collection of highly accurate spatial data in urban canyons where traditional GPS technology is ineffective.

**OTD 1.11.e - Crossbore National Database and Risk Model.** As crossbores, where a natural gas line installed via trenchless construction methods, has penetrated a sewer main/lateral. For example, homes with sloping front yards and no basements may have sewer laterals that are close to the surface and therefore more likely to be intersected by a horizontal directional drilling operation. The objective of this project is to gather as many parameters as possible associated with crossbores actually identified in the field. In addition to the Company, other LDCs are gathering data on crossbores. There has not been a unified effort nationally to collect this data. By combining this data into national database users can identify those situations and field conditions where crossbores are more likely to occur in its own territory, and can prioritize and focus remedial action on the highest risk areas. The purpose of the database is to collect information on crossbores root causes, environmental and situational factors, and compile incident reports to facilitate the sharing of lessons learned and increase public safety.

**OTD 1.12.b – Crossbore Detection Using Mechanical Spring Attachment**
In the concluding phase of OTD 1.11.a, “Evaluation of Chemical Detection Methods for Detecting Sewer Lateral Crossbores,” one of the project funders suggested a brainstorming session for innovative ideas to detect crossbores. The leading idea is to use a simple spring loaded sensor on a drillhead that would “snap open” upon encountering a void, such as would happen if the drillhead suddenly penetrated a sewer lateral.
GTI engineers will design and test a prototype tool that will detect a hit to sewer laterals during the HDD or mole installation of PE gas pipe. The tool utilizes a low-cost and easy to use mechanical system that is attached to the HDD/mole head during drilling or to the PE pipe during pullback. The mechanical system is activated inside the sewer pipe void; thus locating the lateral and providing a real-time alarm identifying a hit. At the conclusion of the project, commercialization activities will begin. A simple yet accurate

method for detecting a crossbore in this fashion is a tremendous benefit to the company because crews are present to immediately rectify the situation.

## Leak Detection and Methane Emissions

Rapid and more accurate leak detection and location (pinpointing) has always been a research focus for the industry and for National Grid in particular. We are funding the following efforts:

**M2010-002/T-776 – Methane MR Sensor/ new Residential Methane Detector Development Program.** NYSEARCH/NGA has been developing a small, reliable, intrinsically safe, line and/or battery powered, miniature methane (natural gas) sensor based on micro-resonator technology that measures the viscosity of a gas mixture. The sensor would be used in detecting natural gas leaks and other applications. The instrument is being developed for two applications; an analytical sensor for measurement with data output, and as an improved safety sensor for use in residential applications. Due to the high reliability and resistance to false alarms, this program has shifted its focus entirely to the residential sensing application. Following extensive testing of advanced prototypes, precommercial prototypes are being tested by UL and a pilot test program is being implemented following completion of UL testing. This project has produced a novel type of methane sensor using the principle of micro-resonance. The theory behind the sensor is that micro-size tuning forks will vibrate at different frequencies when exposed to a methane/air environment than it would in free air. This concept was uncovered during a technology search undertaken as part of the “Oracle” project. After extensive testing it has been found that this methane sensing device does not exhibit false positives in the presence of many household chemicals which is makes it superior as safety device over currently commercialized devices. It has not demonstrated any false positives.

The sensor is capable of measuring the methane concentration from 0% to 100% in air at different pressures, relative humidity levels and in a wide temperature range. The measurement range of primary interest corresponds to 0-100% Lower Explosive Limit (LEL) with the ability to measure gas concentrations up to 100%. [LEL for methane corresponds to approximately 5% methane/natural-gas concentration in air.] The sensor has a detection limit and an accuracy of 0.25% natural gas concentration in air. The sensor is capable of operating at various gas gauge pressures ranging from 30 to 110 kPa and temperatures of -20°C to 50°C. The response time of the sensor is targeted at 1 second or less. To verify and validate the performance of the MR Methane detector (safety sensor/alarm monitor) a pilot testing program will be implemented. Detectors will be deployed in residential settings to test them under real life conditions under a variety of operational conditions and environments. The following issues will be addressed: (a) having a sufficient number of installations, (b) covering a wide range of housing types, (c) evaluating different detector locations within the homes, (d) selecting locations that expose units to possible interfering chemicals (e.g., masking, false positive) and potentially damaging conditions (e.g., humidity, temperature, chemicals, insects), (e) considering the impacts of ventilation rates and air flow patterns in homes, (f) monitoring performance in all seasons, (g) monitoring performance at various elevations, and (h) validating detector performance before, during, and after the field trial.

**M2014-002 - Leak Pinpointing Inside Pipe.** The overall program goal is clear to design, develop and test an innovative system that can precisely locate gas leaks from inside the pipe. The selected technology needs to apply to a range pipe sizes, 2” – 12” in diameter. During testing the experienced JD7 operator inserted the instrument into the flow loop through an ALH/WASK valve fitting after the simulated leak was created and covered. The first round of testing was designed to determine if the JD7 could detect leaks of various sizes and pressures. This initial round of testing was performed without air flow (fans were off). The JD7 proved capable of detecting leaks as low as 6” water column pressure leaking at the rate of 0.12 scf/hr. and at our top simulated pressure of 40 psig with a leak rate of 52.5 scf/hr. The JD7 was also capable of detecting leaks at various pressures and leak rates in between these upper and lower tested limits. A second round of testing was performed. The JD7 was manually inserted down the test pipe and located the leak without knowledge of the leak location. This testing was conducted without air flow and with air velocities of 2.5 mph (one fan) and 12 mph (both fans). The JD7 located leaks at no flow as small as; 1) 0.70 scf/hr. at 12” water column and 20 psig, 2) between 5.23 and 8.33 scf/hr. at 2.5 mph air velocities at both 5 psig and 40 psig, and 3) at 12 mph air velocity with a leak rate of 52.5 scf/hr. at 40 psig. Although initial flow loop testing of the JD7 at Heath was a success, improvements should be made to the JD7 Gas Investigator in a proposed Phase II of this project in order to improve its efficiency of operational performance. These improvements should subsequently be blind tested in a buried flow loop containing simulated leaks with the capability of varying pressures and flows.

**M2014-004 - Technology Evaluation and Test Program for Quantifying Methane Emissions.** The overall objective of the project is to identify, test and validate what technology or technologies are available that can be applied from a mobile platform in an urban environment to quantify methane emissions rates.

**M2015-002 - SRI Standoff Gas Flow Imaging and Analysis System**. The overall objective of the approved program is to quantify the flow rate from gas distribution leaks using the schlerien optical imaging technique as applied on a portable, field-usable system.

**OTD 1.9.a – GPS Based Leak Survey**. The objective of this project is to develop and utilize a software application that automates leak surveying with GPS. Using standard GPS receivers a leak surveyor’s route is automatically uploaded to company maps and a permanent record of the actual route surveyed is created and preserved. The application attaches GPS coordinates to survey routes and leaks while electronically documenting work to demonstrate compliance. The application also allows the user to create and populate an electronic leak form that can be directly transferred to a back-office leak management system or a Geographic Information System (GIS). New leak detection equipment that is on the market will be linked via software to company maps or images to automatically track routes of leak surveyors, thereby creating a traceable record of survey routes walked. The benefits of this project are reduced time for documentation and more accurate record keeping.

National Grid funded an additional phase of the project to conduct an actual field trial of the technology in a select area in New York City. Due to Hurricane Sandy, the pilot was delayed until April 2013 and was completed in August 2013.

**OTD 1.11.c - Methane Sensor** The goal of this project is a low cost reliable methane sensor for in-home use or use in company facilities (gate stations etc.) to detect and alarm on the presence of methane in air. Instruments are available to do this but typically can be set off by non-methane hydrocarbons which could be present in a house basement, paint thinner or hairspray for example. The testing protocol was designed to test the accuracy and stability of the six KWJ MEMS sensors by testing them at various methane concentrations, different temperatures, different relative humidities, and different interfering gases. In order to execute the testing protocol a testing chamber was designed to monitor and control all of the different conditions. After the completion of several basic testing conditions, the project team concluded that further testing should be terminated. Termination of the testing was recommended for several reasons. Because of our concerns on the path forward of this project, National Grid elected not to continue this effort.

**OTD 1.14.d - Field Measurement of Leak Flow Rate.** The goal of this project is to develop an inexpensive and repeatable device that can provide a measurement of the gas-leakage rates in the field from Class 2 and 3 non-hazardous pipe leaks. The current phase of the project involves improvements on an alpha prototype and upgrading the technology to provide increased accuracy, precision, lower cost, and ease of use. In 2015, an enhanced prototype was placed in a test chamber and subjected to varying levels of methane at constant temperature and humidity. The prototype is Wi-Fi enabled and presents an access point that the user can log into. A web page is presented that displays the parameters being measured by the prototype and allows control of the sampling fan. This allows access to the prototype through a device that supports Wi-Fi and a web-browser. Additional work was performed in the area of calibrating the Figaro methane sensor that is used in the prototype. The goal is to develop an accurate calibration curve that relates the raw sensor output voltage to % LEL with corrections for temperature variation. The current version of the prototype measures the flow through the device accurately but is somewhat limited in the range of flows achievable. The flow sensor represents a constriction in the measurement path of the prototype. At this time a high-powered fan is required to draw samples through the system. GTI is currently considering replacing the thermal flow sensor with a rotating vane type that would lower the requirement on the fan and consequently on the overall power consumption.
The alpha prototype was demonstrated to OTD at the fall 2015 meeting. — A basic demonstration of the Phase 2 beta prototype is planned for the fall 2016 OTD meeting.

**OTD 1.14.g - Residential Methane Detectors Program.** In this program, several discrete initiatives are being addressed as tasks, with the initial work being a consumer behavior study to better understand how customers react to potential leaks and the development of a “Fit-for-Purpose” standard for residential methane detectors. This program also includes a comprehensive pilot program to evaluate commercially available detectors that performed well during laboratory evaluations. — A pilot testing program is currently under way, with detectors being placed in residential homes throughout the U.S.

**OTD 1.15.e - Triple+ Shutoff Valve Pilot Program.** Triple Plus Ltd. has made available the Triple+ NGL™ version 4.0 of its gas leak management system, a product capable of detecting gas leaks and automatically shutting off the gas supply and stopping the leak. The objective for this project is to perform controlled testing of the valve portion of the product. Researchers are collaborating with Triple Plus to evaluate a technology that combines a methane detector with an automatic shutoff valve as a safety solution to prevent risks due to leaks and other events (e.g., hurricanes, earth-quakes, floods). This unit is assembled in-line with existing gas systems. If a gas ball valve is installed, there is no need to cut, replace, or remove existing pipelines or valves. — Plans are being made for a testing program with OTD sponsors.

**OTD 5.14.j - Residual Gas Removal - Identify Technologies, Limitations & Best Practices.** This effort reviews current and new venting equipment and strategies utilized by gas operators to effect safe and timely extraction of in-ground residual gas. The presence of residual in-ground gas poses hazards to the public and nearby infrastructure, complicates leak pinpointing efforts and obfuscates effectiveness of performed leak repairs. A lingering presence of odorized gas can also generate secondary leak reports by the public for extended periods after a leak repair has been completed. Numerous equipment and strategies for venting and dispersing residual in-ground gas exist. A number of field visits to residual gas mitigation job sites were made to evaluate current practices and provide best practice guidance to the industry. In light of findings from industry surveys and sponsor discussions, the frequency of residual gas mitigations requiring more than natural venting strategies such as that provided from barholing, trenching or the use of vented manhole covers, was significantly lower than anticipated. Other traditionally employed devices such as aerators and air movers, that utilize pneumatic power to generate suction via the Venturi principle, are highly effective in the bulk of residual gas extraction scenarios. Though ultimately dictated by local soil and site conditions, the need to utilize dedicated or higher flow capacity vacuum extraction approaches is minimal and reflected by slow market uptake of specialty equipment such as Vapor Extraction Unit (VEU). Safety aspects and some factors dictating how best to elevate extraction efforts in dealing with persistent in-ground gas indications at the site of repaired leaks are summarized in the project report. Due to the low frequency of this issue and demonstrated effectiveness of the most simple, low cost strategies in the majority of residual gas removal scenarios faced by operators, it was agreed that there is no need to propose follow-on quantitative evaluation of techniques as of Q1 2015.

**OTD 5.14.w - Testing Program for Valve with Water Sensor for Storm Hardening.** In this project, researchers are evaluating a valve integrated with a water sensor to assist with storm hardening. Phase 1 testing was completed in 2015. Additional phases will be addressed based on development status and needs of the project sponsors. Evaluations involve a battery of tests, including: visual tests, pressure tests, debris tests, water-intrusion tests, corrosion tests, humidity testing, drop tests, and others. — A Phase 1

Final Report was issued in August 2015. Additional work continues in the development and addition of methane sensor to couple with the valve actuator.

**OTD 7.15.b - Remote Gas Sensing and Monitoring for First Responders.** The safety of workers, first responders, and the general public will be greatly increased by being able to monitor the atmosphere of buildings and other structures remotely. In addition, continuous remote monitoring of various gas levels during known gas leak situations will allow for better and quicker analysis of the situation. The remote sensors can be placed and/or operated in multiple buildings, sewers, and other structures in the area of the known gas leak. The remote device can wirelessly provide real-time information back to first responders, gas company personnel and others in charge of monitoring and assessing the gas levels in the structures. The objective of this project is to create a device to remotely monitor the level of gases during emergency situations. The device will provide critical information to first responders and gas company personnel, allowing them to determine the concentration of methane, CO, and possibly other key indicators inside buildings, sewers, and other structures from a safe distance.

## Integrity Management

The passage of the 2002 Pipeline Safety Improvement Act – which required detailed assessments of all pipelines operating at 20% or higher of specified minimum yield strength (SMYS) - is the driver for this research for National Grid. National Grid is funding innovative research in the areas of wall loss sensing for unpiggable pipelines and novel methods to assess the condition of cased pipe. These challenges have resulted in the Integrity Management area being the largest R&D spending area for National Grid. Within the overall category of Integrity Management there are three project areas:

**Robotics**: In line Inspection (ILI) using smart pigs is considered the most desirable method of pipeline inspection among the three methods (In line inspection, Direct Assessment, Hydrostatic Test) specified by the US DOT's Pipeline and Hazardous Materials Safety Administration (PHMSA), yet many of National Grid's older transmission lines are not piggable. To meet this challenge we participate in the NYSEARCH Robotics program which is developing robotic, self powered sensors for 6" through 36" transmission pipe. These inspection tools are battery powered and are launched "live" into the pipeline and communicate via wireless signal. Pipe wall thickness measurements are either remote field eddy current (RFEC) sensing or magnetic flux leakage (MFL) sensing. The robotics program has received significant support and cofunding from the USDOT and other industry outside NYSEARCH; to date about $8 million has been received from the USDOT alone. The benefits of this technology investment is pipeline safety, ILI, as mentioned, is the most desirable of the three mandated inspection methods, and savings can be considerable, though highly site specific. In this reporting period the Company has funded the following projects:

**M2001-014 - Explorer 2026 Robotic Inspection System for Unpiggable Pipelines using Magnetic Flux Leakage (MFL) Sensing.** Explorer 2026 is a live entry, battery powered untethered robot designed to enter and inspect transmission pipelines 20 in. through 26 in. diameter at pressures up to 750 psi. Wall loss measurements are by industry standard MFL sensing. The design of the robot and sensor specifically overcomes the restrictions that cause a pipeline to be designated "unpiggable." These restrictions include short radius or back to back elbows, mitered bends, presence of plug valves (these are valves that do not have a full diameter opening and won't allow a typical pig to pass through) or no/low flow conditions. The robot is launched "live" into a pipeline and travels under its own power along the pipeline taking wall thickness measurements along the way. Explorer 2026 is fully developed and has completed two of three field demonstrations at host LDC sites. It will be in full commercial operation later in 2013.

**M2003-009 - Explorer 6/8 (Explorer II) Robotic Inspection System for Unpiggable Pipelines using Remote Field Eddy Current Sensing (RFEC)**. Explorer 6/8 is a live entry, battery powered, untethered robot designed to enter and inspect 6 in and 8 in diameter pipelines operating at pressures up to 750 psi. Wall loss sensing is through a novel sensor called "Remote Field Eddy Current" (RFEC) sensing. Development of this sensor was itself a separate R&D effort and the sensor represents advancement over state-of-the-art magnetic flux leakage (MFL) sensing. The reason this new sensing technique was developed is that traditional MFL sensing creates high strength magnetic fields and given the small diameter of these pipelines not enough robot power could be developed to overcome these forces and move the robot down the pipeline. The robot is specifically designed to overcome obstacles that traditionally cause a pipeline to be classified unpiggable, such as mitered bends, back to back elbows, and low or no flow conditions. The robot consists of drive modules, steering modules, cameras on front and back, and the RFEC sensing module in the middle. The robot is placed in a specially designed launch tube which is mounted on standard hot tapping equipment affixed to the pipeline. The robot is then launched into the pipeline under live gas conditions and travels down the pipeline under its battery power at about 15-20 feet per minute, collecting wall thickness measurements. After the conclusion of the "pig run," data is analyzed and a report on anomalies found, if any, is made.

An important part of any R&D project is a serious and robust field demonstration phase. For this project, the Company served as a field demo site at its 6 in dia 473 psi gas transmission pipeline in Oneida, NY. During this 3 day demo, the Explorer 6/8 robot scanned over 4900 ft. of this pipeline and found no anomalies. This scan provided the company with added insurance that there is in fact no corrosion defects present in this high pressure gas main. This robot and its supporting technology has been licensed to Pipetel Inc, a robotic inspection services company in Buffalo NY, and is now in full commercial operation.

**M2011-006 – Robotics Supporting Technologies.** Modifications are being designed that will allow in-line battery recharging (to extend the range), new sensors to detect cracks, and a "rescue tool" that will allow a disabled robot to be retrieved.
In testing conducted to date, battery life is the factor most limiting the range of the robots. It was realized by the company and others that a more efficient way was needed to recharge the batteries than removal of the entire robot from the pipeline. The technology developer, Invodane Engineering Inc. conceived of an innovative method of recharging

the robot via an “in-line” charging system. A charging cable will be inserted through a small tap on the main and the robot can remain in the pipe while being recharged overnight. Based on recent industry pipeline accidents there is increased focus on sensors that can detect cracks. Although less of a threat than corrosion wall loss, crack sensing is the focus of new development efforts. The benefit of this technology is increased assurance of the integrity of the company’s transmission system.

A rescue tool” will be developed that will assist in the retrieval of a failed robot. This will give the company greater assurance that the robots can reliably be placed inside its piping network. On some critical pipelines this may be a requirement before the robot is placed in the pipeline. The project is designing, developing and testing additional sensors to add to NYSEARCH’s inspection platform for unpiggable mains. Supporting technologies that are being addressed under this project include mechanical damage sensor/ovality sensor, crack sensor, MFL sensor for 6/8, bend sensor, methods for cleaning the pipe at the launch point and ahead of the tool and methods for in-line active charging as well as a rescue tool for the commercial system. We are also developing and testing a hardness test module to add to the Explorer series of robotic platforms for internal testing of material hardness and yield strength.

**M2011-009 – Explorer 30/36 Robotic Inspection System for Unpiggable Pipelines using Magnetic Flux Leakage (MFL) Sensing.** The Company and two other LDCs are funding Explorer 3036 which addresses larger size transmission piping inspections in 30” through 36” pipelines. This project is still in the development phase and will incorporate all the features of the existing suite of robotic inspection tools such as live launching, plug valve and short radius bend negotiation, all in pipelines up to 750 psi operating pressure.

**M2013-001- Explorer 16/18 - Inspection of Unpiggable Pipelines.** This Special Project was an Accelerated Development effort cofunded by Invodane to design, manufacture, integrate sensors and supporting technologies and test prior to commercialization.

**M2013-002 - RMD Crack Sensor using Eddy Current Technology.** RMD has developed a new eddy current sensor that in early studies has shown promise for detecting crack defects. The new sensor is different from existing eddy current sensors in two regards: (a) it uses solid state technology instead of the traditional coils (which have inherent limitations in providing high accuracy and detectability), and (b) it is easily and inexpensively fabricated in inflexible and flexible substrates using mass production techniques. The combination of these two factors results in an inexpensive sensor with resolution and sensitivity superior to traditional eddy current sensors. This project first proved the feasibility of using their EC technology for the detection of cracks in natural gas pipelines and is now advancing to development and testing as well as integration onto the EXP series of robotic platforms.

**Cased Piping**: Research into cased pipe assessments is an important part of the transmission pipe integrity management program. Transmission piping placed concentrically within a larger "casing" is a common practice when pipelines pass under major highways, railroads or bodies of water. Assessing the condition of these "carrier" pipes within casings can be difficult if the pipeline is not piggable. The company is involved in several research efforts to address this important issue. The efforts consist of software tools to evaluate casings, and inspection hardware to perform inspections. A very promising technology is "Guided Wave," in which an ultrasonic signal is propagated along a pipeline from a remote location revealing flaws in inaccessible areas of the pipeline.

**M2001-003 - Cased Pipe Risk Assessment Model.** This project involved the construction of a software tool program that prioritizes casings in terms of relative risk. The program considers inputs including, but not limited to corrosion rate, degree of cathodic protection, presence of moisture and wall thickness of the pipe and categorizes casings in terms of probability of failure. Casings with higher risk scores can be scheduled for further follow up inspections while those with lower scores can be monitored. Consequence of failure can also be added to the model, thereby producing a total risk score, which is the product of probability of failure and consequence of failure. Depending on the degree and accuracy of the data that is input into the model, the model can also calculate time to failure in years. A follow on to this project involved lab and field analysis of corrosion rates in various environments. With this information, a corrosion rate can be entered into the model which would be most representative of actual corrosion expected in the field, and not theoretical (overly conservative) rates. This project benefits the company by allowing it to prioritize inspections of riskier casings first and perform remedial actions, if required, on those riskier casings.

**M2007-001 - Mini-camera for cased pipe inspections.** This is a crawler camera magnetically attached to the casing. It can navigate down the length of the carrier pipe returning video image of the pipe. The camera has been deployed successfully at several sites and a follow on phase to the project will incorporate ultrasonic sensors for wall thickness readings and humidity gauges to assess the presence of moisture (a key ingredient that can accelerate corrosion). The mini-camera does not, by itself, provide a complete assessment of the carrier pipe condition but is rather another "tool in the toolbox" when used with other assessment methods such as Guided Wave technology.

**M2007-003 - Multi Technology Validation Testing for Cased Pipe Applications.** This is a testing program for various technologies, which may have promise for inspecting wall loss and other defects on carrier pipes within casings. Technologies tested were guided wave, magnetostrictive sensors (an in-situ type of guided wave), the casing camera, and Time Domain Reflectometry (TDR). Some of the technologies tested are commercially available and some are still in the development phase. The results of this test program gave the company valuable information on to the effectiveness of these various inspection techniques. The two most promising are guided wave and the casing inspection camera. The magnetostrictive sensors were not as sensitive as traditional guided wave, and TDR, although promising, will not be seriously pursued at this time. A new phase of this project has recently been authorized which will focus on more detailed testing of guided wave. All tests are conducted at the NYSEARCH test bed, which is a network of above ground and buried pipe containing machined defects. This is an effective way to compare technologies as all tests are on the same piping components, and defect locations are known only to NYSEARCH staff. However, the company took an additional step and developed a test program for guided wave on its own in-service piping. This project is more fully discussed later in this report.

**M2011-007 – Cased Pipe Inspection via Vents.** National Grid has had success in its downstate territory with the mini-camera for cased crossings, described above, but the drawback to this technology is the requirement for costly excavations to gain access to the casing annular space at the end seal. An alternate approach is to gain access to the annular space from above ground, through small diameter vent piping which is present on casings. Technology to provide this visual inspection does not exist. The technical approach on this project is to use commercially available camera technology and adapt it to travelling down through the vent piping until it reaches the casing annular space. Through a technology search for new technology providers, NYSEARCH has qualified a small robotics company, Honeybee Robotics, to perform robotics work, and they will perform on this project in a two- phased approach with a go – no/go decision point after Phase 1. Phase 1 will demonstrate the feasibility of adapting existing technology to the task of negotiating the vent piping to gain access to the casing annular space. Such access will be constrained by the small diameter and sharp ninety degree bends that are normally present in casing vent piping. Cleanliness of these vent pipes may also be an issue. If the testing reveals that access to most typical casings can be gained, then the project will proceed to development of a prototype system that can enter the annular space and obtain meaningful information. The benefit is compliance with pipeline integrity management regulations at a significantly lesser cost than traditional means of gaining access to a casing. This project is focused on developing and testing concepts of a compact tethered robotic camera. The successful robotic camera is intended to provide the operator with insight about a cased pipe by gaining access to the annular space through a typical casing vent without requiring excavation.

## Other Integrity Management Research

Included here are various projects that contribute to our understanding of, or help us meet, transmission or distribution integrity management requirements.

**M2005-003 - Design, Construction & Operation of Regional Test Bed.** An above ground and below ground pipe network that has been built specifically for testing new inspection technologies by member gas engineers. This 1200 foot network features different coatings, known anomalies of different sizes, varying soil types, varying welds with good and bad weld practices, different joints and other features for future use on other gas operations purposes. The test bed site is a NYSEARCH/NGA site that is leased from New York State Electric & Gas in upstate New York (Johnson City near Binghamton).

**M2007-005 - TransKor Remote Inspection Testing (Magnetic Tomography).** The magnetic tomography method (MTM) is a commercial, non-intrusive, above ground method of pipeline inspection developed in Russia by TransKor. Through NYSEARCH, the Company became interested in this technology as an additional "tool in the toolbox" for transmission pipeline assessment. Although other above ground assessment techniques are in use today, they rely primarily on detection of coating failures. MTM measures the inherent magnetic field surrounding a metallic pipeline and detects stress risers in the pipeline by analysis of the pipeline's magnetic field. Stress risers are indicative of wall loss, welds, manufacturing defects, or mechanical damage such as dents or gouges. A test program is underway by the Company and other LDCs who are members of NYSEARCH to thoroughly test the capabilities and accuracy of the MTM. The ultimate goal of the test program is to evaluate the performance of MTM and have it recognized by PHMSA as an "other technology" suitable for transmission pipeline assessment. MTM could provide a significant benefit to the company's Integrity Management plan by providing a much less expensive and more thorough assessment method which requires only a simple walk-over of the transmission pipeline being assessed.

**M2009-001 - Holistic Review of Distribution Integrity Management Plan (DIMP) Risk Practices and Models.** In 2010 the Pipeline and Hazardous Materials Safety Administration (PHMSA) issued regulations requiring operators of natural gas distribution systems to implement a formal distribution integrity management program. The regulations are not prescriptive and don't require specific types of inspections and assessments as do the transmission integrity regulations, but they require operators to risk rank their distribution system. The Company undertook this project to more fully understand exactly what type of risk modeling may be best suited to analysis of a gas distribution system. Some of the projects' findings suggest that age of the distribution piping alone is not a complete indicator of risk, but other factors such as material type, location, and potential for operator error all factor into a relative risk ranking. Availability of data on the distribution system is also key to developing a reasonable and useful risk model. (For example, although age, material type and location of pipeline segments are certainly known, various component types or specific installation practices are not always known with the same certainty.) Conversely, overloading a risk model with too much specific data does not result in a useful risk tool either.
The final report on the project provides suggestions on a risk management approach and guidelines on making decisions on purchase or development of a specific risk model. The benefit is information and guidance to the company regarding the best method to risk rank its distribution network.

**M2012-003 – Enterprise Level Assessment of Data Management Systems.** This project addresses a relatively new requirement for gas distribution operations, namely to establish traceability – from initial manufacture to installation – of gas system piping components, and a means to track the location and installation parameters of these components, and integrate this information into existing company data management systems. The best methods of doing this, both from a hardware and software perspective, are being explored in this project. The company is funding this project to gain important information about this new industry initiative, but because we are conducting active field demonstrations via a similar OTD project (OTD 5.11.m) we will only be observers for this project.

**OTD 2.11.d - RSD X-Ray.** This non-destructive examination (NDE) method has advantages over traditional X-Ray. For example, radiation levels are reported to be lower, and resolution can potentially be higher. Additionally, images can be displayed in real time. As opposed to traditional X-Ray, which requires through-the-wall penetration from the radiation source to a film on the back side of the weld, RSD X-Ray works on the principle of backscatter, or reflection of the X-Ray signal. The detector can be outside the pipe, co-located with the source. Before such a new technique is adopted it needs to be tested to demonstrate that it is capable of identifying flaws in welds with the same sensitivity and accuracy as traditional X-Ray. GTI will work with the vendor of this equipment to perform blind tests to demonstrate this. The results of the blind tests will indicate whether the project should proceed and whether equipment and techniques should be developed for practical applications in the gas industry. If successful, this method of non-destructive examination (NDE) could also be applied to pipeline integrity assessments of existing transmission pipeline segments via incorporation on to a pipeline pig, or a robotic internal inspection device.

Using Nucsafe's Scatter X-ray Imaging (SXI) technology, the first iteration of this investigation utilized standardized PE disks with precisely measured defects placed in the fusion interface. The objective was to develop a repeatable methodology of introducing specific defects into the fusion interface and to scan a sufficient number of replicates that would allow probability of detection statistics to be calculated. A set of calibration specimens was prepared at GTI and sent to Nucsafe for scanning. The scan results showed that while the disks were detectable the interfaces between the disks and the pipe dominated the signal and masked the included defects in many instances. The initial approach was abandoned in favor of that utilized in OTD Project Number 2.6.e which was more successful.

**OTD 4.7.g - Yield Strength Determination.** Operators with incomplete records need a better way to determine the yield strength of their pipeline segments if it is unknown. Current regulations require that operators either take a full size cutout of the pipeline and subject it to laboratory testing, or assume a low value of 20,000 psi. Obtaining full size cutouts is disruptive to pipeline operations as it would require a full shutdown of the pipeline. Assuming 20,000 psi could result in the pipeline being in an (assumed) over pressure condition when in fact it may not be. GTI developed a method to determine the yield strength of a pipeline through lab testing of "sub-size" samples. The samples can be obtained easily by using standard hot tapping equipment without shutting down the pipeline. A follow on phase to the project will utilize sophisticated statistical techniques to possibly lower the number of sub-size coupons required for given lengths of pipeline. The benefit to the company is a less expensive and less disruptive method for positive determination of yield strength, should any of the company's records be incomplete.

**OTD 4.8.a - Guided Wave Equivalent to Hydrotest.** The objective of this project was to perform a validation effort to allow the use of GWUT as an acceptable inspection technique by demonstrating the ability of GWUT to perform equal to, or better than, a hydrotest. The specific objectives of this project were to perform the following: Compile data from GWUT inspections that have been validated by design, ILI, or direct measurement, Demonstrate that GWUT finds defects that would pass a hydrotest (therefore substantiating that GWUT will find all larger defects), and Provide a validated methodology for a new standard. Data collection involved gathering all available and acceptable data from prior GWUT inspections and the associated dig records (defect geometry, pipe diameter, wall thickness and grade). Data was only accepted and reported in this study if the GWUT could be verified through direct inspection. The collected data was used to calculate the failure pressure for rupture using the most conservative federally approved methodology, i.e., ASME B31G for all validated data points. The validation calculations were undertaken to confirm or substantiate the following hypothesis: GWUT misses no defects that would fail a hydrotest, and GWUT misses no defects that were found in the direct examination (i.e., determine the False Call Rate). The percentage wall loss vs. anomaly length diagrams plotted to B31G confirmed that GWUT is equivalent to hydrotesting. The GWUT methodology found all those anomalies that would have been found by the hydrostatic testing and GWUT also found anomalies that were too small to have been detected and would survive in a hydrostatic test to a pressure equivalent to the pipe's Specified Minimum Yield Strength (SMYS).

**OTD 4.8.i - Extended Reassessment via Wax Fill of Casings.** A proper wax fill of a casing eliminates the threat of external corrosion on the carrier pipe by removing any electrolytes in the annular space between the casing and the carrier pipe and replacing it with a dielectric medium (the wax fill). Although techniques for filling casings with wax are well known, there has been no known technique for validating the effectiveness of the wax fill operation so that assessment intervals could be extended. For this project, corrosion monitoring techniques and techniques to determine the completeness of the initial wax fill operation have been developed. Casings were filled with wax and monitored to determine the extent, if any, of corrosion. To simulate actual field conditions, water was left in some of the test sections prior to filling the annular space with wax as well as through ports made through the casing wall and water forced into created voids. Such testing conditions were extreme. Upon post examination, after 1 year of service, extremely low corrosion growth rates were found, at a much lower rate than would be expected. Longer term testing could provide additional data to verify if the corrosion rate drops, stabilizes or does neither over time. More work would be required to quantify actual corrosion rates over a longer time period

**OTD 4.9.a - Leak vs. Rupture Boundary.** The current Pipeline Integrity rule requires that all pipelines operating at 20% or higher of the specified minimum yield strength (SMYS) are subject to the more stringent transmission integrity assessments. (20% is thought to be the lower limit of pipeline stress at which pipelines fail by rupture). However, there remained questions as to whether 20% is a realistic lower limit. With the support of the USDOT, investigations of past failures coupled with detailed mathematical modeling can confirm that the 20% limit is overly conservative and a more realistic lower limit may be 30%. The Company may then elect to designate certain pipeline segments as covered under the new Distribution Integrity Management rules. GTI investigated over 20,000 pipeline failures worldwide and was able to draw conclusions as to the parameters that cause pipes to fail via leakage vs. rupture. Not only yield strength but also diameter, pressure, and toughness are factors that determine whether pipes fail by rupture or leakage. The project results showed that for most modern pipeline materials the leak-rupture boundary is more like 30%. Using the results of the project, operators can – with proper regulatory approval – place their pipeline segments in the appropriate integrity management program. The benefit would be that company resources can be directed to assessing the more vulnerable pipeline segments.

**OTD 4.11.f and T 768 (non-Millennium Project) - Understanding Threat Interactions.** Part of an operator's Transmission Integrity Management program is a relative risk assessment of the various threats that could impact a pipeline. There are various risk models in use that can quantify the relative risk of pipeline failure via the threats that are present. What is not so well developed is a ranking methodology that accounts for threats that can interact, or occur simultaneously on a pipeline segment. For example, what is the additional risk to a segment if external corrosion occurs on a manufacturing defect, or if earth movement occurs in an area with a defective weld? This project will examine a realistic combination of multiple threats that can reasonably be expected and will calculate the additional risk of failure to a pipe segment due to the presence of these interacting threats. This is timely work since the Company and others have been questioned during safety audits by regulators on their methodology for addressing interactive threats. This benefits the company by allowing the most accurate risk ranking and subsequent assessment of the integrity of those segments. Because this is an important issue the Company funded two parallel projects. The first is a short term effort through NYSEARCH that focuses on (but is not limited to) evaluating interacting threats through the existing Kiefner Model, which many LDCs use today. This effort took far longer than expected but an algorithm is now available (Nov. 2015) for use in determination of the risk associated with interactive pipeline threats. Yearly updates will be made to this model as incident data is reported and updated through the DOT under a 5-year contract with the developer. The second is a longer term more theoretical approach by GTI which could provide more overall flexibility.

**OTD 4.12.b – Correlating Pipeline Operation to Potential Crack Initiation and Growth.** Based on recent industry events coupled with new or proposed regulations, the gas industry is expected to increase the amount of pressure, or "hydrostatic" testing on existing pipelines. In addition to a standard pressure test (in which the pipeline is pressure tested to 1.5 times its operating pressure) there is the possibility that operators would be required to perform a "spike test" in which the pipeline is raised to 90% of yield strength (which could be significantly higher than a normal hydrostatic pressure test).
Such pressure testing, while having advantages over other integrity assessments, can cause cracks to initiate and/or grow. This has been observed in other industries (boiler tubes) but is not well understood in the gas industry. The Company is aware of the advantages of pressure testing but wants to understand the risks that could present themselves due to pressure and spike testing. GTI will leverage previous work done in

the boiler tube industry to develop a model to predict crack growth due to pressure testing. Validity of the model will be tested by subjecting actual pipe specimens to laboratory pressure cycling which can simulate years of pressure testing and/or pressure excursions in a matter of hours. The deliverable of the project will be a model that will relate historical and planned pipeline operations to potential crack initiation, growth and arrest. This benefits the company by insuring that pressure testing does not degrade the pipe segment being tested, with the associated possibility that the pipe could fail while in service.

**OTD 4.13.a - DIMP Consequence Model.** The objective of this project was to develop a model that quantifies the consequence of failure for distribution systems and DIMP based factors such as population density, proximity of critical infrastructure and business districts, failure mode based on material properties, gas migration patterns, soil and surface conditions, pressure and potential energy. The deliverable of this project is a DIMP consequence model that operators and software vendors can incorporate into existing risk modeling tools.

**OTD 4.13.b - Demonstration of 3D Scanners for Anomaly Assessment.** A validated tool that eliminates manual data collection of in-the-ditch anomaly measurements using a pit gauge will improve data quality and increase operational efficiency. Automating the process of measuring anomalies found through ECDA and ILI runs could be achieved through various 3D scanning devices. This project's goals are to validate and demonstrate the performance of 3D scanners for automated in-the-ditch anomaly measurement and assessment of corrosion, dents and gouges. The two 3D scanners that were tested demonstrated the ability to provide more accurate and reliable anomaly assessments compared to manual pit-gauge measurements. Recommendations for further assessment include: 1) Evaluate the cost of the products in relation to the value that they provide in terms of improved data accuracy and reliability and time savings during data collection and management. 2) Ensure that 3D scanners are compliant with federal and state regulations.

**OTD - 4.13.c EMAT Sensor for Small Diameter and Unpiggable Pipe**. This project goal is to develop a bi-directional electromagnetic acoustic transducer (EMAT) sensor that can be used to assess small diameter and unpiggable pipelines containing reduced diameter fittings and other restricting features. Phase 2 focuses on constructing and testing a field-ready prototype based on the success of the bench-scale prototype sensor developed in Phase 1. This research will enable natural gas pipeline operators to identify defects that are traditionally difficult to find and assess and therefore improve system integrity and public safety. The EMAT sensor will be designed to find and characterize cracks in welds and pipe walls. PHMSA is co-funding phase 2 effort with industry funders of this project.

**OTD - 4.13.d.3 - Hydrotest Alternative Ph 3.** The third phase of this program is to identify and validate inspection and assessment technologies that are equivalent to a 1.25x Maximum Allowable Operating Pressure (MAOP) hydro-test for Integrity Verification Process (IVP) compliance. Phase 2 created the Finite Element Analysis

(FEA) critical flaw data and collected Probability of Detection (POD) data for Electromagnetic Acoustic Transducer (EMAT) and Acoustic Resonance Technology (ART) sensors. Phase 3 will create the critical flaw curves that will allow a comparison to In-Line Inspection (ILI) tool detection capabilities. The deliverable of Phase 3 will be a tool that operators can potentially use to demonstrate equivalence to a hydrotest for a specific pipe segment. The ability to use internal and/or external inspection tools to perform an integrity assessment as a regulatory acceptable alternative to hydro-testing would ensure the operator of the safety of the pipeline and provide significant cost savings in complying with new regulations. It would also provide operators an integrity assessment solution for those critical pipelines that cannot be taken out of service. Furthermore, hydro-testing may increase risk by introducing water that cannot be removed and may accelerate crack growth for certain susceptible pipeline materials. Acceptable alternative methods to hydrotesting are a critical need.

**OTD - 4.14.a Fitting and Component Catalogue for IVP.** The goal of this project is to develop a catalogue of legacy fittings and components to assist operators in identifying and characterizing assets to comply with PHMSA’s Integrity Verification Process (IVP). The envisioned catalogue will contain pictures, descriptions, strength class ranges, and material and mechanical properties. A catalogue of legacy fittings and their characteristics will assist operators in complying with pending federal regulations, specifically the new IVP requirements. An industry catalogue will reduce the cost of gathering and compiling this information and provide support for strength requirements and assumptions when a fitting can be positively identified. This project has encountered issues with obtaining suitable documentation of data for inclusion in the catalog. Initially critical documentation had been located via the internet (only 2 copies existed) and one copy was ordered but the shipment never arrived. The other copy is not for sale and is owned by Chinese interests. Securing composite catalogs of vendor products and parts from the desired pre-1970 era are actively being worked and GTI is in the process of obtaining a paper copy of a large document from Gulf Publishing via loan that may include useful information. Digitizing and collating the potentially thousands of relevant vendor catalog pages from Gulf documents could ultimately lead to generation of a searchable online tool for LDC use. This effort would likely require significant resources outside the scope and budget of this project.

**OTD 4.14.c - Surface Indentation for Material Characterization Correlation of Surface Properties Based on Vintage.** There is a need to develop correlation factors to relate surface properties to actual material properties to allow surface indentation techniques to be used for material property validation for pipelines. These correlation factors will be based on pipe vintage by decade. Past research has proven the ability of surface indentation techniques such as stress-strain microprobes and hardness testing to accurately determine material properties of pipes within a localized area, but variations in material properties through the wall are problematic for local interrogation techniques. GTI will develop probabilistic confidence intervals that will allow operators to use surface indentation techniques by applying correlation factors to pipe materials that may have through-wall variability. The ability to characterize material properties, particularly yield strength, of in-service pipelines without taking the line out of service or removing samples will significantly reduce the cost of complying with existing and pending federal regulations. Backfilling records with material property information such as yield strength and toughness also improves integrity management through system knowledge that allows enhanced modeling and analysis. It is anticipated that the results of this research will facilitate the regulatory approval of stress-strain microprobes and hardness testing to characterize material properties of in-service pipe. It will also empower internal inspection tools (such as PRCI's signature pig under development or TDW's MFL tool that may be able to detect signatures) to use surface readings from the inside of the pipe to be applied to the entire pipe wall.

**OTD 5.8.e - Tracking and Traceability.** One of the requirements of a Distribution Integrity Management program is to "know your system." But there is no industry standard for manufacturers to mark gas piping and appurtenances with critical manufacturing information nor is there a standard for LDCs to record data when installing permanent additions to their gas systems. On the manufacturing side, date of manufacture and lot number need to be recorded in a standard fashion across industry, and installers need a standard way to record location of the installation and identify the crew doing the work. For this project, GTI and a subcontractor formed a steering committee to identify which commonly used materials should be identified, and what pertinent information should be recorded. The steering committee consisted of manufacturers and LDCs. An ASTM F2897 standard was developed to which capture the results of the Steering Committee's decisions and a bar coding protocol was agreed upon. A future phase of the project will develop methods to record, store, and retrieve, if necessary, data on installed components.

**OTD 5.9.j - Gas Distribution Model.** With Distribution Integrity Management Program (DIMP) regulations now in place, operators will be developing data collection strategies to ensure compliance. One tool that could help operators in this process is a non-proprietary, industry standard data model for distribution assets and operations. A standard data model, the Pipeline Open Data Standard (PODS) model was developed to assist transmission operators in managing their data and ensuring regulatory compliance. The PODS model is an open, industry-standard data model that has successfully been used for over ten years to reduce the cost of implementing software and improve interoperability for the pipeline industry.

Now with DIMP there is a similar need for an industry-standard data model for distribution assets and operations. Gas Technology Institute (GTI) initiated a program to develop the Gas Distribution Model (GDM) to meet this need with three specific purposes. First, the model will be used as a data exchange function between operator data models and vendor's software products to reduce the need for customization. Second, the model can store both transmission and distribution data and will facilitate vertical data integration. Third, GDM could be used as the primary data model for operators to avoid the need for internally developing a model. The Company engineers and IS personnel felt that such a data model would benefit the business and also would facilitate transition to the new SAP system. The GDM initiative brought together a diverse group of operators, vendors, and industry experts to collaboratively develop a GIS-neutral model that holds promise to reduce the cost of software implementation and improve interoperability. GDM is a flexible model that will grow and expand with continued use and development.

**OTD 5.11.m – Intelligent Utility Installation Process (Asset Tracking and Traceability).** This project will develop methodology and suggest field processes for capturing data during new installations. It is a logical follow on to the requirements of recently enacted DIMP regulations which require operators to "know their systems." It also will provide the means to implement the results of the "Tracking and Traceability" project which created an industry standard for manufacturers to mark their products with manufacturing data. A key component of the Intelligent Utility Installation project is to achieve standardization across industry. When this project is implemented the company will benefit by knowing precise attributes of its distribution system and will be able to quickly react to reports of possible defective pipe material or fittings.

**OTD 5.15.b - Roadmap for an Enterprise Decision Support System (EDSS).** By striking the proper balance between competing influences, operators will maximize business health. There is a growing realization among operators and regulators that ad hoc decision making, based on the latest crisis, is not the optimal method for enterprise management and ultimately system reliability, safety, and efficiency. The objective of this project to develop an Enterprise Decision Support System (EDSS) technology roadmap. The EDSS will allow LDC operators to integrate all data and business knowledge sources into a decision support system that will optimize policies related to: risk mitigation, safety, code compliance, customer satisfaction, environmental stewardship, efficient operations and future growth. It is increasingly necessary to optimize various operational decisions based on predefined rationale coupled with comprehensive knowledge of data/system inputs and a methodical risk analysis. Enterprise decisions and risk analysis that will be supported through this process include repair vs. replace vs. rehabilitate, predictive threat interactions and consequence of failure, risk based prioritization of O&M activities, scenario analysis for various risk mitigation strategies, economic analysis, amongst others. Additionally, new asset-based data streams are continually being developed as directed by distribution and pipeline integrity programs as well as the relative ease in which large volumes of system data can be collected. The EDSS will integrate these disparate data streams into a logical system capable of rationalizing the inputs to enable sound decision making. The deliverable of this project will be a well formulated roadmap that provides guidance on how to realize an EDSS. This roadmap will be used to execute a series of stage-gate linked projects that progressively move us towards the goal of a fully functional EDSS.

## Plastic Pipe Research

The bulk of piping added to LDCs' networks each year is medium or high density polyethylene (PE), or plastic pipe. Last year alone, the Company added over 500 miles of such pipe to our system. Working with NYSEARCH and GTI, the Company is involved in several research projects designed to improve our understanding of PE performance and develop new products.

**M2000-001 - PE Repair Sleeves for Damaged PE Pipe.** As an alternative to squeeze off and cutout of minor defects on PE pipe, the Company and others are developing, through NYSEARCH, repair sleeves to reinforce PE pipe in the area of the butt fusion joint, or along the length of the pipe. During routine operations such as new service additions or main extension, minor damage – not causing leakage - can be noticed on the existing PE pipe that is uncovered. The substandard conditions noticed can be either a scratch or gouge on the pipe itself, or a questionable appearing butt fusion joint. The solution, up to now, is removal of the defective pipe segment. Removal is usually accomplished by first "squeezing off" ahead of and behind the pipe segment in question, then cutting it out and replacing it. As an alternative, the PE repair sleeve can be fitted over the defective area in question and fused on to it. The fitting is designed to withstand line pressures up to 124 psi but will not be installed if an active leak is present. The benefit of this technology is lowered repair costs and improved reliability of PE piping systems by reducing the amount of "squeeze-offs" made. These repairs can also be made without causing an outage, whereas a squeeze-off may require a short outage if the pipe is a one way feed.

**M2006-002 – Butt Fusion Integrity**. This project examines current butt fusion parameters such as pressure and temperature at the joint interface with an aim towards optimizing them. Through a novel test method, the "whole pipe creep rupture test" several test fusions are made and subject to this laboratory destructive test. This test more accurately simulates stresses that actual in-service pipe experiences, and results of these tests can serve to further refine butt fusion parameters and associated procedures.

**M2008-010 – UV Degradation of PE Pipe.** The Company wants to understand, through testing, what the real time limit for PE pipe to withstand UV exposure without a harmful effect would be. Current USDOT regulations specify two years but the current version of ASTM D2513 (the industry standard for manufacture and use of PE pipe) specifies an outdoor storage limit of 3 years for medium density PE pipe and 10 years for high density PE pipe. But this current standard has not been accepted by the USDOT, who recognize the previous version which limits outdoor storage to 2 years. This project was undertaken to demonstrate, through testing, that pipe stored outdoors longer than 2 years is still suitable for use. Both non-destructive and destructive tests have demonstrated that pipe stored outdoors for three years is suitable for use. The work now is to present the information to the USDOT and request a rule change. The benefit to the Company will be immediate; National Grid recently discarded over $300,000 worth of PE pipe that exceeded the 2 year requirement.

**M2009-008 – Ultrasonic Inspection Device for PE Butt Fusions.** The aim of this project is to develop a field instrument to rapidly and easily examine butt fusions in the field, providing on-the-spot assurance of the integrity of a newly made butt fusion joint. A low cost user friendly butt fusion inspection device has been a goal of gas industry research for quite some time. Such a device gives greater assurance of butt fusion quality by allowing "on-the-spot" inspections by field crews or supervisors actually doing the work. The Welding Institute (TWI), located in the UK, is a leader in plastic pipe research and was selected to carry out this work in a phased approach. In the first phase, an instrument was configured to examine and return information on the presence or absence of flaws in the butt fusion. The next phase of the project is to determine which flaws can be accepted and which will cause the pipe to fail. This is done via destructive testing; fusions with varying degrees of flaws are subjected to testing and a "library" of flaws is developed and flaws are categorized as either "causes failure" or "does not cause failure." Based on similar European technology for metric sizes, the objective is to develop and test a nondestructive tool for examination of butt fusion joints (particularly for use with advanced PE materials). This project has taken advantage of significant research already performed by The Welding Institute (TWI) for the European gas and PE piping industries. Extended long term testing is being performed because the test protocols/data from Europe showed that U.S. failures do not occur as rapidly and to test to failure, different conditions needed to be imparted. The significance of this extensive testing is that NYSEARCH and TWI are developing acceptance criteria for use in a tool that does not require a trained technician. Other phased array NDE tools are either not state-of-the-art OR they require a trained technician. In its final form, the instrument will examine field fusions and compare them to fusions in the "library" and be able to give a simple "good fusion" or "bad fusion" reading. The benefit of this work is greater assurance of the quality of a butt fusion and increased safety and reliability of the gas distribution network.

**OTD 5.13.c - PE Pipe Splitting—Technology Evaluations, Enhancements, and Standardization of Tool Kits** A research team is evaluating and refining existing PE pipe-splitting equipment and developing guidelines. In October 2015, manufacturers performed various pipe-splitting activities with plastic-pipe-replacement construction techniques. — Researchers are seeking additional field sites for this project.

.

## Live Inspection, Maintenance and Repair

The Company is always looking to minimize customer downtime or gas main shutdown during routine maintenance activities. The following projects help us meet this goal.

**M2001-006 - Development/Testing/Commercialization of Real Time Gas Distribution Sensor Network - Phase I-V.** This distribution sensing system is intended to provide network sensor data acquisition, robust wireless communication and encrypted data accessible for pipeline monitoring and assessment. Data from these real-time sensors will include pressure, temperature, humidity, flow volume, and direction. The objective of the program is to complete development and testing to the point where Enetics/Telog can commercialize the technology.

**M2008-003 - Evaluation of Rapid Crack Propagation.** A study to model and test the existing ISO correlation formulas used to determine rapid crack propagation in PE pipe. Through this project, it has been determined that existing formulas are overly conservative and need to be changed.

**M2014-001 - sUAS Technology - Regulatory & Technology Assessment**. The objective of the project is to evaluate regulatory issues and technology of small unmanned aerial systems (sUAS) devices as applied to gas industry inspections and surveys. Further, NYSEARCH has been investigating development of methane leak detection module and control system capable of using at tree-top level for leak survey and methane emissions measurement on a sUAS.

**M2014-005 - Critical Valve Operability.** The objective of the project is to develop a method of confirming valve position and provide validation of a critical valve operability test.

**M2016-001 (Millennium); T-770 and T-776 (non-Millennium) - Cured In-Place Composite Liners projects and Technology Transfer, Demonstration & Post Mortem Testing of Cast Iron & Steel Pipe Lined with Cured-in-place Pipe Liners.** The objectives of the project were to: 1) gain understanding and support from regulators using Cured-in-Place Pipe (CIPP) Liners as a rehabilitation technique for cast iron and steel pipe, 2) provide an engineering assessment to advance the understanding of liner/host pipe interaction and demonstrate structural equivalence towards repair/remediation of lined pipe/appurtenances, and 3) validate the effectiveness of CIPP-lined cast iron and steel pipe through examination of past studies & further demonstration and lab testing.

**M2016-001 (Millennium) - Chemical Longevity & Post Mortem Slow Thermal Cooling Testing of Field Aged Cured-In-Place Lined (CIPL) Cast Iron and Mechanically Joined Steel Pipe.** The primary objective of this proposed Phase II project is to further address regulatory concerns by testing field aged extracted cured-in-place segments as they interact with host steel or cast iron pipe to demonstrate the actual impact of slow thermal cooling and perform chemical aging longevity evaluation tests to (100) years. Six test segments of CIPL pipe, three steel (12"-16" diameter) with a mechanical coupling, and three for cast iron (12"-16" diameter) are proposed to be extracted after years of gas service and will be further tested using a solid foundation of protocols by scientists at Cornell University. The cast iron pipe will be flexed to create a circumferential crack prior to testing. Project goals include: 1) performing thermal testing to simulate actual slow cooling in the field, and, 2) conducting independent tests to examine the chemical longevity of a new CIPL pipe to a (100) year life cycle equivalent, 3) completing a workshop with funding member SME's and Cornell professional staff on "best practices" for evaluating corrosion and structural limitations of host steel and cast iron pipe segments, and, 4) providing a platform that encourages industry and regulatory dialogue regarding the use of CIPL pipe as an option for the renewal of our aging pipeline infrastructure. This will involve preparing information so that the gas industry sponsors develop a unified approach to addressing levels of host pipe corrosion acceptable for CIPL use in field aged CI or steel pipelines.

**OTD 2.11.a - Above Ground Leak Repair Systems Testing.** The Company and other LDCs desire to qualify various repair products that are sold for repair of above ground leaks on natural gas piping as a permanent repair system. The application is for above ground meter piping on distribution systems. No use of these products on below ground piping is contemplated. Two available products are being tested. Initial tests will be short term testing to establish the proof, or "burst" pressure of the repair system. These tests

are complete with burst pressures found to be well above (by an order of magnitude) normal operating pressures. Plans for long term testing are now underway.
A successful outcome of this project would be that these repair systems would qualify as a permanent repair thus repairs can be made more inexpensively than a shutdown and rebuild of meter piping, with the associated inconvenience to the customer.

**OTD 2.12.e - Selection of Liners Composites for the Rehabilitation of Distribution and Transmission Lines.** This project is an evaluation of the use of composite pipes and cured-in-place (CIP) liners in the rehabilitation of gas distribution and high-pressure lines. The replacement and rehabilitation of these pipeline systems in congested, urban areas with very limited right of way space is particularly problematic. This project investigates the trenchless rehabilitation options of these pipes.

**OTD 2.13.b - Guidelines for Special Permits for Structural Composite Rehabilitations.** The objective of this project is to develop guidelines for submitting special permits to state and federal regulators to request approval to use composite materials for structural pipe rehabilitation. The need for new techniques to repair and replace pipe will continue to increase as infrastructure continues to age. While open trench replacement will be the most cost effective technique for many applications, some situations will require the use of trenchless or alternative techniques that use the host pipe as a conduit for installing a new pipe. Composite materials hold much promise for rehabilitating aging infrastructure, including high pressure pipes. Composite materials can have properties that are superior to steel and can be installed in flexible configurations. Guidelines for submitting special permit requests will reduce the cost and time associated with filing the application. Guidelines will also improve the likelihood of obtaining approval through a special permit by ensuring that permit applications are complete and address the issues that are of interest to state and federal regulators. Other means are being explored for regulatory acceptance, as such; this project is temporarily on hold.

**OTD 2.13.c - Long-Term Evaluation of Liners and Composite Pipe Materials.**
An engineering assessment was conducted to improve testing methods for predicting the long-term performance of liners and composites used in the rehabilitation of aging gas distribution and transmission lines. The focus was on high-pressure (up to 350 psig) composites and liners installed using trenchless technology. — A Final Report containing guidelines is being prepared.

**OTD 2.14.a - Composite Repair Wrap for Polyethylene Systems**
Researchers are evaluating a new composite pipe-wrap system for the repair of damaged PE gas pipe. Efforts are under way to establish the correct combination of adhesive and wrapping material. — Repaired specimens are being monitored under long-term hydrostatic pressure testing.

**OTD 2.14.b - Steel-Pipe-System Repair Technique**
A novel repair method for live leaking steel-infrastructure applications was developed and tested. The method uses a mold, resin, and composite wrap to provide safe,

permanent repairs. The goal is to have the technique applicable to steel couplings, threaded joints, cast-iron bell joints, and service tees. Testing is complete and a patent for the technology was filed. — A Final Report is being prepared. Discussions with potential manufacturers are under way.

## Trenchless Technology

The Company's primary research effort in this program area is to find ways to complete maintenance with minimal excavation. These technologies will lower cost and result in less disruption to the customer.

**M2010-001 – Service Tee Renewal** The purpose of this project is to develop a means to renew a service tee under live conditions without an excavation. Gas mains can be rehabilitated via cured in place lining with minimal excavations. Steel service lines are routinely renewed by inserting plastic tubing, with no need to shut the main down. An alternate process, called "Renu" seals the interior of a steel service line with access gained at the meter. The weak link in this process is the service tee, usually made of carbon steel, which is not routinely replaced during the above mentioned gas main and service rehabilitation projects. The Trenchless Technology Center, retained by NYSEARCH to conduct this research, focused first on an appropriate sealant that would effectively seal the interior of the service tee. Spray coatings, liners, and mechanical seals were investigated. A hybrid mechanical seal concept was judged the best of the three alternatives but significant design challenges existed, mostly related to delivery of the sealing system down the length of the service line to the tee (up to 100 ft in some cases). Because of the uncertainties associated with these approaches the Company and the other funders will request proposals for alternate solutions.

**T 773 (non-Millennium) - Trenchless Replacement of Small Diameter Steel Gas Service Lines.** The objective of the project is to design, develop and test a new system for extracting small steel services, bare or wrapped in the size range of ¾" – 1 ¼" diameter to replace them with same size or larger size PE pipe. If successful for the smaller steel services, the contractor and cofounder also envisions a Phase II to address steel services with diameters of 1 ½" and larger.

**OTD 2.8.e - Structural Liners – Technology Search**. Large diameter cast iron mains can be effectively rehabilitated by lining them and Ngrid has been using this technology successfully since 2003. The current approved liner for use on gas systems relies on the structural integrity of the host pipe. For this reason, lining is generally limited to cast iron or protected steel pipelines. If a liner could be developed that had structural properties (meaning it would resist external loads such as traffic loading) more pipelines could be candidates for lining.
Four liner manufacturers who make structural liners for other industries (water) were contacted and their products' capabilities were discussed. One manufacturer seems to have a product that may meet the requirements for gas service and further evaluations will be required. This project would benefit the Company by expanding the available pipelines that could be rehabilitated by lining as opposed to replacement, resulting in lower cost and less disruption to the community and customers.

**OTD 5.10.f – Cold Assisted Pipe Splitting** One of the methods to renew deteriorated steel pipe is to split it by pulling a tool with cutters through it. A new length of PE pipe is attached to the rear of the cutter. When the cutter emerges from the pipe, the new length of PE pipe remains as the new gas carrier. This can be a cost effective rehabilitation method but many times the splitting operation is difficult because of the ductility of steel pipe. This project investigated whether liquid nitrogen or some other cryogenic liquid could lower the temperature of a steel pipeline to a level at which the pipe would transition into the "brittle" zone and be easier to split.
GTI Engineers determined that the quantities of cryogenic liquid required would be excessive, and further found that during testing; the cooling effect was not uniform through the length of the pipe. Since the project had reached a go / no-go milestone the Company decided not to continue further funding.

## Gas Quality

The gas supply picture for the Company's service territory – and indeed for much of the nation – is evolving, and unconventional supplies such as LNG, shale gas, biogas, and gas from other geographic regions will soon be a part of our supply picture. While research into supply itself is outside the scope of the Millennium funding mechanism, the effect that these diverse supplies may have on our existing infrastructure is a new and growing R&D area for us.

**M2005-005 – Gas Interchangeability for Installed Components** A multi-phase study investigating LDC coupling components and associated materials and whether varying gas compositions in a range of temperatures and pressures can create leakage in the couplings. This project studies the effect that a wide range of future expected gas supplies from non-traditional sources may have on installed infrastructure components such as gaskets, O-rings, seals, and diaphragms. Anecdotal evidence exists that suggests that gas supplies outside of normal expected limits may have been the cause of component failure in two east coast LDC distribution systems, but no definite conclusions can be reached, and no similar studies have ever been undertaken. This test program is designed to determine, through controlled laboratory testing at GTI test facilities, whether gas composition changes affect the performance of elastomer components mentioned above. Baseline and test gasses were agreed upon and procured, and infrastructure components were removed from the field and sent to the GTI lab for testing. Components are cycled through a "baseline" gas (the gas normally expected) and then cycled through several "test" gases (representing future expected supplies). During this cycling, pressure and temperature are also varied. The results of this test program will allow the Company to take action by removing and replacing components determined to be "at risk" or set new supply tariff limits with a scientific basis for setting them.

**M2011-002 - Storage Effects on Gas Quality -** A portion of the gas entering the Company's system comes from underground storage in geological formations. There is anecdotal evidence that gas leaving storage can have different properties than gas entering storage, for several reasons. These reasons can include presence of water or other substances in the storage formation, temperature variations in the formation (which could affect dew point), blending (or lack of blending) and others. None of this is well understood or modeled. The Company would like to understand this better from the perspective of the ultimate effect on our distribution system. This would help us better negotiate tariffs for gas delivered that would not have harmful effects on pipe materials as well as gaskets, seals and diaphragms. NYSEARCH commissioned a subcontractor for a two phase effort; the first phase is a literature search which will identify the key parameters that affect gas quality in storage. Assuming a successful outcome of the first phase, a second phase would develop a predictive model so that ultimate gas qualities can be more accurately projected. This benefits the company by enabling it to better predict quality, set tariff limits that recognize the potential for change in the quality of the gas in storage, and ultimately insure the integrity of our infrastructure.

**M2011-003 – Odor Masking.** Odor Masking is a phenomenon recently observed in gas distribution systems in which the odorant, although present in the required concentrations, is not perceptible to the human sense of smell. It is manifested by no odor or a markedly different odor than is usually associated with natural gas. This is different from Odor Fade, in which the concentration of odorant is lowered due to its being absorbed by the pipe (common in new piping systems) or by trace constituents in the gas stream. The Company is concerned about this issue because absence of the characteristic gas odor will prevent recognition of gas leaks or other hazardous situations.
Odor Masking is not well understood but the Company and other NYSEARCH members are working with Cardiff University in the UK and a professor there who has done some research in this area.

It is known that pairs of compounds, called "antagonistic pairs" can act together to change the perception or intensity of an odor and that this reaction actually occurs in the human nose or brain. In Phase I of this project, researchers at Cardiff University have demonstrated that certain chemicals that can be present in a natural gas stream can mask the odor of some sulfur compounds that are commonly used in odorant. This was shown by actual tests involving volunteers at the university who ranked the intensity and pleasantness of these chemicals before and after mixing. The Phase 1 work will attempt to identify as many of these antagonistic pairs as possible. In Phase II, just beginning now, researchers will attempt to identify where this human response is taking place. This is important because it will lead to certain mitigative strategies depending on where the response takes place.

The ultimate goal and benefit of the project is a practical pipeline operator guideline on how best to mitigate this phenomenon. For example, the guideline could call for tariff limits on certain trace constituents be set at a lower level, or it could recommend the use of certain odorant types that are more resistant to masking. A successful project outcome would eliminate the situation where a gas leak goes undetected with potentially catastrophic results, such as the Texas school explosion in 1937. The project identified the causes and mechanisms associated with a phenomena that is not fully understood, odor masking. The overall goal was to develop guidelines to mitigate odor masking and anticipate issues that arise from variations in gas quality. While the mechanisms were identified and confirmed, the program did not move to distinct measures for mitigation due to results that unveiled more issues to resolve in terms of human variability in terms of concentration sensitivity. Status is “Complete” until parallel work determines need

**M2013-003 - WKU Advanced Chemical Sensor.** Through the TecFusion/Oracle program, NYSEARCH identified the smart nose technology of Western Kentucky University (WKU). This technology uses nanosensors to develop a smart nose that is rather sensitive and can be used to also detect a certain gas signature. The Western Kentucky University (WKU) project first completed a feasibility study for using an “artificial nose” system to detect a series of analytes of interest to the natural gas industry. The nanosensor technology leads itself very well to small, low power instruments, ideal for field deployment. This project is now advanced to development and testing of advanced prototypes.

**OTD 7.8.a – Pipeline Quality Biomethane: Guidance Document for Landfill and Water Treatment Conversion.** This is a national study and sampling program to determine acceptable gas quality for introduction of landfill and wastewater-derived biomethane into Ngrid’s distribution system. No such standard exists in the US today. Information was assembled on landfill and wastewater biogas production, treatment, gas quality standards, and test protocols surrounding biogas production and use. A lab test program was executed testing raw and processed biogas samples for over 400 chemical species. A guidance document was prepared for safe interchangeable use of landfill and wastewater treatment biomethane in LDC networks. The results of this project show that these biomethane sources can be safely introduced into LDC networks.

**OTD 7.9.c – Assessing Acceptable Siloxane Concentrations in Biomethane**
Siloxanes are a class of compounds that are silica-based and found in many personal hygiene and health care products. As such, they enter waste streams and can be found in biomethane produced from landfill or wastewater biogas cleanup systems. There is evidence that siloxanes, when combusted, can result in excessive deposits of silicon dioxide on boiler tubes or gas turbine blades. The Company is also concerned because the effect of siloxane on standard infrastructure components is unknown. GTI is assessing industry data and attempting to determine what levels of siloxanes in biomethane would lead to issues with end use equipment or pose indoor air quality issues. In addition to the acceptable concentration of siloxane, other unknowns must be understood, such as where, and at what ratio, the biomethane enters the LDCs’ distribution systems, and what flows and velocities can occur at the end use equipment. This project fills an important knowledge gap and allows the company to prepare for the introduction of another non-traditional supply into our existing infrastructure.

**OTD 7.10.a – Trace Constituents in Natural Gas.** Significant research to identify the complete range of trace constituents in natural gas has not taken place in 20 years. In that time span, non-conventional supplies are entering LDC systems and these supplies are expected to have trace constituents in them. The objective of this project is to build a database of trace constituents specific to current supplies of gas flowing into LDC systems. The Company will use this database to assess new gas supplies from unconventional sources such as shale gas to see whether these new supplies are compatible with existing supplies. Routine analysis of natural gas supplies is an established practice. Heating value, specific gravity, hydrocarbon content, and some inerts such as nitrogen are measured periodically, but trace constituent analysis is not routinely done. A partial list of trace constituents of concern would include halocarbons, volatile organic compounds (VOCs), siloxanes, ammonia, trace metals, and bacteria. Comprehensive knowledge of the presence and amount of these constituents would allow intelligence to be placed on setting limits for these constituents in future supplies.

**OTD 7.10.b - Odor Fade.** Odorants used in the gas industry in North America all contain sulfur, carbon, and hydrogen and belong to a category of chemicals known as organosulfurs. The most common odorants used are alkyl mercaptans such as t-butyl mercaptan, alkyl sulfides such as dimethyl sulfide (added to lower the freezing point of the mixture), and tetrahydrothiophene (a cyclic odorant). This project was designed to investigate causes of odor fade in natural gas distribution systems. A preliminary literature survey reviewed the availability of current and historical data. It concluded that the primary causes of odorant fading include: 1) surface interactions of odorants with different pipe materials, 2) scrubbing or dissolution by condensates or cleaning fluids, 3) chemical reaction/oxidation of odorant with other components in the gas stream, and 4) other system state variables. Thermodynamic prescreening was one tool used to look at the possible reactions involving more common blend stock odorants. In addition to forming (mainly) disulfides and iron sulfides, mercaptans might also decompose or react with trace gas processing constituents (e.g., methanol). Analysis of data collected by funders over the study period indicated that: most odor fade events were reported to have been prompted by weak sniff test results and most respondents reported performing follow-up quantitative analyses. No instances of solvent odors were reported. Two odor fade events were reported with plastic (PE) pipe, the others with steel pipe. Ambient temperature ranged from 20-90°F. All events involved a single source of natural gas. No pipe cleaning was mentioned as having been employed by any of the respondents. Odorants involved were t-butyl mercaptan mixtures with either dimethyl sulfide, i-propyl mercaptan, or tetrahydrothiophene; no odorizer operational issues were noted. Supplementary odorant injection was employed to increase odorant levels by all but one of the respondents. Findings include: analysis of TBM loss in plastic pipe with respect to temperatures. THT loss with respect to temperature, TBM reactivity with steel pipe vs. plastic pipe material, and steel pipe and odorant levels of TBM and THT in relation to presence of rust. When water was introduced into the steel reactor, the rate of loss increased further. Water by itself had no effect (as seen in the inerted reactor tests), but had a significant effect when iron was present. Initial modeling of the 1-step versus multi-step reaction mechanism showed the multistep mechanism to be more robust. The information gained in this project was used to prepare a suggested revision to Chapter 7 of the current edition of the AGA Odorization Manual, last revised in 2000. This study was completed end of 2014

**OTD 7.11.a – Gas Quality Resource Center.** The Gas Quality Resource Center is intended to provide technical support necessary to identify and fill knowledge gaps regarding potential industry issues associated with changes in gas composition profiles in North America. The Resource Center will provide a centralized “clearing house” for information related to gas quality, analysis of current flowing gas supplies in North America, identification of constituent trends across identified regions, analysis of current technical regulatory trends associated with pipeline tariff negotiations and identification of research needed to help fill information gaps ultimately aimed at maximizing supplies while balancing the needs of pipeline integrity and end use concerns. The resource center would maintain information on gas compositions and pipeline tariffs, and would serve to identify and launch research as appropriate related to gas quality issues. Issues such as odor masking or siloxane levels are examples of the types of research that could result from the Company’s participation in the Gas Quality Resource Center.

**OTD 7.11.b – Trace Constituents Sensors** This project will identify candidate sensors or sensor technologies for measuring, perhaps in real-time, trace constituents in new gas supplies, such as landfill gas, biomethane derived from a variety of biomass sources, and unconventional supplies such as shales, tight sands and coal bed methane. The Company is aware that its future fuel mix will include renewable and unconventional gas. The need to understand the composition of a new gas supply and to monitor its components is increasing as the number and variety of sources grows along with their frequency of introduction into the natural gas pipeline network. The project will proceed on a phased approach, future supplies must be identified, and constituents of concern present in these supplies also need to be identified. For some new supplies such as landfill gas, research into gas trace constituents had already taken place, for others for example shale gas, less information exists. Once the constituents have been identified, instruments that can sense these constituents will be identified and assessed. The benefit of this work is the ability to monitor the composition of new gas supplies and the associated capability of protecting our distribution assets.

**OTD 7.15.a - Real-Time Gas Quality Sensor.** The introduction of shale gas and upgraded biogas into the gas transmission network is increasing the importance of accurate and regular monitoring of the natural gas heating value and composition. Currently used gas chromatographs (GC) are expensive and slow. The project objective is to demonstrate development of a practical, reliable, and real-time gas quality sensor (GQS) that can detect changes in gas quality (heating value, and concentrations of methane, ethane, propane, butane and carbon dioxide concentrations) in real time and can provide this data to the operators of an LNG plant or other facility.

## Environment

Projects in this area are focused on new technologies to more easily and cost effectively remediate MGP sites. A more recent focus in the Environment area is related to Climate Change Concerns.

**M2001-002 – Management of Impacted Sediments.** The company formed and led this project, which was funded by other NYSEARCH members as well as a national consortium of industry and the US Navy. This project studied the correlation between polycyclic aromatic hydrocarbon (PAH) concentrations in manufactured gas plant (MGP) sites and the actual bioavailability of these compounds to living organisms, with the goal being more realistic guidelines for site remediation. Not all PAHs at MGP sites are actually bioavailable, and therefore harmful, to organisms and the environment. This project developed a new analytical method to determine actual bioavailability. Benefits include the potential of a greatly reduced remediation area. A final report has been submitted and accepted by the project funders as well as the USEPA, the NY State DEC and the NY State Department of Health. In February 2012 the NY State DEC issued a remedy decision based on the new analytical method for the city of Hudson NY (Water Street) company site. Savings realized for this one remediation are approximately $26M.

**M2008-006 – Expanding the function of No Blow Tools.** Tools to make "live" taps into gas mains are commercially available but during certain operations small amounts of blowing, or escaping gas are present. A set of innovative tooling was developed to enable plug insertion or removal, or insertion of stoppers. This benefits the environment by reducing the amount of methane (a greenhouse gas 21 times more potent than carbon dioxide) released into the atmosphere, and also contributes to worker safety. A second phase of the project developed an innovative method to reinject gas into an adjacent main segment rather than blow it off to atmosphere during a special test called a "flow test." This method reduced greenhouse gas emissions and lessens customer concerns and complaints.

**M2009-003 – Adaptation to Climate Change**. The company and others recognize that there are two aspects to climate change, how we, through our methane and CO2 emissions, affect climate change, and how we, as LDCs, adapt to climate change effects and impacts that are certain to occur in the future. To meet this latter goal the Company and others commissioned a study that investigated a range of future climate models, predicted maximum and average expected temperatures and sea level rise, and developed a framework for estimating risk and remedial action to address those climate changes. Phase II examined more detailed flood risks at the local level for sponsoring companies. The benefits of this project will be the development of a gas-industry specific risk-based framework for addressing the impacts of climate change on a broad geographic level to give LDCs quantitative information on which climate effects and impacts to focus on and which portions of our natural gas infrastructure are most susceptible to those climate impacts. A final report has been issued and sea level rise has been identified as the main threat to a natural gas distribution system.

**M2010-002/ T 776 – Methane MR Sensor/Residential Methane Sensor Pilot Testing Program.** See details under Leak Detection and Methane Emission section of this report.
**M2010-004 – Soil Vapor Intrusion** The work in this project involves characterizing manufactured gas plant (MGP) coal tar vapors so that volatile organic compounds (VOCs) can be conclusively identified as either coming from an MGP or from some other source. For example, benzene, a constituent in coal tar, could also be present in a dwelling from common household sources. If compounds such as benzene are identified near a dwelling, current regulations require extensive sub-slab (below the basement or slab of a dwelling) sampling at a cost of $10,000 per dwelling. However, if MGP coal tar can be ruled out as the source of the contamination, less expensive investigations would be warranted.

**M2011-004 – Carbon Calculator.** The Company has been voluntarily reporting fugitive methane emissions since the mid-nineties and is committed to reducing its carbon footprint. One component of that carbon footprint is carbon dioxide emissions resulting from normal construction activities. The intent of this project is to quantify the emission reduction that would result from choosing a less energy intensive method of construction. For example, there are two alternatives to installing a new gas main. The first is traditional open trench, where a trench 18 in wide by 3 ft deep is excavated along the proposed length of the installation. In an alternate method, the pipe may be installed via directional drilling. This latter method is quicker, uses less equipment for a shorter time, and eliminates the bulk of new paving that must be applied. But up until now there has been no way to quantify the reduction in emissions. This project involves quantifying the emissions that result from each step of the construction process.

NYSEARCH, together with the North American Society for Trenchless Technology (NASTT) is working with ETA/Environ, to develop the spreadsheet tool. In the first phase of the project, subject matter experts from the participating companies are quantifying types and time on the jobsite of various pieces of construction equipment used on various construction activities. Then, ETA/Environ will use the latest EPA "non-road" emission factors to compile emission rates for the various pieces of equipment. In the final step, ETA/Environ will create a robust, user friendly spreadsheet tool to enable gas company managers to compare the carbon impact of alternative constriction practices.

There are several benefits from this project; determining the construction methods with the least environmental impact, validating the additional (environmental) benefit to public authorities who may be skeptical about the use of a newer or non-traditional construction technique; and it could allow the Company to be proactive in tracking and reporting (if required) these emissions.

**OTD 6.8.a - Carbon Management Information Center.**
The Carbon Management Information Center (CMIC) was established in 2007 to serve as an on-line clearinghouse for relevant carbon management information. The CMIC serves the gas industry, its customers, and other stakeholders by developing resources and analytical tools to provide clear, concise, and technically-sound information on issues related to reducing the nation's energy consumption, source energy codes and standards, and carbon emissions.

**OTD 7.9.d and 7.10.c – Improving Methane Emission Estimates for Natural Gas Distribution Companies**. The Company and other LDCs have been voluntarily reporting fugitive methane emissions from their distribution systems under the US Environmental Protection Agency (EPA) "Star" Program since the 1990s. With the recent passage of EPA "Subpart W" LDCs are now required to report these emissions.
To report emissions from its piping network, which account for over 80% of the Company's fugitive emissions from its gas distribution system, the EPA allows the use of emissions factors, expressed in terms of cubic feet of methane per mile of pipe per year.

Different pipe materials have different emissions factors. The factor is simply applied to the mileage of pipe in the system and total emissions are reported.

These emissions factors were developed in the early nineties via a testing and measurement program sponsored by the USEPA and conducted by the Gas Research Institute and subcontractors. The factors have never been updated and the Company and industry in general, are aware that the factor for plastic (PE) pipe is unrealistically high. For example, a similar study in the UK conducted in the early 2000s resulted in a leakage factor for PE pipe that is one half the value used in the US. PE piping systems are fabricated with improved materials and installed under better quality control than in the nineties, and the emissions testing program for PE pipe done then only contained six data points – for the entire nation!

Working through GTI and subcontractors, and with the knowledge of the USEPA, the Company and others are replicating the test methods from the previous study and attempting to develop a more realistic emission factor. Project funders (there are 18 LDCs participating) are identifying leaks in the field and the GTI team measures them. In parallel with conducting the leakage measurement (which involves exposing the leaking pipe segment) an alternate measurement technique is being applied which involves only surface measurement of leakage. If the two separate techniques agree, more field measurements can be taken with the less expensive surface measurement technique. Several field tests have taken place so far with others scheduled. After the PE leakage factor is revised, a second phase of this project will revise the factors for cast iron and bare steel pipe materials. The benefit of this project is more accurate reporting and a better representation of the company's contribution to greenhouse gas emissions.

## Infrastructure Support

The following projects benefit overall company operations in areas such as safety, sensing and measurement, advanced material research, community and customer concerns, and general operations improvements.

**M2009-002 - Mercaptan Sensor Development**. To insure proper odorant levels in natural gas, LDCs are required to perform a periodic "sniff test." The human nose can detect odorant levels in the ppb range and if the gas is properly odorized this provides adequate warning to the public that gas is present at levels well below the "lower explosive limit" (LEL). However, sniffing by humans is subjective and technicians performing these tests can sometimes be desensitized to the odor of mercaptan. Also, the recently identified phenomenon called "odor masking" can cause the characteristic odor of mercaptan to change or disappear. This project aims to develop a portable sensor that can detect mercaptan in the ppb range. It would not replace the sniff test – which is required by code – but would supplement those tests, and would also be installed in areas where odor fade or masking is suspected, to verify that proper odorant levels are present. The technical approach is a unique combination of standard gas chromatography and a relatively new technology called differential mass spectroscopy. This technology was discovered via the NYSEARCH "Oracle" project mentioned above. Feasibility testing has been successfully completed and a prototype instrument is being built. Due to an instability issue, re-design work was attempted by the first contractor in place of additional field tests. With that work not solving the problem, NYSEARCH sought additional expertise and is now working with UC Davis to resolve the engineering issue associated with instability before going to advanced prototyping and testing. The benefit is advanced warning of possible odorant deficiencies.

**M2010-002/T-776 – Methane MR Sensor.** See details under Leak Detection and Methane Emission section of this report.

**M2010-003 – PCB Absorption in PE Piping.** Every year the Company discards quantities of polyethylene (PE) pipe that have been removed from service because they have been damaged by third parties, or for other miscellaneous reasons. The Company ships such pipe to a special landfill that accepts PCB-contaminated pipe because there is no EPA-approved method for decontaminating PE pipe potentially exposed to PCBs. The Company determined that the same approved procedures used to clean and decontaminate steel pipe may be applicable to PE pipe, if it can be proven that PCBs are not absorbed into the wall of PE pipe. Such testing has never been conducted for PE pipe. This is a Material Science Study to evaluate whether there are particular PE pipe characteristics that interact with PCBs. Address decontamination issues so that abandoned PE pipe can potentially be left in place. The Company, through NYSEARCH, engaged Jana Labs – a respected plastic pipe research and testing laboratory – to conduct this testing. The tests are underway with Jana. Pending a successful outcome of the test program, the Company will work with the USEPA to create a standard for cleaning and decontaminating PE pipe so it may be discarded in a normal fashion.

**M2011-001 – Self Healing Pipe.** Through the NYSEARCH "Oracle" Program, the Company has become aware of advances in material science through nanotechnology. Several concepts related to advanced materials were addressed and the two most promising were self locating pipe (pipe containing materials that would respond to conventional above ground locators, thereby solving the problem of broken or malfunctioning tracer wire) and self healing pipe. (Self locating pipe was discussed among NYSEARCH members and the group, after careful consideration, decided not to pursue that technology at this time.) The Company and other NYSEARCH members want to explore further the concept of self healing pipe so this project was authorized. Our investigations indicated that the addition of different types of nanoparticles into polyethylene (PE) material can enhance its mechanical or electrical properties. One type of adder can actually induce self-healing capabilities in the base PE material. A crack in the material will release a bonding agent and lab experiments conducted by others show recovery of up to 75% of tensile strength of the base material. The Company wants to pursue this further and feasibility discussions with manufacturers will commence. This is a long term project with ultimate benefits realized perhaps 25 years into the future. The project will be carefully monitored and will proceed in phases. Reduction in distribution pipeline incidents due to damage is the benefit of this research. The objective of the program is to develop a new generation of PE based pipes with self-healing properties for use in the natural gas industry. Following completion of the feasibility study, additional work was completed to prove that the PE pipe when altered for the self-healing nanomaterial would retain its required strength properties and at those conditions, still provide self-healing capability. It has been proved that the strength properties are maintained. Additional research is necessary as to evaluation of all conditions and development of various PE piping appurtenances. NYSEARCH is reframing the program to move from feasibility testing to more advanced development.

**OTD 1.12.b - Cross-Bores Detection Using Mechanical Spring Attachment.** Research is under way to develop a tool that will detect a hit to a sewer pipe during the installation of a gas pipe. A prototype for field testing was built that uses a mechanical spring system that is activated inside the sewer pipe void to provide a real-time alarm identifying a hit. Laboratory and field tests were conducted in 2013-2014 and a patent application for the technology was filed. In testing, the tool was able to successfully indicate the voids in pipes which were hit (i.e., providing positive indications). Several modifications of the proto-type may be performed with future commercializers. — A report on the results of field-test activities is being prepared.

**OTD 1.13.a - Real-Time, Multiple Utility Detection During Pipe Installation Using HDD Systems.** Research and testing is being conducted on an acoustic-based technology to detect obstacles during horizontal directional drilling (HDD) operations. The ultimate goal is to develop a system that can automatically and rapidly detect buried pipes/obstacles in front of and adjacent to the drill-head of HDD machines. The system was tested with seismic/noise sources and under differing attack angles to pipes. Post-processing data showed that the acoustic system was able to achieve the average pipe detection accuracy of ± 2.1' during the trials. — New and improved noise sources are being developed for further evaluation.

**OTD 1.14.e - Plastic Pipe Locating—Alternatives to Traditional Tracer Wire.** OTD along with GTI and 3M submitted a White Paper to DOE/PHMSA for a project that would have a very similar work scope as this current OTD project. The proposal resulted in an award from PHMSA with work expected to begin in the fourth quarter. The revised scope of the project is to develop an electronic marking system that will provide locatability on various-diameter HDPE and MDPE pipes. The project will also assess the technology capabilities versus pipe diameter, burial depth, and pipe-burial methods (horizontal directional drilling, open trench, etc.) —The contract for the new PHMSA-supported project is being finalized.

**OTD 1.15.a - Cross Bores—Sewer System Cleanout Safeguard Device.** This project focuses on the development of a safety device that provides the ability to seal the sewer-system cleanout opening in the event a natural gas line (inadvertently installed in a sewer) is struck by a power auger or other mechanical tool. The project team finalized a prototype cap design. Based on evaluations, 35 split caps were manufactured and shipped to sponsors for evaluation. — The project team has been in discussions with a manufacturer regarding commercialization of the split-cap safety device.

**OTD 1.15.d - Improved Camera Imaging to Identify Cross Bores.** The objective of this project is to provide an evaluation of imaging systems with the potential to work in conjunction with various types of trenchless pipe-installation technologies (including the use of horizontal directional drilling equipment with drilling mud) and still be able to positively identify a cross bore. An initial patent/literature search produced no new information on sewer camera technology. This, along with discussions with experts in the industry, indicated that there is little that can be done to improve this technology without additional technology platforms. Subsequently, several potential alternative platforms were identified. — Communications are being arranged with project sponsors to discuss the technologies identified and deter-mine future plans.

**OTD 2.7.d - Cold Adhesive Repair and Joining of Polyethylene Pipes with Minimal Surface Preparation.** In this project, researchers tested a cold-adhesive repair technique in an effort to develop an economical, reliable, and safe technology to quickly and effectively repair damaged plastic gas pipes. Long-term test results of PE pipes patched with the repair method found that the patching system can be effective. Testing also resulted in additional information about the effective application of the adhesive. — A Final Report on the project is being prepared.

**OTD 2.10.b - In-Service Field Evaluation of Polyurea Coating Systems.**
As a follow-up to a previous project, research into field-applied polyurea coatings for gas industry use is being conducted on promising coatings. Long-term field trials will be performed to evaluate these coatings and determine a cost-effective coating-application method and process for structural liners. — Installation and evaluation of the coating was successfully completed at a sponsor site in November 2015.

**OTD 2.11.a - Development of a System for Repair of Aboveground Leaks.**
Researchers are conducting a thorough evaluation of repair methods for leaks on aboveground piping in an effort to establish a basis for choosing the right repair method for a specific leak, establishing levels of adequate preparation, and providing the proper installation for increased reliability. Prototype test samples were constructed to simulate aboveground leaks from varying levels of corrosion (pin holes) and from threaded joints. Test samples were fabricated, fitted with the corresponding repair systems, and hydrostatically tested to failure. — Testing is ongoing.

**OTD 2.12.a - Integrated Expert Monitoring and Training System for Butt Fusion.**
A set of critical fusion variables is being developed to provide an integrated technology package for use in pipe-fusion training and field operations. The goal is to produce a system capable of flagging marginal fusions in all operating conditions. In the third quarter of 2015, all butt-fusions and low-temperature high-speed tensile tests were completed and creep testing initiated. A significant amount of test data post-processing was completed and correlation of the test data to butt-fusion conditions initiated. — A Final Report is being prepared.

**OTD 2.14.c - Assessment of Squeeze-Off Location for Small-Diameter Polyethylene (PE) Pipe and Tubing.** Researchers developed a model for predicting the effects of squeeze-off on small-diameter PE pipes. Mechanical testing was tailored specifically for the squeeze-off mod-el to capture the application's conditions. Technicians prepared a total of 230 specimens for testing. The results from the squeeze-off FEA model indicate that a squeeze-off can be performed at a distance three pipe diameters from a fitting with any size pipe. The project team initiated efforts to revise ASTM F1041; however, feedback received from ASTM indicates the project needs to address squeeze-off near mechanical fittings as well. This additional scope of work is to be submitted to the project sponsors for consideration.

**OTD 2.14.e - Guidelines/Best Practices for Scraping PE Pipe and Fittings**
Research is focused on the development of a functional set of improved, up-to-date guidelines for PE pipe and fittings that take into account current tooling and practices (e.g., scraping) while addressing the variables associated with fusion execution. Information from survey results was combined with data from previous projects and a test matrix for the pertinent tools was developed.

**OTD 3.8.a - Addressing Jackhammer Noise Abatement.** In urban areas of the Company's territory there is increasing pressure from city officials to lower the noise of commonly used construction equipment. Evening and weekend work, such as is required for emergency response work, only amplifies this need. Pneumatic jackhammers are among the noisiest of commonly used construction equipment. National Grid, in New York City, experimented with insulated fabric jackets that are placed around the jackhammer and while these helped to reduce noise levels, a more permanent solution is desired. The Company and others are working through GTI to try to engage jackhammer manufacturers to examine the design of a typical jackhammer to see if there is any opportunity to reduce the noise produced. It is recognized that noise from a jackhammer is produced from three distinct sources, the internal piston operating inside the cylinder, the air exhaust, and the bit striking the pavement.

The objective of the project is to engage manufacturers and determine whether they are open to a basic redesign effort of their tools to make them less noisy. GTI identified several manufacturers but only one was willing to attend a meeting to discuss the intent of the project. As a result, the project will most likely not proceed to Phase 2, which would have involved detailed noise analysis and would have served as the basis for a redesigned jackhammer.

**OTD 3.14.a - MBW Soil Compaction Survey Enhancements.** The SCS fills a need to verify soil compaction levels during field operations (excavation back-filling). The memory media that was used in the previous version of the SCS is cumbersome to use and has become obsolete. The industry practices in field data collection have also evolved considerably since the SCS was first introduced. The objective of this project is to upgrade the capabilities of the Soil Compaction Supervisor (SCS) to make it compatible with modern Geographic Information System (GIS) data capture practices as well as more user friendly through better data logging and reporting capabilities. Initial efforts will also be investigated to determine the SCS's ability to be correlated to a standard proctor value or range. The ability to attach metadata such as GPS coordinates and photos to compaction data is now wanted for entry into a GIS. Transferring compaction data from a mobile device to a GIS with the additional capabilities available on mobile devices (GPS, camera, etc.) will be incorporated into the data acquisition for the compaction record. By redesigning the SCS, a useful tool will continue to be available and the data generated can be directly imported into utility GIS or other data systems. Capturing and archiving the soil compaction data will help ensure that compaction is being performed properly (quality control) and will enable a utility to validate proper compaction to jurisdictional and/or regulatory authorities. The testing portion of the project seeks to better understand the correlation of the SCS data with that from a nuclear densitometer to provide a lower cost alternative.

**OTD 3.14.b - Update ASTM Standard of DCP Compaction Control.** Through this project, interactions were made with ASTM to update its current standard on the five-pound Dynamic Cone Penetrometer (DCP) compaction control device. The ASTM standard D7380-08 (Test Method for Soil Compaction Determination at Shallow Depths Using 5- lb. DCP), which was developed in an earlier OTD project, completed the balloting process of its standards in September 2015. The OTD-developed standard passed both the sub-committee ballots with no negatives. —The project team is following up with the ASTM Publications Committee to complete the process of adding the new version to the ASTM 2016 standards publication.

**OTD 5.6.e – Portable Propane Air Temporary Residential Supply, Phase II**
Many routine gas operations require temporary disruption of service to customers. Replacement of aging gas mains requires a brief interruption while the service is transferred from the old main to the new main. Meter change activities also require a brief shutdown. Rehabilitation techniques such as cured-in-place lining can require an outage lasting 12 hours or more. In such cases compressed natural gas (CNG) bottles can be used but they are heavy and cumbersome. The propane air mixer has been under development since 2006. It mixes propane from a standard gas barbecue tank with air and delivers the mix at the proper heating value. A prototype was built by GTI engineers and subjected to extensive operational and end use testing, including local field testing in Chicago. Tests were successful with the exception of results with one particular brand of water heater, which shut down on high flame temperature. Phase II of this project will redesign the unit to produce a cooler flame and the testing will be repeated on a mix of appliances. Firing rate, flame temperature and emissions will be recorded. If the testing is successful (meaning all appliances performed within spec on all tests) then a new phase of the project will investigate commercialization of the unit. The benefit is better customer service using a more efficient and ergonomic method.

**OTD 5.7.p - GPS/GNSS Consortium.** The project objective is to facilitate the sharing of information related to the use of GPS, Global Position System [US reference] and GNSS, Global Navigation Satellite Systems (International reference) technology for utility operations. The GPS/GNSS Consortium is a cost effective way for utilities to better understand this rapidly growing technology field and how GPS technology can best be applied to daily operations to create operational efficiencies, enhance regulatory compliance, and improve the quality of field collected data. The program activities include technology development and integration, workshops, pilot projects, demonstrations, best practices/standards development and general information sharing. Over the last two years, the GPS Consortium has focused on technology development that will reduce the cost and complexity of deploying GPS for routine construction and O&M activities. A Real Time Kinematic (RTK) base station has been installed, on GTI's main campus. This base station was built using GNSS Consortium funds in 2014 and continues to be an important asset for GNSS and GIS research at GTI. The following emerging technologies were selected for evaluation; Garmin GLO, Swift Navigation Piksi RTK Kit, uBlox Neo-7P & EVK-7P. Additionally, the following well known legacy units were tested to provide base-line comparisons; Trimble GeoExplorer XH, Navcom SF-3040, Geneq SxBlue III. GTI has completed testing and results are currently being compiled.

**OTD 5.8.a - Automated Welding.** This project will identify and select an automation manufacturing partner, develop a beta prototype automated welding unit, and create procedures to perform the welds on various types of tees and nipples. Throughout the project, the project team will work with the selected manufacturer(s) to assist with the implementation of the unit as a commercially viable product for the industry. A final report will document these efforts.

**OTD 5.8.d - Tool for the External Classification of Pipe Contents**
Research is being conducted to develop a practical tool that can detect "live" three-phase electrical cable in pipe without breaching the pipe wall. The ultimate objective is to develop an affordable tool that could be carried in each crew truck. The current project phase involves the construction and demonstration of a pre-production proto-type tool. Recently, the main focus was to debug the software required to perform the Fast Fourier Transform (FFT) on the vibrations detected on a pipe. The hardware platform was demonstrated to run the FFT library functions correctly; however, the signal level captured was somewhat low. This will need to be corrected in the hard-ware by adding amplification between the vibration sensor and the processor. The project is behind schedule and potentially will require additional time. — Software and hardware modifications are under way.

**OTD 5.08.e.2ab - Enhanced Material Tracking and Traceability-Development of Standardized Protocols/Identifiers for Meters, Regulators, and Transmission Pipelines, Phase 2 (TEJ).** The objective of the program is to utilize the previously established base-62 di encoding system methodology and develop a series of unique identifiers and format to characterize pertinent information for meters and regulators conforming to ANSI B109 requirements. TEJ continued its work related to proposed changes to ASTM F2897 to incorporate key data related to transmission pipeline components (pipe / appurtenances). The initial ballot for the F17.60 subcommittee ballot was submitted in December 2013 (one negative and five comments were received). The negative has been resolved and proposed ballot has been revised accordingly. The revised amendments were submitted for concurrent main and subcommittee voting. Provided that the ballot is approved, all the necessary identifiers required to produce a 16-character code schema to mark transmission pipeline components should be in place. It is important to emphasize, even with the proposed changes in place, this simply provides all the elements needed to develop a similar 16-character code for transmission components and satisfy the objective of this phase of the program. Additional work will need to be incorporate these requirements within applicable API 5L standards and resolve underlying procurement practices and supply chain considerations within utility companies.

**OTD 5.9.h - North American Outreach Manufacturer Outreach Program**
Research was conducted to identify promising technologies that are under consideration but not currently under development by qualified North American manufacturers. The focus was on prospective products or technologies and that have sufficient commercial value to natural gas utilities to justify submission of a funding proposal to OTD. — A Final Report detailing project results is being prepared.

**OTD 5.10.d - Remote QA QC.** Development of a remote monitoring program with map based application for smartphones and tablets for field data capture and documentation will advance utility operations and quality inspections. The goal of this project will develop a mobile application with a supporting step-by-step field procedure for its use including guidelines. The focus is to develop technologies and protocols to allow operators to remotely monitor and record the quality of various operations. The quality of field work can then be monitored in real-time using a step-by-step procedure, GPS-enabled cameras, and a web-repository to capture, store, and share photos and create permanent records. Using smartphones to capture time-stamped photographic documentation during field operations improves quality and enhances quality control, particularly for new installations. Field crews, both in-house and contractors are encouraged to follow specifications and procedures because pictures are used to document important steps. Using remote QA/QC methods allows 100% of new installations to be monitored by a quality inspector or office manager and support staff, no matter where they are, they will be able to view pictures of all new installations in real-time and share information. Further, pictures are captured in a GIS environment and can be stored for long-term usage such as validating regulatory compliance, future locating, and engineering operations.

**OTD 5.11.a – Dewatering System for Mains.** Excessive amounts of water in gas mains can cause service outages. This “water intrusion” is particularly prevalent in low pressure areas where groundwater can enter into a gas main through leaky joints in high water table areas. The normal solution is to locate the area of water intrusion and pump the water out. This project is investigating novel methods to remove residual moisture that can be present even after water is pumped out. Two methods that have been investigated are desiccant and molecular sieve technologies that can more permanently dry out the interior of a gas main, and chemical additives such as methanol foam which can allow moisture to flow out of low points and not collect there. Once the feasibility of such methods is evaluated, the next step in the project will be to decide whether the successful technology can be adapted to installation on a gas distribution system. This project will decrease the amount of customer outages in areas prone to water intrusion. Completed June 2015.

**OTD 5.12.b – Development of a Portable Flash Fire Suppression** System. During live gas operations the potential for rapid ignition of natural gas (a flash fire) is present. Although workers follow strict safety procedures and are protected with fire retardant clothing and breathing air apparatus, bodily harm can occur within milliseconds if an ignition were to occur. A true industry need exists for a system that can rapidly detect and extinguish flash fires. The project was initiated in GTI's Sustaining Membership Program (SMP). Two separate and distinct challenges were investigated, the ability of a sensor to detect a flash fire in less than ½ second, and the ability of a fire suppression system to limit injury as low as is reasonably achievable. In testing at GTI facilities both concepts were proven; a UV detector reliably detected fires within 30 milliseconds, and two separate suppression systems, high velocity air, and nitrogen extinguished the fire but each had some drawbacks needing further investigation. The Company is extremely interested in this project and Safety Dept. personnel will act as advisors to the GTI project team. A successful outcome of the project will be a portable flash fire suppression system that will effectively detect and extinguish flash fires should they occur and be simple to deploy. Enhanced worker safety and avoidance of serious or even fatal injuries is the obvious benefit of this research.

**OTD 5.12.g – Evaluation and Adaptation of Kleiss Inflatable Stoppers for the US** Natural Gas Industry. Current line stopping equipment in the natural gas industry has been used since inception (~ 50 years) in the same trim without substantial re-design. This equipment certainly works but is heavy, costly to maintain, and is somewhat time consuming and labor intensive when the installation of the necessary components required are taken into account. New line stopping equipment that may reduce these problematic issues, while providing the same assurance of safety and performance, could contribute to substantial time and money savings when incorporated into day-to-day operations. Through a technology search such equipment was sourced. This apparatus is produced by a European Vendor, Kleiss and Co., and has shown promising performance. The objective of this effort is to evaluate these existing medium and high pressure inflatable stoppers as an alternative to currently employed stopping equipment for use on US natural gas distribution systems. GTI will test and evaluate this inflatable stopper suite of tools (capable of stopping off line pressures of 60 psig at pipe diameters up to 24-inches). Deliverables include the development of testing criteria and a program to evaluate the current offering. In addition, it will identify the necessary modifications to the bagging system(s) and identify deployment fittings required to meet the US natural gas industry standards so that the system may be introduced and deployed for use in the US.

**OTD 5.12.o and 1.14.h – Guidelines for Cast Iron Winter Operations and Cast Iron Winter Patrols study.** The Company and others want to know the best methods for determining when to initiate winter frost patrols on their cast iron (CI) piping systems. Simply starting the patrols when the ground temperature or air temperature reaches a certain limit may not be optimum. There are other factors, in addition to temperature, which may influence the propensity of CI piping to break in frost conditions. Some of these factors are diameter and pressure of the main, age, soil type, and presence of other adjacent underground facilities. The ultimate deliverable of the project is a practical guideline for operators as to when to initiate frost patrols. GTI was selected to perform the study and is investigating – through examination of LDCs' records - the frequency of breaks in the presence or absence of the potential breakage factors. The study is not complete but has already determined that diameter is a key variable and that most breaks take place on smaller diameter piping and, at least for one LDC, there is no record of breakage for pipelines larger than 18" diameter. As more data is accumulated and analyzed patterns like this should emerge. The end result should be a fact-based guideline, based on the above parameters that affect breakage, stating exactly when, and for which segments, winter frost patrols should begin.

Under OTD 1.14.h, the company did an evaluation with GTI using Picarro's CRDS and some of Picarro's latest algorithms to evaluate if this advanced leak detection system and methodology could improve our winter patrols and identify CI breaks more rapidly. The frost conditions were extreme during the course of the investigation which was ideal for the study. However, it was found that numerous passes are required and the processing of the data took a great deal of time. GTI is evaluating the data to determine if there was significant improvement in detection, however to date, this has not translated into cost savings with this approach for CI winter patrols.

**OTD 5.13.d - Transmission Cut In Valve.** The development of proposed cut-in valve system will give operators options for the placement of valves without the need to shut off the flow of gas along with the benefit of greatly reducing the cost of installation. This valve concept can lead to: faster installation times especially in urban environments, no need for flow control and/or bypass of gas, single excavations with no need to stop off the flow in the pipe and no need to install a bypass, enhanced safety, and lower cost of installation. This system will be a unique design that meets all material and performance expectations while delivering a compact and fast alternative to traditional valve installation methods. It will be developed to provide important performance and installation benefits to pipeline operators working under difficult conditions and with critical needs. Initially, a concept transmission EZ Valve will be developed for sizes up to 12-inches with working pressures up to 300 psig. After initial proof of concept, a 6 inch prototype valve will be constructed.

**OTD 5.13.f - Low-Cost Collision-Avoidance System**
Efforts are under way to develop a low-cost, low-speed, collision-avoidance system that would provide gas industry utility vehicles the ability to provide driver alerts and, when necessary, automatic braking. A complete set of laboratory-based testing scenarios was conducted using an experimental test apparatus to generate datasets that represent typical driving maneuvers. Field tests of a wireless tablet PC user interface were completed. For testing, a video system was successfully integrated with the test hardware. — A video is being prepared to demonstrate the capabilities of the system.

**OTD 5.13.g - Post Disaster Risk Assessment with LiDAR and GIS.** The project objective is to develop pipeline risk assessment tool to identify high risk pipe segments after post-disaster events to prioritize repair and restoration activities. This work is performed along with a DOT-funded project with Rutgers, the State University of New Jersey, to develop a mobile mapping platform that harnesses commercially available technologies to provide remote sensing data collection capabilities and to implement a GIS-based platform for data management and pipeline risk assessment. Progress thus far: the risk assessment approach and model is completed, the Bayesian Network has been integrated into a web-based computer model, and a case study is being entered into this model to estimate damage potential of pipe segments at Ortley Beach, NJ after hurricane Sandy.
The results are pending at this time.

**OTD 5.14.a - RFID Testing Program.** A testing program is being conducted to compare the performance and features of multiple radio frequency identification (RFID) and related technology solutions for locating and tracking gas utility assets. RFID tag installations were completed for the 3M Marker Ball, the Berntsen Infra Marker, and the Eliot Marker System. Programming of tags, along with user experience and impressions, were recorded. Assets targeted for RFID tagging included a mix of steel and PE systems from existing pipe test beds in addition to available utility hook-ups (gas, electric, and water). — The project team is in the process of locating, reading, and testing all installed above- and below-ground tags.

**OTD 5.14.b - Smart Leak Repair Form.** A smart leak repair form will improve the quality of data collected during the leak repair process and will lead to improved threat identification and risk assessment for DIMP. The objective is to develop a system to capture more detailed information to allow for more granular analysis to be performed, such as the identification of leak trends. Development of a Fault Tree Analysis and Decision Tree logic will be employed in this framework to resolve issues concerning proper identification of root causes and categorization of failures. The objective of the sponsors is to define an appropriate logic for electronic data collection forms.

**OTD 5.14.d 2a – Tracking &Traceability for Transmission Phase 2a: Standards for MTR and Coating Reports and Phase 2b: Data Collection Technology.** The goal of this project is to develop standards, guidelines, and technology for tracking and traceability of transmission pipe and components. The ability to automate the process of capturing and storing tracking and traceability information for transmission pipe will improve data quality and reduce risk. Data quality will be improved by using electronic records and barcode scanning to capture data essential for MAOP calculations and integrity management. Eliminating manual, paper-based data collection will reduce the occurrence of human errors when capturing and transferring data into the asset management system. In addition to data quality, operators will have access to pipe and coating data that can be used for threat identification and risk modeling as part of integrity management. The results of this project will provide the industry with a standardized approach for capturing pipe, appurtenance, welding and coating data. Phase 1 identified data collection requirements, developed barcode labeling specifications, and created a design document for field data collection software. Phase 2a will create standardized forms for Mill Test Reports (MTR) and factory applied coating information. Phase 2b will create technology to capture manufacturer information using standardized barcodes and develop and test the technology in a proof-of-concept project. Phase 3 (future) will create standardized forms and technology to capture field welding and field applied coating data. GTI will propose a Phase 3 to develop standards and technology for data collection of field applied coatings and field welding operations.

**OTD 5.14.f - Battery and Electric Powered Tool Evaluation, phase 1.** The use of battery-powered power tools in Class 1 Division 2 environments is limited by most LDC's best practice policies; however, this project aims to investigate this topic to propose alternative ways to improve safety of these highly useful devices.

**OTD 5.14.n - Construction Compliance Monitoring System.** The goal of this project is to develop a risk-based Construction Compliance Monitoring (CCM) system to assist operators in ensuring and quantifying the compliance of new construction. The CCM system will be composed of a model and software. The system will assess new construction work from a system-risk perspective and will deploy audit resources based on the probability and consequence of failure for specific job sites. It will identify high risk construction activities, generate prioritized audit schedules, provide electronic audit forms on tablet computers, collect audit results, and quantify the level of compliance using industry-standard statistical methods. This project will create the CCM model and a proof-of-concept system that will be tested with one operator. Full commercialization will be pursued in a second phase, if desired by OTD. The deliverable of this project will be a model and software sufficient to prove the concept and demonstrate the value of a compliance monitoring system. Provide documentation of compliance that can be used in communicating with regulators, insurance providers, or in the event of potential litigation. The benefits of the project: Maximize the efficiency of resources devoted to ensuring compliance. Implementations of this methodology may reduce the number of field inspectors required to achieve the desired level of confidence by targeting and optimizing the deployment of audit resources, improve construction performance and efficiency, and continuously improve risk management efforts by better understanding the sources and frequency of installation error.

**OTD 5.14.p - Developing Devices to Use with the Jameson Directional Insertion Tool**
The objective for this project was to evaluate and modify devices or attachments for use with the Jameson insertion tool to increase the use and capabilities of live in-pipe inspection. A survey was conducted to obtain information on the current tooling and practices for live camera insertion, water removal, and digital mapping. Tests were performed to evaluate the ability of a camera to be inserted into a two-inch PE pipe through various access fittings. Tasks related to water removal and mapping-device insertion have not moved forward as survey results did not identify any devices that sponsors are currently using. — A Final Report is being prepared.

**OTD 5.14.t - Methods to Detect Inserted Plastic in Steel Mains.** This is an investigation into the feasibility of techniques for detecting inserted PE pipe. Three methods were considered as the most promising from an ease of field application perspective: 1) flow noise, 2) rate of cooling, and 3) modal analysis. Measurement of flow noise and/or cooling rate should work for large volume flows and the results are a function of flow rate, becoming ambiguous when volume flow decreases to zero. Using a combination of the two requires developing a method relating flow noise to cooling rate that is different for pipes with an insert and no insert. Because gas flow in a main varies greatly (including zero flow), a method independent of gas flow would be preferable for this application. An impulse modal analysis, being independent of gas flow, was seen as the most promising for identifying inserts across the largest range of flow conditions. Practical, reproducible, and easy to apply methods for generating and detecting the acoustic waveforms were identified. This technique can be used on the crown of the pipe. Measurements were performed indoors on bare, 2-inch diameter steel pipe found a large number of acoustic vibration modes. The amplitudes of the frequencies are different and depend on the insert diameter and the separation distance between the impact point and transducer location. Although the spectra are complex and additional work is required, the indoor results suggest it should be possible to distinguish among no insert and various insert diameters. Similar measurements were made in the GTI's pipe farm. The 2 and 4-inch diameter steel pipes were longer, coated with fusion bonded epoxy, and buried at both ends beneath raised earthen berms. The frequency range was greatly reduced and any differences between inserted and non-inserted pipe were small at best. It is unclear whether the reduced spectral content of the signals is due to earth and/or pipe coating attenuation, or variations in the method of attachment for the accelerometer to the external pipe surface. Additional work would be required to determine if any of the three techniques are feasible. The work performed to date has been on the impact modal analysis technique. As noted above, promising results from the indoor work did not translate to the outdoor setup with soil and coating interactions. This work was completed in 2015.

**OTD 5.14.u - Evaluation of Geospatial Technologies.** The purpose of this project is to evaluate two new geospatial technologies that could have engineering and operations applications for operators. The technologies to be evaluated could include wearable augmented reality devices (such as Google Glass) and handheld 3D mapping tools (such as Google's Project Tango). This project will test select technologies at GTI and local utility sites and develop recommendations for applications such as leak survey guidance, facility location and attributes, equipment repair, mapping of new and existing facilities, and emergency response. There are many advancements being made in the consumer hardware space and that the hardware and devices being developed can hold a lot of potential for the gas industry. Through efforts such as this project, research on new technologies can identify applications for the gas industry. Not every technology is going to provide the benefits that are intended, but through testing and identification of these technologies, ongoing research can bring new technologies to the gas industry. Microsoft HoloLens and other successful technologies such as Google Project Tango were identified in this project as technologies showing potential for further gas applications from which the company and the entire gas industry may benefit.

**OTD 6.6.a - Keyhole Consortium**. This GTI program develops continuous improvements and innovations to small hole (keyhole) technology. Keyhole excavations involve 18" diameter road openings to perform many routine operations that would traditionally require a 4 ft. x 4 ft. opening. Soil is vacuumed out and work takes place from street level using special long handled tools. This reduces paving costs and in many cases the 18" core is reused – set back in the excavation so there are no paving costs associated with the work. The Keyhole Consortium meets twice yearly; Company representatives attend with other LDCs and manufacturers. At the meeting common issues and needs are discussed and new research ideas are generated.

**OTD 7.14.a - Next Generation Water Clean-up Technology.** The U.S. Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) has proposed IVP regulations that will require operators to verify the integrity of transmission pipes without pressure test records. These regulations could potentially require the industry to hydrotest up to 90,000 miles of in-service pipe. Cleaning and disposing of the hydrotest water is a significant component of the overall cost of hydrotesting. The objective of Phase I of this project is to conduct a technology review and business case to quantify the cost of disposing of water using current methods and the potential savings that could be achieved with new technologies. It is anticipated that development and implementation costs will be significant, thereby warranting a formal business case prior to pursuing technology development or technology transfer. Results of the industry survey taken in this project indicates that conventional management of pipeline discharge waters most often includes either hauling of the water to a publicly owned treatment works (POTW) for disposal or field-based filtering of the water through a ring of hay bales. The POTW alternative requires significant expense in transportation and in discharge fees; all costs connected with this option often exceed $0.50/gallon (2014 dollars). The hay bale alternative (whereby water is forced through a ring of hay bales) is sometimes used in the field, but the method only seems to work for the control of oils and greases and suspended solids but is not effective in removing many soluble organic compounds of concern such as benzene. Clearly, a second generation treatment system is needed that allows low cost field based treatment that is reliably compliant with water quality criteria specified in permits for water reuse and discharge to surface waters. Primary treatment systems used by industry in the past such as sedimentation and dissolved air flotation have been effective in control of suspended solids and free oil and grease. Granular activated carbon (GAC) is effective in removal of soluble organics, but becomes expensive when treating waters that are greater than 1-5 mg/l of total organic carbon (TOC). Biological treatment can be used to remove soluble organics, but the process requires too much of a footprint to be practical. Chemical oxidation, however, can be used for oxidizing most of the soluble organics while taking up a very small footprint. What is needed, however, is a chemical oxidant that is easy to handle and use in the field as a part of the integrated mobile treatment system. A review of commercial chemicals indicates that many of them are not suitable for implementation in a highly mobile, treatment system applied to 1-2 day processing of hydrostatic test waters. A list of information gaps is described in the report; these gaps can be resolved with research and development concentrated on the oxidation step of the advanced treatment flowsheet.

On the basis of this technical evaluation, it is recommended that the industry consider development and optimization of the manganese dioxide oxidative process for the conditioning of pipeline discharge wastewaters. This development work should be pursued in the context of an integrated prototype that includes all of the treatment steps that preceded and follow the oxidation process.

## Cathodic Protection, Coatings and Corrosion Related

**M2012-001 - Development of a Corrosion Sensor Array.** This project will attempt to develop a novel method of monitoring for external corrosion on a gas pipeline by installing an "array" of sensors on a pipeline. If successful, pipeline operators will have another "tool in the toolbox" for monitoring critical pipelines for external corrosion. This project utilizes an existing microsensor-based system to provide corrosion monitoring of full sections of gas pipelines. The project will initially modify the system and then assess its suitability for the natural gas industry through lab testing. The core technology employed is the micro-linear polarization resistance sensor developed originally for aerospace applications.

**OTD 2.9.c - Field Applied Pipeline Coatings**. Modern pipe materials are factory coated and these coatings stand up very well as long as they are not damaged by external forces. However, in locations where field welds or other field installed fittings are present, the necessary pipeline coating needs to be field applied. Field applied coatings vary in quality and are not always installed under ideal environmental conditions such as would be present in a pipe coating factory. This project tested the performance of several different types of coatings on buried pipe at Gas Technology Facilities in Chicago.
Throughout the world, a variety of generic coating systems are commonly applied to field girth welds, including the following: (1) fusion bonded epoxy (FBE), (2) heat shrink sleeves (HSS), (3) liquid applied coatings, (4) composite systems, and (5) tapes/wraps. Eighteen (18) manufacturers supplied seventy-five (75) different coating systems for the test program. The coatings were installed by the manufacturers on a network of 8" and 24" steel piping buried in rocky, sandy, and clay-like soils. Coating systems were unearthed and examined at 2, 5, and 7 year intervals. Some coatings exhibited no rust on any of the pipes in any soil, and other coatings exhibited rust on pipe in all soil. A key conclusion of the test program is that strict adherence to the manufacturers' recommended installation procedures is absolutely necessary. A final report on project results has been prepared. The benefit is improved pipeline safety and assurance that superior products, from a long term performance point of view, are installed on company facilities.

**OTD 5.9.c - Mitigating Electrical Interference on Cathodic Protection Systems.** Electrical interference can impair or negate the effect of cathodic protection systems. The objective of this project is to understand the types of interference that can be present near pipeline systems and make recommendations to mitigate the effect of these interferences. Interferences can be steady state, such as would be present from adjacent high voltage power lines or transient, caused by a lightning strike or power line surge.
To implement the project, GTI selected three host sites and installed data logging instrumentation on cathodic protection systems there. Transient events and steady state

interference data is being gathered. The results of the data gathering exercise will be recommendations for enhanced equipment or better surveillance of cathodic protection systems to better protect them. Enhanced integrity of piping systems protected by cathodic protection is the benefit of this research.

**OTD 5.9.f – Cathodic Protection Monitor**. The objective is to develop and deploy a Cathodic Protection Monitor prototype that stores monthly CP readings. GTI has partnered with 3M to develop a completely encapsulated, direct burial monitoring device. A 3M handheld locator/reader is used to retrieve the readings electronically from above ground without requiring a direct connection. The data, consisting of 12 sets of monthly readings, can be downloaded from the handheld devices as tabular data. The first version of the CP Monitor has been successfully tested; as a result of testing additional product requirements were identified. The objective of Phase 2 is to develop and test a modified CP Monitor prototype with some or all of the following features: ability to record AC potential readings to detect stray currents, increased data storage, improved range with the ability to capture readings from a moving vehicle, programmable data recording intervals, and ability to transfer data to other handheld devices via Bluetooth for direct GIS integration. The benefit is improved monitoring of CP performance on protected piping, with the potential cost savings of making mobile readings

**OTD 5.11.n – Quality Control Procedure for High Potential Anodes.** The Company recently has been experiencing quality problems with magnesium anodes as delivered from manufacturers. Anodes that appear – upon visual inspection – to be sound have been experiencing premature failures in the field. Quick and simple voltage tests may initially reveal that the anode is generating the required voltage potential but this may be indicative of good quality of the surface layer of the anode only. If the entire anode is not of the same quality and purity the anode will deteriorate prematurely. The standard industry test for measuring anode purity, ASTM G97, is expensive and time consuming and it is not practical to conduct this test for all new anodes received. Therefore, there is an industry need for a quicker test that can validate the requisite quality and purity of anodes. GTI has received anodes from project participants and is currently evaluating alternate methods of testing them that can give results similar to the G97 test. As an indication of the need for this project, GTI reports that the project has experienced delays due to the time consuming nature of the G97 test, which is being performed in parallel as a control. The benefit is better assurance of the quality of materials received and installed in the company's gas system.

**OTD 5.12.n – Advanced Tools for Improved AC Corrosion Prevention and Mitigation**. Alternating Current (AC) corrosion is not common but can occur if gas mains are in proximity to railroads or overhead electric transmission lines. When it does occur, the corrosion rates can be rapid, thus the need for the Company to quickly identify and mitigate the occurrence of AC corrosion. The company is working with GTI on this project and they have proposed a two part solution, a model to predict rates of AC corrosion, and a calculator to determine the most effective mitigation measure. The project will draw heavily on existing work done by the National Association of Corrosion Engineers (NACE) and the Company's and other funders' experience. The final deliverable of the project will be the model and calculator, which can be used to prioritize inspections and gauge the impact of various mitigating measures on both new and existing gas pipelines.

**OTD 5.14.x - Risk-Based Atmospheric Corrosion/Leak Survey Considerations**
A study reviews historical and current data on atmospheric corrosion of indoor service piping. A detailed review of the published, peer-reviewed literature related to field data on indoor corrosion was made. A comparison of the fundamental principles of indoor and outdoor atmospheric corrosion was made. The research conducted compares and contrasts indoor atmospheric corrosion to outdoor corrosion for iron and steel piping materials. In addition, thousands of recent inspections in NY and New England States were completed on outdoor and indoor services by operators the data was collected and statistically analyzed to determine the trends and drivers behind the observed corrosion rates. A similar analysis was completed on exclusively indoor leak survey data from LDC operators. Finally, all the findings were summarized and related to risk-based considerations for setting appropriate inspection intervals for indoor service piping. This art of the study was completed in late 2014.

## General and Other Areas Not Covered Elsewhere

**M2001-013 - Millennium Website Development.** A project for maintenance and upgrading of NYSEARCH's website and for use by the NY LDCs who utilize NYSEARCH as a clearinghouse for reporting to the NY PSC on the use of the Millennium R & D funds

**M2002-008 - Oracle Technology Concept Investigation.** Through the NYSEARCH research consortium, the Company and others fund a concept known as “Oracle.” The purpose of this program is to look outside the gas industry for novel technology solutions to gas industry needs. In the past, technologies from the military, biomedical, and telecommunications industries have been tracked. More recently, our focus has been sensor technologies using fiber optics or nanotechnology, and material science advances. Applications from these industries, when identified, will be funded as separate projects. An example of that is a current effort to take nanocomposite particles used in plastic in other industries and create self-healing PE pipe. Another example that came from this is the methane sensor using tuning fork technology.

**OTD 5.14.c - Improving Cybersecurity for LDCs - Needs Identification & OTD 5.15.a Cybersecurity Collaborative.** Initiated in February 2014 an initiative to review and to provide information on the status of cybersecurity R&D activities for LDCs and identify the short and long-range needs for cybersecurity capability improvement for LDCs. A workshop was conducted on April 16-17, 2014 at GTI facilities in Des Plaines, IL. Day 1 included presentations by representatives from GTI, AGA, DHS and SRI to orient the attendees to cyber related activities focused on the energy sector and natural gas specifically. Day 2 was dedicated to sharing lessons learned and identifying technology needs and gaps, and prioritizing project ideas. A summary report was prepared which identifies the industry need and business value of addressing cybersecurity issues, and summarizes the cybersecurity lessons learned for the participating utilities, A follow on effort under OTD 5.15.a continues as a multi-year collaborative program between natural gas distribution companies and the Department of Homeland Security (DHS) to address the high priority cybersecurity issues of participating members through a focused outreach and education process and a technology evaluation and transfer initiative.

**OTD 6.14.a - Quality Audit Program for Natural Gas Utility Suppliers.** Distribution Integrity Management regulations encourage utility companies to place a new focus on supplier and supply chain quality. Identifying threats and mitigating risks starts with the manufacturing process. Reducing supply chain risk requires a comprehensive and well-coordinated supplier audit program to ensure that the integrity of the supply chain is controlled and that the supplier is following policies and procedures required by customers and regulators. The purpose of this effort is to develop an audit program and provide natural gas utility operators with a mechanism to collaboratively audit supplier's quality management systems. The program will conduct an independent and unbiased assessment on behalf of participating operators to provide a reliable and standardized approach for monitoring suppliers. Participating operators will benefit from a collaborative program by creating efficiencies and promoting information sharing. Supplier audits identify non-conformances in manufacturing, shipping, engineering change, invoicing, and quality processes. After the audit, the supplier and auditors jointly identify corrective actions which must be implemented by the supplier within an agreed-upon timeframe. A future audit ensures that these corrective actions have been successfully implemented. While the need for enhanced quality audits and monitoring programs is increasing, the availability of resources to conduct these programs is decreasing due to operator's focus on operations and efficiencies. Therefore, there is a need for a coordinated collaborative audit program to allow gas utilities to efficiently monitor supplier processes. Participation in the collaborative program will provide value in the following ways: create efficiencies and cost savings by consolidating audits into one program, increase the number of audits performed, create leverage and increase influence with suppliers, utilize RAB/IRCA certified auditors with extensive experience, provide a high quality audit due to consistency and standardization of audit methodology and allow internal resources to focus on the core business rather than auditing. National Grid has participated in the development and pilot which has helped us review and improve our own auditing process but we are currently evaluating if we will continue in this GTI program.

## Joint Industry Projects

The following three projects have been are jointly funded and managed between DET NORSKE VERITAS, DNV, and various industry co-funders:

**Development of Industry Best Practices for Hot Tap Branch Connections Joint Industry Project (JIP)** – a welding procedure is being developed and draft sent out to the group for comments, particularly for preheat. Concerns for maintaining preheat on a flowing pipeline are to be addressed.

**Development of Industry Best Practices for Girth Weld Repair** The objective of this JIP is to develop industry best practice for repair of pipeline girth welds during new construction activities, which will include the development and qualification of a suite of repair welding procedures in accordance with Section 10 of the Twenty-first Edition of API 1104. A guideline for selecting an appropriate procedure for a given application will also be developed. The scope will also include the development of guidance pertaining to other technical aspects of girth weld repair and repair welder qualification (e.g., preheating requirements, inspection requirements, time delay prior to inspection, minimum-required and maximum-allowable repair length, practical limits on wall thickness, etc.) that will be used to develop a generic company specification for repair of pipeline girth welds during new construction.

**Validation of the ASME Procedure for Estimating Lower Bound Yield Strength of Pipe from Hardness Data.** Forty-nine pipe samples representing a wide range of age, size, grade, composition, and manufacturing method were tested to demonstrate the validity of using hardness test data to estimate lower bound yield strength (YS) of steel pipe. Three different types of field portable hardness testers were used on each pipe sample. The hardness testing was performed in accordance with ASME CRTD-Vol. 91. The hardness test results were converted to estimated lower bound YS values using the correlations described in ASME CRTD-Vol. 57. The estimated lower bound YS was compared to the results of standard API 5L tensile tests. In addition, the metallurgical attributes of each pipe were characterized to determine if certain subsets of pipes produced better (or worse) correlations of estimated lower bound YS to YS determined from tensile tests. The results showed that hardness data can be used to estimate conservative values of lower bound YS using a range of different confidence levels.

## National Grid Managed Projects

National Grid funds projects outside the NYSEARCH and OTD consortia and manages them ourselves or jointly with other LDCs. The following two projects are jointly funded and managed between National Grid Downstate and Consolidated Edison Co (Con Ed)

**M2001-009 - Construction Interference Cost Reduction (CONCORD) Program.** National Grid and Con Edison, along with the Urban Utility Center of Polytechnic Institute of New York, are working with New York City to introduce trenchless technologies to the city's construction program. Trenchless technology – as compared to traditional "open cut" construction – can save National Grid and Con Edison significant dollars by eliminating the need to relocate our gas facilities if they interfere with the city's new construction. We have introduced new trenchless technologies to the city's engineers, conducted training programs, performed lab testing, and these efforts have culminated in New York City's decision to rehabilitate two miles of a major water main in Manhattan via a trenchless method. This method involves insertion of a plastic liner into the existing cast iron water main and few adjacent gas facilities will need to be relocated. Con Ed estimates significant savings. If this program is successful and NY

City adopts trenchless technology for future construction, the savings to National Grid and Con Ed could be significant for years to come.

**M2002-015 Cast Iron Sealing Robot (CISBOT):** National Grid and Con Edison jointly fund and manage this project to design, construct and test a live, tethered robot that will internally seal cast iron joints. National Grid has the highest inventory of cast iron pipe in the nation, over 6000 miles, with over 2600 miles in the State of New York alone (Source, US DOT report). Cast iron is a very durable material but over time the joints – mechanical connections packed with jute and lead – can dry out and are the source of leakage. National Grid's predecessor company, KeySpan, partnered with Con Edison of New York to jointly fund the development of CISBOT. The robot was built by ESI Corp of Toronto, Canada. Upon completion of the robot Con Ed and National Grid entered into an agreement with ULC Robotics, a small high tech firm located on Long Island, to 'commercialize' the device and ultimately become the service provider for the CISBOT services. This is a typical business plan for high tech deployment in the gas distribution sector; ULC Robotics performs this type of work as their main line of business. To date, National Grid has spent over $2.2 Million on the project, with a similar amount funded by Con Edison. CISBOT is designed to seal joints in 16" through 36" diameter cast iron gas mains operating at pressures up to 25 psi. An excavation will be dug at a convenient point along the gas main and a special fitting is installed on the main which allows a 12" opening to be cut into the main in "live" conditions with no shutdown required and no blowing gas. (This is a fairly common procedure in the gas industry.) The CISBOT robot is then inserted into a launch tube and the launch tube is attached to the fitting on the main. The launch tube is purged of air with nitrogen and then a valve is opened and natural gas fills the launch tube. The robot is then lowered into the gas main. A tether connects the robot with external power and communication, and a small tube in the tether contains the anaerobic sealant which is used to seal the joints. An operator drives the robot using onboard cameras as a guide and stops at the first joint. A small hole is then drilled into the joint at a predetermined spot. Once the hole is drilled, a nozzle is inserted up into the drilled hole and anaerobic sealant is pumped into the hole, saturating the joint. Cameras on the robot are positioned to view the wicking action of the anaerobic fluid and pumping is stopped when the operator judges that a particular section of the joint is filled with sealant. The robot is then repositioned to a different "clock position" around the circumference of the joint and the drilling and sealing operation is repeated. Once the operator judges that the joint is sealed the robot will travel down to the next joint and the process is repeated.

CISBOT is undergoing an extensive program of field demonstrations over the past three years in New York City and Boston. Costs for the demonstrations outside NY State are borne by the area conducting the demonstration. In parallel with the demonstrations, the Company and Con Edison are negotiating a Commercial License with ULC Robotics. The cost of the service will be determined by ULC Robotics prior to their offering the service as a commercial business. National Grid NY and Con Ed will receive a discount from the stated list pricing. Because the final cost of the service has not yet been determined, it is difficult to accurately predict savings but assumptions can be made.

The basis for our assumed savings of $2.5M annually is to assume that CISBOT is deployed to a main segment where 50% of the joints are or will soon be leaking. Per job that's about 15 joints at an estimated cost of $3000 per joint to repair, total cost $45,000. This figure can vary depending on the final pricing structure set by ULC Robotics. Standard repair including a tight sheeted pit is estimated at $20,000 per repair for total repair cost of $300,000. Actual costs for tight sheeted pits in congested urban areas have been reported as much higher but this is a conservative estimate. Based on these assumptions the net savings is about $255,000 per job. Assuming full successful deployment of CISBOT, 10 such jobs per year could be performed, resulting in annual savings of $2,550,000.

National Grid expects to deploy this technology in its large diameter cast iron mains in New York State and Massachusetts. Any royalties received will be returned to NY ratepayers through the Millennium Fund.

Attachment 2 shows spending for these projects described above.

## National Grid Gas R&D Spending

Includes Ngrid Downstate (KeySpan) and Ngrid Upstate (NMPC)

Calendar Year Expenditures ($)

| | Actual | | Projected | | |
|---|---|---|---|---|---|
| **Year** | **2014** | **2015** | **2016** | **2017** | **2018** |
| National Grid Internal Program | | | | | |
| Utilization | $ 104,800 | $ 211,426 | $ 758,574 | $ 170,000 | $ 170,000 |
| Operations | $ 57,708 | $ 28,476 | $ 200,000 | $ 263,000 | $ 263,000 |
| Ngrid Labor and Expenses | $ 229,692 | $ 184,741 | $ 201,640 | $ 207,689 | $ 228,094 |
| **TOTAL INTERNAL** | **$ 392,200** | **$ 424,643** | **$ 1,160,214** | **$ 640,689** | **$ 661,094** |
| National Grid Millennium Program | | | | | |
| NYSEARCH Projects | $ 2,265,234 | $ 1,311,235 | $ 1,571,000 | $ 1,687,000 | $ 1,150,000 |
| OTD Projects | $ 750,000 | $ 870,279 | $ 750,000 | $ 750,000 | $ 750,000 |
| National Grid Projects | $ 40,000 | $ 103,502 | $ 352,000 | $ 400,000 | $ 450,000 |
| **TOTAL MILLENNIUM** | **$ 3,055,234** | **$ 2,285,016** | **$ 2,673,000** | **$ 2,837,000** | **$ 2,350,000** |
| **TOTAL MILLENNIUM AND INTERNAL** | **$ 3,447,434** | **$ 2,709,659** | **$ 3,833,214** | **$ 3,477,689** | **$ 3,011,094** |
| **NYSERDA Assessment** | $ 3,565,124 | $ 4,906,042 | $ 5,000,000 | $ 5,250,000 | $ 5,550,000 |
| **TOTAL R&D PROGRAM** | **$ 7,012,558** | **$ 7,615,701** | **$ 8,833,214** | **$ 8,727,689** | **$ 8,561,094** |

Note: Total spend, from books of Company

| PROJECT NUMBER | PROJECT | START DATE | END DATE | TOTAL NGRID COMMITMENT | TOTAL SPEND 2013 | TOTAL SPEND 2014 | TOTAL SPEND 2015 | TOTAL NGRID SPEND Joe YEARS |
|---|---|---|---|---|---|---|---|---|
| M-2000-001 | Variable length sleeve - NYSEARCH | 2000 | 2013 | $ 147,356 | | $ 29,586.33 | | $ 111,970.00 |
| M-2000-004 | Explorer Commercialization, Phase I | 2000 | 2006 | $ 341,239 | | $ 14,906.96 | | |
| M-2001-002 | Mgmt of Impacted Sediments - NYSEARCH | 2001 | 2011 | $ 430,061 | | | | $ 430,061.00 |
| M-2001-003 | Cased Pipe Risk Assessment Model | 2001 | 2011 | $ 274,472 | | $ 4,007.04 | | $ 184,501.00 |
| M-2001-005 | PipeHawk Hand-Held Pipe Locator - NYSEARCH | 2001 | 2013 | $ 435,090 | | $ 23,892.72 | | $ 392,895.00 |
| M-2001-006G | Development / Testing / Commercialization of GASNET(tm) - Phase V | 2001 | open | $ 392,485 | | | $ 31,593.94 | |
| M-2001-009 | Interference Avoidance/UUC Technology Demo Lab | 2001 | 2010 | $ 475,000 | | | | $ 446,000.00 |
| M-2001-013 | Millennium Web Development | 2001 | ongoing | $ 37,998 | | $ 5,751.81 | $ 1,612.19 | |
| M-2001-014 | InspectionTool for Unpiggable Facilities - Automatika (TIGRE) | 2001 | 2011 | $ 967,261 | $ (9,098.34) | | | $ 959,781.00 |
| M-2002-008 | Technical Expert (Oracle) to ID Quantum Leap Technologies | 2002 | ongoing | $ 53,931 | | $ 13,585.11 | $ 179.87 | $ 29,396.00 |
| M-2002-011 | FFT AUra Damage Prevention Systems - Testing Program - Phase III | 2002 | open | $ 202,380 | | $ 109,480.05 | $ 43,194.73 | |
| M-2002-015 | CISBOT-Live IP CI Joint Sealing (KSE/ConED/ESI/ULC) | 2002 | 2013 | $ 2,356,825 | | | | $ 2,219,476.00 |
| M2002-018 | Infrasonic Sensor for Remote Pipeline Monotoring - NYSEARCH | 2002 | 2010 | $ 129,711 | | | | $ 104,858.00 |
| M2003-009 | Explorer II | 2003 | 2012 | $ 483,030 | | $ 24,727.35 | | $ 451,452.00 |
| M2005-003 | Test Bed Maintenance and Improvements | 2005 | ongoing | $ 110,108 | | $ 518.11 | $ 1,225.31 | |
| M2005-005 | Gas Interchangeability for LDC Infrastructure | 2005 | 2014 | $ 753,336 | | $ 96,150.43 | $ 25,514.42 | $ 644,948.00 |
| M2006-002 | Butt Fusion Joint Integrity | 2006 | 2011 | $ 70,198 | | $ 9,776.81 | | $ 53,213.00 |
| M2007-001 | Mini-camera for Cased Crossings | 2007 | 2012 | $ 150,952 | | $ 10,491.88 | | $ 228,563.00 |
| M2007-003 | Multi Technology Validation Testing for Cased Pipe Applications | 2007 | 2013 | $ 73,315 | | $ 897.85 | $ 2,952.00 | $ 49,676.00 |
| M2007-005 | Testing Program for Remote Inspection-Transkor | 2007 | 2012 | $ 133,080 | | $ 15,387.64 | $ 1,803.50 | $ 75,901.00 |
| M2007-007 | Technology Advancement in Damage Prevention Tools and Communications | 2007 | 2011 | $ 91,973 | | $ 7,268.87 | | $ 64,243.00 |
| M2008-001 | Third Party Detection - Magal | 2008 | 2013 | $ 58,297 | | $ 5,522.13 | $ 4,202.49 | $ 29,419.00 |
| M-2008-005 | Developing Platelet Technology for use in Gas Transmission and Distribution Centers | 2008 | open | $ 23,280 | | $ 23,279.52 | | |
| M2008-006 | Expand Function of No Blow Tools to Reduce GHG | 2008 | 2012 | $ 122,329 | | $ 6,055.00 | | $ 82,078.00 |
| M2008-010 | UV Degradation of PE Pipe | 2010 | 2013 | $ 14,125 | | | | $ 8,070.00 |
| M2009-001 | Holistic Review of DIMP Practices and Models | 2009 | 2012 | $ 48,750 | | $ 3,995.78 | | $ 44,409.00 |
| M2009-002 | Mercaptan Sensor Development | 2009 | open | $ 330,462 | | $ 60,282.16 | | $ 266,030.00 |
| M2009-003 | Adaptation Study | 2009 | 2012 | $ 23,500 | | | | $ 23,500.00 |
| M2009-007 | Particulate Dispersion Study | 2009 | 2011 | $ 75,000 | | | | $ 60,516.00 |
| M2009-008 | Ultrasonic Evaluation System for PE Butt Fusion | 2009 | open | $ 133,700 | | $ 20,632.90 | | $ 2,079.00 |
| M2010-001 | Service Tee Renewal | 2010 | open | $ 73,170 | | $ 27,692.85 | | $ 20,118.00 |
| M2010-002 | Methane MR Sensor Development | 2010 | open | $ 126,730 | | $ 12,318.70 | $ 41,955.00 | $ 23,265.00 |
| M2010-003 | PCB Absorption in PE Piping | 2010 | 2013 | $ 194,000 | | $ 60,613.68 | | $ 121,228.00 |
| M2010-004 | Soil Vapor Intrusion | 2010 | 2012 | $ 83,100 | | $ 39,199.82 | | $ 43,877.00 |
| M2010-005 | Guided Wave Test Program | 2010 | 2012 | $ 175,000 | | | | $ 95,082.00 |
| M2011-001 | Self Healing Pipe | 2011 | open | $ 232,442 | | $ 123,440.62 | $ 45,986.48 | $ 7,397.00 |
| M2011-002 | Storage Effects on Gas Quality | 2011 | 2013 | $ 26,555 | | $ 9,470.17 | | $ 12,628.00 |
| M2011-003 | Odor Masking | 2011 | open | $ 126,695 | | $ 89,198.22 | | $ 23,158.00 |
| M2011-004 | Carbon Calculator | 2011 | open | $ 24,450 | | $ 1,156.83 | | $ 12,234.00 |
| M2011-005 | Fiber Sen System Development and Testing | 2011 | open | $ 71,248 | | $ 32,464.79 | $ 28,342.19 | $ 6,316.00 |
| M2011-006 | Robotics Supporting Technologies | 2011 | open | $ 1,020,009 | | $ 411,841.51 | $ 169,306.28 | $ 152,941.00 |
| M2011-007 | Cased Pipe Inspection via Vents | 2011 | open | $ 386,760 | | $ 168,393.96 | $ 94,646.85 | $ 41,630.00 |
| M2011-008 | BioBall Test Program | 2011 | 2013 | $ 37,630 | | $ 37,630 | | $ - |
| M2011-009 | Explorer 30 - 36" | 2011 | 2013 | $ 500,000 | $ 64,500 | | | $ 435,000 |
| M2012-001 | Development of Corrosion Sensor Array | 2012 | open | $ 72,310 | | $ 20,811 | $ 49,013 | $ - |
| M2012-003 | Enterprise Level Assessment of Data Management Systems | 2012 | 2014 | $ 33,900 | | $ 33,900 | | $ - |
| M-2013-001 | Explorer 16/18 - Inspection of Unpiggable Pipelines | 2013 | 2015 | $ 1,230,915 | $ 307,730 | $ 615,460 | $ 307,725 | $ 1,230,915 |
| M-2013-002 | Non-Destructive Inspection of Gas Pipes Using AMR Sensors for Eddy Current Testing (ECT) | 2013 | open | $ 342,668 | | $ 2,883 | $ 45,940 | |
| M-2013-003 | Integrated Nanosensors for Analysis of Chemical Compounds in Natural Gas Applications (WKU Advanced Chemical Sensor) | 2013 | open | $ 189,885 | | $ 4,563 | $ 152,422 | |
| M-2014-001 | Aeryon sUAS Technology - Regulatory & Technology Assessment | 2014 | open | $ 131,880 | | | $ 10,396 | |
| M-2014-002 | Leak pinpointing inside pipe | 2014 | open | $ 27,380 | | | $ 8,717 | |
| M-2014-003 | Picarro Methane Emissions Analyzer System | 2014 | open | $ 129,748 | | | $ 129,748 | |
| M-2014-004 | Technology Evaluation & Test Program for Quantifying Methane Emissions Related to Non-Hazardous Leaks | 2014 | open | $ 54,210 | | | $ 14,825 | |
| M-2014-005 | Critical Valve Operability | 2014 | open | $ 18,155 | | | $ 7,033 | |
| | | | | $ 14,248,084 | $ 363,132 | $ 2,177,234 | $ 1,218,335 | $ 9,188,824 |
| Keyspan dues | | | | | $ 55,000 | $ 55,000 | $ 60,000 | |
| NMPC dues | | | | | $ 33,000 | $ 33,000 | $ 33,000 | |
| | | | | | **$ 451,132** | **$ 2,265,234** | **$ 1,311,335** | |
| | | | | | | | | |
| OTD 1.08.a | GPS-Based Excavation Encroachment Notification | 2008 | open | $ 134,269 | $ 19,176 | | | $ 134,269 |
| OTD 1.08.a.CA | GPS Based Excavation Encroachment Notification for ROW Monitoring- CA (GTI) | 2008 | open | $ 33,142 | $ 33,142 | | | |
| OTD 1.08.c | GPS-Enabled Leak Surveying and Pinpointing (see 1.9.a) | 2008 | open | $ 50,000 | | | | |
| OTD 1.8.f | Electromagnetic and Acoustic Obstacle Detection Refund | 2004 | 2011 | $ 24,599 | $ (12) | | | $ 24,599 |
| OTD 1.8g | Acoustic Sewer Lateral Locator | 2008 | 2012 | $ 80,289 | $ 7,300 | | | $ 72,989 |
| OTD 1.09.a | GPS Leaks - Phase 2 (from 1.8.c) | 2009 | 2013 | $ 129,080 | $ (437) | | | $ 121,780 |
| OTD 1.h and 1.10.c | Hand Held Acoustic Pipe Detector and tech transfer | 2003 | 2013 | $ 287,260 | | | | $ 287,260 |
| OTD 1.10.e | Enhancing Damage Prevention in New York | 2010 | 2015 | $ 16,500 | | | | |
| OTD 1.11.a | Chemical Methods to detect crossbores | 2011 | 2011 | $ 2,870 | | | | $ 2,870 |
| OTD 1.11.c | Low-Cost MEMS Methane Sensor Platform Phase 1 | 2011 | 2015 | $ 30,000 | | | | $ 30,000 |
| OTD 1.11.e | Cross Bores - National Database and Risk Model | 2011 | open | $ 35,000 | $ 3,000 | | | $ 35,000 |
| OTD 1.12.b | Cross-Bores Detection Using Mechanical Spring Attachment | 2012 | 2014 | $ 10,000 | $ 5,314 | | | $ 10,000 |

| PROJECT NUMBER | PROJECT | START DATE | END DATE | TOTAL NGRID COMMITMENT | TOTAL SPEND 2013 | TOTAL SPEND 2014 | TOTAL SPEND 2015 | TOTAL NGRID SPEND Joe YEARS |
|---|---|---|---|---|---|---|---|---|
| OTD 1.14.d | Field Measurement of Leak Flow Rate | 2014 | open | $ 9,994 | | $ 5,000 | $ 4,994 | |
| OTD 1.14.g | Evaluation of Residential Methane Detectors | 2014 | open | $ 85,000 | | $ 85,000 | | |
| OTD 1.14.g.2 | Evaluation of Residential Methane Detectors-Phase 2 | 2014 | open | $ 32,097 | | $ 15,446 | $ 10,000 | |
| OTD 1.14.g.2a | Evaluation of Residential Methane Detectors-Phase 2 Pilot | 2014 | open | $ 175,000 | | | | |
| OTD 1.14.h | Picarro Surveyor Winter Patrol Implementation | 2013 | 2015 | $ 572,500 | | $ 25,000 | $ 547,500 | |
| OTD 2.07.a | 2.7.a Refund | | | | $ (9,014) | | | |
| OTD 2.8.e | Structural Liners and Sleeves - Technology Search | 2008 | 2013 | $ 12,132 | | | | $ 12,132 |
| OTD 2.9c | Field Applied Coatings | 2009 | 2012 | $ 67,000 | | | | $ 67,000 |
| OTD 2.11.a | Development of a System for Repair of Above Ground Leaks | 2011 | open | $ 44,611 | $ 4,375 | | | $ 40,236 |
| OTD 2.11.d | RSD X-Ray for Metallic Pipe Assessment - Testing and Validation | 2011 | 2012 | $ 20,000 | | | | $ 20,000 |
| OTD 2.11.d Refund | 2.11.d Refund | | | | | | $ (2,737) | |
| OTD 2.12.e | Selection of Liners Composites for the Rehabilitation of Distribution and Transmission Lines | 2012 | 2015 | $ 15,000 | $ 15,000 | | | |
| OTD 2.13.b | Guidelines for Special Permits for Structural Composite Rehabilitations | 2013 | open | $ 38,000 | $ 38,000 | | | |
| OTD 2.13.c | PHMSA Accelerated Dynamic Testing for Long Term Evaluation of Liners and Composite Pipe Materials add (PHMSA-21501) | 2013 | open | $ 39,063 | $ 25,000 | $ 14,063 | | |
| OTD 2.14.a | Composite Repair Wrap for Polyethylene (PE) Systems | 2014 | open | $ 5,000 | | $ 5,000 | | |
| OTD 2.14.b | Pipe System Repair Technique | 2014 | open | $ 40,000 | | $ 20,000 | $ 20,000 | |
| OTD 2.14.c | Assessment of Squeeze off Location for Small Diameter Polyethylene (PE) Pipe and Tubing | 2014 | open | $ 8,190 | | $ 5,000 | $ 3,190 | |
| OTD 2.14.d Refund | 2.14.d Refund | 2014 | | $ (17,964) | | $ (17,964) | | |
| OTD 2.14.d | Universal PE Entry Fitting | 2014 | cancelled | $ 20,000 | | $ 20,000 | | |
| OTD 2.14.e | Guidelines/Best Practices for Scraping PE Pipe and Fittings | 2014 | open | $ 1,251 | | $ 1,000 | $ 251 | |
| OTD 2.b | Service Applied Main Stopper | | | $ 152,078 | | | | |
| OTD 3.8a | Jackhammer Noise Abatement Issues | 2008 | 2010 | $ 20,000 | | | | $ 36,463 |
| OTD 3.9a | Backfill Evaluation & Ecoroads | 2009 | 2012 | $ 24,295 | | | | $ 30,869 |
| OTD 3.14.a | Soil Compaction Supervisor Enhancements | 2014 | open | $ 36,355 | | $ 25,000 | $ 8,934 | |
| OTD 3.14.b | Update ASTM Standard of DCP Compaction Control | 2014 | open | $ 1,000 | | $ 1,000 | | |
| OTD 4.7.g | Yield Strength | 2007 | 2012 | $ 27,672 | $ 2,500 | | | $ 25,172 |
| OTD 4.08.a | Guided Wave Validation as Hydro Equivalent | 2008 | 2015 | $ 52,843 | | | | |
| OTD 4.8.i | Extended Reassessment Interval Validation Through Dielectric Wax Casing Fill | 2008 | 2012 | $ 58,929 | | | | $ 58,929 |
| OTD 4.9a | Leak vs. Rupture Boundary | 2009 | 2012 | $ 68,048 | | | | $ 68,048 |
| OTD 4.9.a Refund | 4.9.a Refund | | | $ (99) | | | $ (99) | |
| OTD 4.11.f | Understanding Threat Interactions for Risk Analysis (GTI) | 2011 | 2013 | $ 30,000 | | | | $ 30,000 |
| OTD 4.12.b | Correlating Pipeline Operations to Potential Crack Initiation Growth Arrest (GTI) | 2012 | open | $ 74,678 | $ 30,000 | $ 14,678 | | $ 30,000 |
| OTD 4.13.a | DIMP Consequence Model | 2013 | 2015 | $ 55,200 | $ 30,000 | $ 25,200 | | |
| OTD 4.13.b | Validation of 3D Scanners for Anomaly Assessment | 2013 | 2013 | $ 25,000 | $ 25,000 | | | |
| OTD 4.13.c.2 | PHMSA EMAT Sensor for Small Diameter and Unpiggable Pipe Phase 2 Construct and test field ready prototype | 2013 | open | $ 10,000 | | | $ 5,000 | |
| OTD 4.13.d.3 | Hydro-testing Alternative Program - Phase 3 | 2013 | open | $ 8,658 | | $ 5,000 | $ 3,658 | |
| OTD 4.14.a | Fitting and Component Catalogue for IVP | 2014 | open | $ 5,000 | | $ 5,000 | | |
| OTD 4.14.c | Surface Indentation for Material Characterization Correlation of Surface Properties Based on Vintage | 2014 | open | $ 58,301 | | $ 30,000 | $ 28,301 | |
| OTD 4.e | Inspection Platforms for Unpiggable Pipelines (NYSEARCH) | | | $ 303,963 | | | | |
| OTD 5.06.e | Portable Propane Air Residential Temporary Gas Supply | 2006 | open | $ 90,062 | $ 14,851 | | | |
| OTD 5.07.f | Automated Meter Shut-Off Device (AMS) | 2007 | | $ 47,596 | | | | |
| OTD 5.07.p | 5.07.p (GTI) GPS Consortium | 2007 | open | $ 15,000 | | | | |
| OTD 5.08.a.2 | 5.08.a.2 Development of Automated Welding Unit for Installing Laterals – Phase 2 (GTI) | 2008 | open | $ 42,500 | $ 20,000 | $ 22,500 | | |
| OTD 5.08.d.3 | 5.08.d.3 Tool for External Classification of Pipe Contents, Phase 3 | 2008 | open | $ 1,000 | | $ 1,000 | | |
| OTD 5.8e | Gas Material Traceability | 2008 | 2012 | $ 77,008 | $ 4,020 | | | $ 72,988 |
| OTD 5.08.e.b (b) | 5.08.e.2ab Enhanced Material Tracking and Traceability-Development of Standardized Protocols/Identifiers for Meters, Regulators, and Transmission Pipelines, Phase 2 (TEJ) | 2008 | open | $ 6,749 | | $ 5,000 | $ 1,749 | |
| OTD 5.08.e.a (a ) | 5.08.e.a (a )Enhanced Material Tracking and Traceability Development of Standardized Protocols Identifiers For Meters and Regulators | 2008 | open | $ 5,000 | | | | |
| OTD 5.08.e.b (b) | 5.08.e.b (b) Enhanced Material Tracking and Traceability Development of Standardized Protocols Identifiers For Transmission Pipeline | 2008 | open | $ 30,916 | $ 7,916 | | | $ 30,916 |
| OTD 5.08.k Refund | 5.08.k Refund | | | | $ (287) | | | |
| OTD 5.08.l Refund | 5.08.l Refund | | | | $ (271) | | | |
| OTD 5.9c | Mitigating Elec. Interference on Cathodic Protection Systems | 2009 | 2012 | $ 80,522 | | | | $ 80,522 |
| OTD 5.09.f | CP Monitor Prototype Modification and Field Trials Phase 2 | 2009 | 2015 | $ 46,739 | $ 15,326 | $ 6,413 | | $ 25,000 |
| OTD 5.09.f Refund | 5.09.f Refund | | | | | | $ (546) | |
| OTD 5.09.h | 5.09.h North American Manufacturer Outreach | | | $ 1,893 | | | | $ 1,893 |
| OTD 5.9j | Gas Distribution Model | 2009 | 2012 | $ 103,600 | | | | $ 103,600 |
| OTD 5.9k | Low Impact Marking Study | 2009 | 2012 | $ 50,261 | | | | $ 50,261 |
| OTD 5.10.d.2 | 5.10.d.2 Remote Field QA/QC Phase 2 | 2010 | open | $ 73,450 | | $ 40,000 | $ 33,450 | |
| OTD 5.10.f Refund | 5.10.f Refund | | | $ (21,616) | $ (21,616) | | | |
| OTD 5.10.f | Cold Assisted Pipe Splitting (CAPS), Phase 1 | 2010 | 2012 | $ 46,615 | | | | $ 46,615 |
| OTD 5.10.g | Indoor Air Quality and Safety Issues | 2010 | open | $ 25,000 | | | | $ 25,000 |
| OTD 5.11.a | Dewatering Systems for Mains | 2011 | 2013 | $ 66,927 | | | $ 2,000 | $ 66,927 |
| 5.11.a Refund | 5.11.a Refund | | | | | | $ (229) | |
| OTD 5.11.m | Intelligent Utility Installation Process | 2011 | 2014 | $ 278,297 | $ 191,000 | $ 18,344 | | $ 68,953 |
| OTD 5.11.n | Quality Control Procedure for High Protential Anodes | 2011 | 2013 | $ 44,929 | $ 4,045 | | | $ 40,884 |
| OTD 5.11.n.2 | 5.11.n.2 Quality Control Procedure for High Potential Anodes – Phase 2 | 2011 | 2015 | $ 20,000 | $ 20,000 | | | |
| OTD 5.12.b | Development of a Portable Flash Fire Suppression System (PFFSS) | 2012 | 2014 | $ 34,430 | $ 14,430 | | | $ 20,000 |
| OTD 5.12.b.2 | 5.12.b.2 Development of a Portable Flash Fire Suppression System (PFFSS) Phase 2 | 2012 | open | $ 10,000 | | $ 10,000 | | |
| OTD 5.12.g | Large Diameter Medium Pressure Inflatable Stoppers Evaluation of Kleiss System for the U.S. Natural Gas Industry | 2012 | 2014 | $ 20,000 | $ 8,007 | | | $ 20,000 |

| PROJECT NUMBER | PROJECT | START DATE | END DATE | TOTAL NGRID COMMITMENT | TOTAL SPEND 2013 | TOTAL SPEND 2014 | TOTAL SPEND 2015 | TOTAL NGRID SPEND Joe YEARS |
|---|---|---|---|---|---|---|---|---|
| OTD 5.12.n | Advanced Tools for Improved AC Corrosion Prevention and Mitigation | 2012 | 2013 | $ 70,000 | $ 35,000 | | | $ 35,000 |
| OTD 5.12.o | Guidelines for Cast-Iron (CI) Winter Operations | 2012 | 2013 | $ 108,000 | $ 48,000 | | | $ 60,000 |
| OTD 5.12.o.2 | Assessment of Frost Impact on Cast Iron Pipes Phase 2 | 2012 | 2015 | $ 37,410 | | $ 37,410 | | |
| OTD 5.12.p | NG Appliance Immersion Study | 2012 | 2015 | $ 104,606 | $ 104,606 | | | |
| 5.12.p refund | 5.12.p Refund | 2012 | | | | | $ (5,722) | |
| OTD 5.13.c | PE Pipe Splitting Technical Evaluations, Enhancements, and Standardization of Tool Kits | 2013 | open | $ 30,000 | $ 30,000 | | | |
| OTD 5.13.d.2 | Transmission Cut In Valve Phase 2 | 2013 | open | $ 50,000 | | $ 25,000 | | |
| OTD 5.13.f | Low Cost Collision Avoidance System | 2013 | open | $ 18,338 | $ 10,000 | $ 8,338 | | |
| OTD 5.13.g | Post Disaster Risk Assessment with LiDAR and GIS | 2013 | open | $ 50,000 | $ 25,000 | $ 25,000 | | |
| OTD 5.14.a | RFID Testing Program | 2014 | open | $ 25,277 | | $ 15,000 | $ 10,277 | |
| OTD 5.14.b refund | 5.14.b Refund | 2014 | | $ (829) | | | $ (829) | |
| OTD 5.14.b | Smart Leak Repair Form | 2014 | open | $ 18,500 | | $ 18,500 | | |
| OTD 5.14.c | Improving Cybersecurity for LDCs-Needs Identification Workshop | 2014 | open | $ 5,000 | | $ 5,000 | | |
| OTD 5.14.d | Tracking and Traceability for Transmission Pipe Materials | 2014 | open | $ 15,000 | | $ 15,000 | | |
| OTD 5.14.d.2a | Tracking and Treaceability for Transmission-Phase 2a Standards for MTR and Coating Reports, Rev | 2014 | open | $ 19,141 | | $ 10,000 | $ 9,141 | |
| OTD 5.14.d.2b | Tracking and Treaceability for Transmission-Phase 2b Data Collection Technology, Rev | 2014 | open | $ 23,725 | | $ 10,000 | $ 9,091 | |
| OTD 5.14.f | Battery and Electric Powered Tool Evaluation Phase 1 | 2014 | 2015 | $ 20,000 | | $ 20,000 | | |
| OTD 5.14.j | Residual Gas Removal Identify Technologies Limitations Best Practices | 2014 | open | $ 15,000 | | $ 15,000 | | |
| OTD 5.14.n | Construction Compliance Monitoring System | 2014 | open | $ 29,234 | | $ 15,000 | $ 14,234 | |
| OTD 5.14.p | Pipe Insertion Technologies - Develop Devices to Use with Jameson Directional Insertion Tool | 2014 | open | $ 1,663 | | $ 1,000 | $ 663 | |
| OTD 5.14.t | Methods to Detect Inserted Plastic in Steel Mains | 2014 | 2015 | $ 11,909 | | $ 11,298 | $ 611 | |
| OTD 5.14.t Refund | 5.14.t Refund | 2014 | | $ (27) | | | $ (27) | |
| OTD 5.14.u | Evaluation of New Geospatial Technologies | 2014 | 2015 | $ 5,125 | | $ 5,000 | $ 125 | |
| OTD 5.14.u Refund | 5.14.u Refund | 2014 | | $ (1,221) | | | $ (1,221) | |
| OTD 5.14.w | Testing Program for Valve with Water Sensor for Storm Hardening | 2014 | open | $ 21,625 | | $ 21,625 | | |
| OTD 5.14.x | Atmospheric Corrosion / Leak Survey Considerations | 2014 | 2014 | $ 35,000 | | $ 35,000 | | |
| OTD 5.15.b | Roadmap for Enterprise Decision Support System | 2015 | open | $ 2,778 | | | $ 2,500 | |
| OTD 5.16.b | Alternative Caps for PE Service Tees Fusible Caps | 2016 | open | $ 5,620 | | | | |
| OTD 5.16.c | Piercing Tool Redevelopment Enhancement to Remove "Mole" from Small Excavations (12mo) | 2016 | open | $ 22,150 | | | | |
| OTD 5.16.d | Stopping Off LP Mains with No Excavation | 2016 | open | $ 19,982 | | | | |
| OTD 5.16.f | Improved Safe Excavation Productivity for Locating Buried Utilities | 2016 | open | $ 5,274 | | | | |
| OTD 5.16.g | Enhancement of the Dynamic Cone Penetrometer (DCP) Compaction Device | 2016 | open | $ 53,033 | | | | |
| OTD 6.a | Sustaining Membership Program - GTI (discontinued) | 2003 | 2012 | $ 152,000 | | | | $ 152,000 |
| OTD 6.6.a | Keyhole Consortium - GTI | 2006 | 2012 | $ 100,000 | $ 20,000 | | $ 20,000 | $ 60,000 |
| OTD 6.08.a | (GTI) Carbon Management Information Center | 2008 | ongoing | $ 65,000 | | $ 25,000 | $ 25,000 | |
| OTD 6.11.a | PRCI Membership | 2011 | 2015 | $ 10,000 | | $ 10,000 | | |
| OTD 6.13.a | Quantitative Risk Assessment Methodology Protocol for LNG Facilities Siting (AGA) | 2013 | open | $ - | $ (10,000) | $ 10,000 | | |
| OTD 6.14.a | Quality Audit Program | 2014 | open | $ 40,000 | | $ 20,000 | $ 20,000 | |
| OTD 7.8.a | Pipeline Quality Biomethane: Guidance Document for Landfill and Water Treatment Conversion | 2008 | 2012 | $ 65,990 | | | | $ 65,990 |
| OTD 7.9.c | Assessing Acceptable Siloxane Concentrations in Boimethane | 2009 | 2012 | $ 52,972 | | | | $ 52,972 |
| OTD 7.9.d and 7.10.c | Improving Methane Emission Estimates for NG Distribution Companies, Phase 1 and 2 | 2009 | 2014 | $ 67,674 | | | | $ 67,674 |
| OTD 7.10a | Trace Constituents in Natural Gas | 2010 | 2013 | $ 78,205 | | | | $ 78,205 |
| OTD 7.10.b | Odor Fade (GTI) | 2010 | 2014 | $ 36,940 | | | | $ 36,940 |
| OTD 7.10.b Refund | 7.10.b Refund | 2010 | | $ (1,570) | | | $ (1,570) | |
| OTD 7.10.b.2 | Odor Fade Phase 2 (GTI) | 2010 | 2014 | $ - | | $ (10,000) | $ 10,000 | |
| OTD 7.10.c Refund | 7.10.c Refund | 2010 | | | | | $ (43) | |
| OTD 7.10.c.2 | Improving Methane Emission Estimates for NG Distribution Companies, Phase 2 | 2010 | 2014 | $ 67,674 | | | | $ 67,674 |
| OTD 7.10.c.3 | Improving Methane Emission Estimates Phase III - Cast Iron and Unprotected Steel Pipes | 2010 | 2014 | $ 99,839 | $ 50,000 | $ 49,839 | | |
| OTD 7.10.c.4 | Improving Methane Emission Estimates for Natural Gas Distribution Companies Phase IV | 2010 | 2014 | $ 6,880 | | $ 5,000 | $ 1,880 | |
| OTD 7.11.a | Gas Quality Resource Center | 2011 | 2013 | $ 65,000 | $ 20,000 | $ 20,000 | | $ 25,000 |
| OTD 7.11.a.2 | Gas Quality Resource Center | 2011 | 2013 | $ 20,000 | | | $ 20,000 | |
| OTD 7.11.b | Trace Constituents Sensors | 2011 | 2014 | $ 27,610 | | | | $ 27,610 |
| OTD 7.14.a | Next Generation Water Clean-up Technology Phase 1 | 2014 | open | $ 25,000 | | $ 25,000 | | |
| OTD 7.15.a | Real Time Gas Quality Sensor | 2015 | open | $ 4,981 | | | $ 2,500 | |
| OTD 7.15.b.2 | Remote Gas Sensing and Monitoring Phase 2 | 2015 | open | 3000 | | | | |
| OTD 7.16.a | Leak Repair Prioritization | 2016 | open | 20110 | | | | |
| OTD 7.16.b | Evaluate Gas Imaging Technologies for LDC Applications | 2016 | open | 30000 | | | | |
| OTD 7.16.c | Secure Communication for Networked Gas Sensors | 2016 | open | 21302 | | | | |
| OTD 8.16.a | Intelligent Field Data Collection Platforms | 2016 | open | 19956 | | | | |
| OTD 8.16.b | Remote QA/QC: Fusion Inspection and Reporting | 2016 | open | 39441 | | | | |
| OTD 9.16.a | Determining Data Quality Implication | 2016 | open | 56224 | | | | |
| OTD 9.16.b | Establishing Risk Tolerance | 2016 | open | 25358 | | | | |
| | | | | $ 6,229,580 | $ 838,371 | $ 834,690 | $ 802,024 | $ 2,520,240 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| T759 | Ergonomic Study to Develop New Needle Bar | 2005 | 2012 | $ 29,889 | | $ 557 | | $ 25,366 |
| T763 | Rock Impingement | 2007 | 2011 | $ 19,250 | | | | $ 21,100 |
| T764 | Auto Gas Lamp Evaluation | 2009 | 2012 | $ 27,500 | | $ 10,443 | | $ 10,314 |

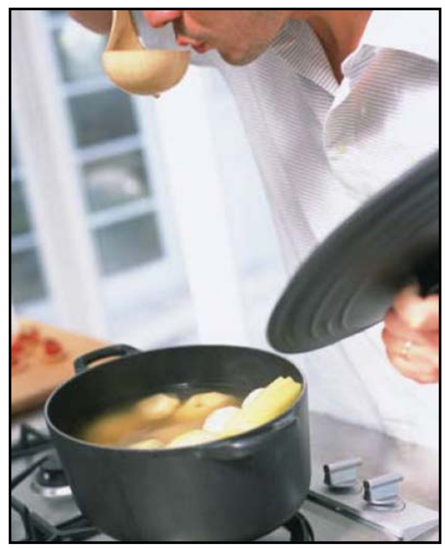
gti®

*the Energy to Lead*

**TOPICAL REPORT**

GTI PROJECT NUMBER 20733

# National Grid Foodservice Market Assessment



**Report Issued:**
March, 2010

**Prepared For:**
National Grid

**GTI Technical Contact:**
Dr. Frank Johnson
Senior Engineer
End Use Solutions
847-768-0670
Fax: 847-768-0501
frank.johnson@gastechnology.org

**Gas Technology Institute**

1700 S. Mount Prospect Rd.
Des Plaines, Illinois 60018
www.gastechnology.org

## Disclaimer

*This information was prepared by Gas Technology Institute ("GTI") for National Grid.*

*Neither GTI, the members of GTI, National Grid, nor any person acting on behalf of any of them:*

*a. Makes any warranty or representation, express or implied with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately-owned rights. Inasmuch as this project is experimental in nature, the technical information, results, or conclusions cannot be predicted. Conclusions and analysis of results by GTI represent GTI's opinion based on inferences from measurements and empirical relationships, which inferences and assumptions are not infallible, and with respect to which competent specialists may differ.*

*b. Assumes any liability with respect to the use of, or for any and all damages resulting from the use of, any information, apparatus, method, or process disclosed in this report; any other use of, or reliance on, this report by any third party is at the third party's sole risk.*

## TABLE OF CONTENTS

EXECUTIVE SUMMARY ..... 1
FOOD SERVICE INDUSTRY MARKET CHARACTERIZATION ..... 3
Product Drivers ..... 8
ENERGY USE AND NATURAL GAS V. ELECTRIC POSITIONING ..... 11
ENERGY EFFICIENCY PROGRAMS AND ENERGY STAR ..... 17
GAS INDUSTRY RD&D AND COMMERCIALIZATION ..... 22
Natural gas R&D ..... 22
Commercialization ..... 26
COMMERCIAL FOODSERVICE MARKET CHANNELS ..... 28
Commercial Foodservice Trade Associations ..... 28
National Restaurant Association ..... 28
The North American Association of Food Equipment Manufacturers (NAFEM) ..... 28
Foodservice Equipment Sales and Service Channels ..... 29
Market Channel Participant Interviews ..... 29
Phone Survey ..... 29
CONCLUSIONS ..... 32
REFERENCES ..... 34
APPENDIX A: MARKET SURVEY RESULTS ..... A-1
APPENDIX B: NATIONAL RESTAURANT ASSOCIATION DATA SHEETS ..... B-1
APPENDIX C: COMMERCIAL FOODSERVICE PUBLICATIONS ..... C-1

## LIST OF FIGURES

Figure 1: Foodservice Market Segmentation ........ 3
Figure 2: Commercial Sector Energy Intensity (DOE-EIA 2003 CBECS) ........ 5
Figure 3: Commercial Food Service Equipment Sales by Category (2006, $millions) ........ 8
Figure 4: Commercial Food Service Site Energy Use – Electric and Natural Gas ........ 12
Figure 5: Commercial Food Service Source Energy Use – Electric and Natural Gas ........ 13
Figure 6: Consumer Perceptions of Environmental Friendliness ........ 15
Figure 7: Product Development and Commercialization Process ........ 23
Figure 8: Piedmont Natural Gas Test Kitchen Profile (Source: GFEN, Spring 2009) ........ 27

## LIST OF TABLES

Table 1: Selected State Foodservice Data (2009) ........ 3
Table 2: 2010 Restaurant Sales and Segmentation ($Billions) ........ 4
Table 3: Restaurant Annual Sales Data (% of restaurants) ........ 5
Table 4: Top Seven Challenges for Foodservice Operators in 2008 ........ 6
Table 5: Commercial Foodservice Product Sales (2006, Source: Fryett) ........ 7
Table 6: Typical Restaurant Cost Stack ........ 11
Table 7: Restaurant Energy & Utility Costs by Restaurant Type (% of revenue) ........ 11
Table 8: Energy Costs By Sales Volume and Energy Costs Percent of Sales ........ 12
Table 9: National Electric and Gas Site Energy Use for Commercial Food Service ........ 13
Table 10: Natural Gas and Electric Strengths and Weaknesses ........ 14
Table 11: Comparison of Energy Costs in New York and Massachusetts ........ 14
Table 12: Restaurant Energy Cost and Consumption Comparisons in New York City and Boston ........ 15
Table 13: Natural Gas and Electric Opportunities and Threats ........ 16
Table 14: NRA Sustainability Survey – Planned Actions ........ 17
Table 15: Energy Efficiency Funding Comparison ........ 18
Table 16: CEE Qualifying Commercial Foodservice Products (2010) ........ 20
Table 17: Energy Star Availability Ratings for Commercial Food Service Equipment ........ 20
Table 18: Example UTD-Supported Commercial Foodservice Products ........ 23
Table 19: Supply Channel Actors ........ 29

# National Grid Foodservice Market Assessment

## Executive Summary

The commercial and institutional food service sector represents an important – **and growing** – market for the natural gas industry. According to the National Restaurant Association (NRA), there are approximately 525,000 commercial food service establishments nationwide with annual sales of $580 billion. Remarkably, nearly one in ten workers in the U.S. is a restaurant employee. The NRA indicates total U.S. commercial foodservice employment is 11.2 million – a substantial figure that is projected to grow to 14 million by 2020 (25 percent growth).

There are approximately 37,400 restaurants in New York with gross sales of $27.8 billion and over 672,000 employees. In Massachusetts, there are over 14,000 restaurants with annual sales of $11.8 billion and 304,000 employees. Rhode Island has nearly 2,700 restaurants with $1.8 billion in sales while New Hampshire has over 2,800 restaurants with annual sales of $2.1 billion. Together, this totals nearly 57,000 establishments with annual sales in excess of $43 billion. Using a nominal value of 3.4 percent of sales, commercial food service annual utility cost (electricity, natural gas, water, etc) exceed $1.4 billion in these four states and approach $20 billion nationally.

According to Energy Information Agency (EIA) survey data, commercial foodservice customers have 2.2 times the energy intensity (Btu/ft$^2$) of the average commercial customer. Audits conducted by Southern California Gas and Piedmont Gas found that natural gas sales to commercial foodservice customers account for 12 percent of the volume of gas sold, but comprise a healthy 19 percent of their profits.

In terms of new equipment, the estimated annual sales of new commercial foodservice equipment totaled about $1.2 billion in 2006. Of this, about 69 percent was natural gas-based products – indicating a strong market position for natural gas relative to electricity. The report provides further analysis of sales by product category and, an important consideration, the limited availability of Energy Star-rated natural gas products.

While a significant and growing market, there are continual threats and opportunities to assess within the commercial food service market segment. This project was undertaken to generate insights on the current gas foodservice market in National Grid's Northeastern United States market territory, with findings intended to guide a course of action for future RD&D and marketing initiatives within the foodservice arena. In addition to market and technology insights from GTI's experience and literature review, interviews were conducted with six foodservice consulting firms and equipment dealers within National Grid territories.

From this, the following observations, trends, opportunities, and threats are identified for the natural gas industry in the commercial foodservice marketplace:

- Natural gas market share is currently strong and holding against electric market share. New electric products; perceptions of electric as clean, simple, and reliable; and growing electric energy efficiency programs represent potential threats. There is also a market perception that electric equipment is more advanced or higher end than gas equipment, posing a significant threat.

- Natural gas is perceived as more cost-effective by users, with current electric-to-natural gas price ratios of 4.5:1 or higher. A typical restaurant is paying over twice as much annually for electricity than natural gas – underscoring the perception of natural gas as being cost effective.
- Rising labor, food, and energy costs are motivating foodservice providers to seek new and innovative equipment designs that could save operating costs through productivity improvements and speedier delivery.
- **Labor issues are a dominant factor in this sector** – major issues are obtaining and retaining quality workers, labor costs, and productivity. Increased labor turnover motivates foodservice providers to seek methods or equipment to improve the working environment for employees in terms of comfort, ease of equipment usage, and cleaning.
- Key purchase factors for new equipment include price, efficiency (operating costs), after-sales support, and productivity improvement. Equipment obsolescence and deterioration is typically the main reason to buy new equipment. With older gas equipment lasting for many years, added effort is required to convince users to purchase new equipment. Getting information to users about the cost and energy saving associated with new equipment is needed along with meaningful incentives from energy efficiency programs.
- There is a paucity of Energy Star recognized standards and, subsequently, natural gas products in the commercial foodservice sector. This can impact the ability to use utility energy efficiency program funds to incentivize the shift to higher-efficiency equipment.
- More investment is needed to develop advanced, energy efficient natural gas appliances that would satisfy current or future Energy Star labeling requirements.
- Trends toward healthier and/or more environmentally responsible eating habits can influence the market, but the economic benefits/effects are not fully understood by the industry.
- The industry is concerned about lower emissions standards (including $NO_x$ and particulates) – especially where such requirements have been imposed on residential appliances.
- Ventilation advancements represent an opportunity to increase energy efficiency and kitchen comfort and indoor air quality for workers. Improvements include demand ventilation systems.
- The green movement is a threat to natural gas. Consumer surveys show that electric is perceived as being more green, possibly due to the site-based efficiency claims. There is an opportunity to position new gas equipment as green through consumer education - identifying the financial, source energy, and environmental benefits.

## Food Service Industry Market Characterization

The food service industry is a growing and diverse segment of the commercial market. Figure 1 shows the major segments of this estimated $580 billion industry, including "eating places" (i.e., various types of restaurants), vending & recreation, non-commercial (i.e., institutional), managed services, lodging, as well as bars & taverns.

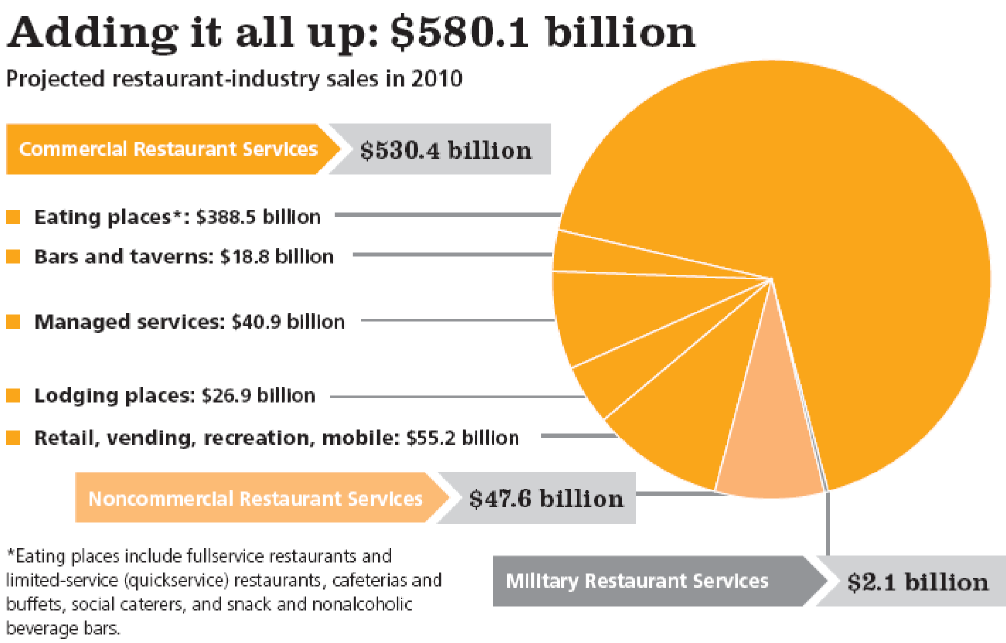



**Figure 1: Foodservice Market Segmentation**

(Source: NRA 2010 Restaurant Industry Forecast)

There are approximately 525,000 foodservice establishments across the country. State-level characteristics on four key states – New York, Massachusetts, Rhode Island, and New Hampshire – are shown in Table 1, with additional state profile data from the National Restaurant Association included in the appendix to this report. These four states include 56,900 commercial foodservice locations with annual sales in excess of $43 billion.

**Table 1: Selected State Foodservice Data (2009)**

| Sales Volume | Foodservice Establishments | Annual Sales ($Million) | Employment |
|---|---|---|---|
| **New York** | 37,400 | $27,800 | 672,000 |
| **Massachusetts** | 14,000 | $11,800 | 304,000 |
| **New Hampshire** | 2,800 | $2,100 | 61,200 |
| **Rhode Island** | 2,700 | $1,800 | 51,900 |

Source: National Restaurant Association

The foodservice market can be further broken down into major and niche segments (Table 2). Eating places are dominated by full-service restaurants – around $184 billion -- and limited-service (or quick-service) restaurants at over $165 billion. Together, these two groupings comprise 60 percent of the foodservice market. Beyond this are a number of smaller market niches, including institutions such as hospitals, schools, and universities.

**Table 2: 2010 Restaurant Sales and Segmentation ($Billions)**

| GROUP I COMMERCIAL RESTAURANT SERVICES | 2010 Sales | Growth? |
|---|---|---|
| EATING PLACES | | |
| Full-service restaurants | $184.176 | |
| Limited-service (quick-service) restaurants | $164.837 | ☑ |
| Cafeterias, grill-buffets and buffets | $7.671 | |
| Social caterers | $7.090 | ☑ |
| Snack and nonalcoholic beverage bars | $24.736 | |
| TOTAL EATING PLACES | **$388.510** | |
| Bars and taverns | $18.844 | |
| TOTAL EATING-AND-DRINKING PLACES | **$407.354** | |
| MANAGED SERVICES | | |
| Manufacturing and commercial offices | $9.218 | |
| Hospitals and nursing homes | $5.053 | ☑ |
| Colleges and universities | $13.649 | ☑ |
| Primary and secondary schools | $5.863 | ☑ |
| In-transit restaurant services (airlines) | $2.061 | |
| Recreation and sports centers | $5.025 | ☑ |
| TOTAL MANAGED SERVICES | **$40.869** | |
| Lodging Places | $26.943 | ☑ |
| Retail-host restaurants | $30.936 | ☑ |
| Recreation and sports | $12.518 | |
| Mobile caterers | $0.635 | |
| Vending and Non-store retailers | $11.097 | |
| TOTAL — GROUP I | **$530.352** | |
| GROUP II NONCOMMERCIAL RESTAURANT SERVICES | | |
| Employee restaurant services | $0.426 | |
| Public and parochial elementary, secondary schools | $6.144 | |
| Colleges and universities | $6.083 | |
| Transportation | $1.830 | ☑ |
| Hospitals | $15.225 | ☑ |
| Nursing homes, homes for orphans, disabled | $7.145 | ☑ |
| Clubs, sporting, recreational camps, community centers | $10.694 | |
| TOTAL — GROUP II | **$47.547** | |
| GROUP III MILITARY RESTAURANT SERVICES | $2.161 | ☑ |
| GRAND TOTAL | **$580.060** | |

Source: NRA 2010 Restaurant Industry Forecast

Schools, universities, hospitals are addressed using either in-house foodservice (non-commercial) and by "managed services" such as foodservice contractors. For example, the total university segment includes a non-commercial component of over $6.1 billion and a managed services component of about $13.6 billion (which is growing faster than the non-commercial segment). Managed service providers could be an attractive point for targeted marketing by National Grid.

Restaurants have a wide level of variability in their size and operations. Table 3 shows a breakdown of annual sales volumes based on average check cost. More than half of restaurants do more than $1 million annually in sales, with nearly one quarter being greater than $2 million. Not surprisingly, sales volume tends upward with higher average check businesses.

**Table 3: Restaurant Annual Sales Data (% of restaurants)**

| Sales Volume | Average Check <$15 | Average Check $15-25 | Average Check >$25 |
|---|---|---|---|
| **<$500K** | 19.3% | 9.6% | 12.3% |
| **$500K-$1000K** | 25.5% | 30.7% | 15.8% |
| **$1000-$2000K** | 31.7% | 33.3% | 31.0% |
| **>$2000K** | 23.5% | 26.4% | 40.9% |

Source: NRA and Deloitte, Restaurant Industry Operations Report (2006/2007 Edition)

Most restaurants are either owned by a private corporation (around 60-65 percent), sole proprietorship, or partnership (the latter two each being about 15-20 percent of the market). This ownership structure is true of those restaurants which are tied to a major public corporation. For example, an estimated 85 percent of McDonald's restaurants are owned and operated by franchisees or private joint ventures.

The food service industry is attractive because, on a per square foot basis, it uses much more energy than most other commercial buildings (Figure 2). Food service establishments use 2.2 times the energy per square foot of the typical commercial building (258 versus 116 kBtu/ft$^2$) and have the highest energy intensity in the commercial building sector.

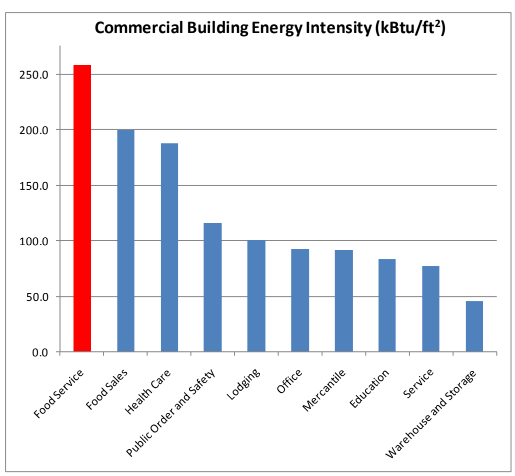



**Figure 2: Commercial Sector Energy Intensity (DOE-EIA 2003 CBECS)**

As evidenced by the relative energy intensity of foodservice establishments, energy is cited as one of several key factors of concern to food service operators. The following table shows results from the National Restaurant Association survey on key challenges perceived by full-service restaurant operators. Energy typically falls in the range of the top 5-6 areas of concern – and varies somewhat depending on the type of restaurant.

**Table 4: Top Seven Challenges for Foodservice Operators in 2008**

| | Tableservice Segment | | |
|---|---|---|---|
| | Family Dining | Casual Dining | Fine Dining |
| Recruiting and retaining employees | 17% | 23% | 14% |
| Building and maintaining sales volume | 12 | 11 | 22 |
| The economy | 13 | 13 | 17 |
| Competition | 17 | 6 | 13 |
| Labor costs | 11 | 10 | 10 |
| Gas and energy costs | 11 | 8 | 5 |
| Food costs | 7 | 10 | 3 |

Source: National Restaurant Association, 2007 Tableservice Operator Survey

The National Restaurant Association estimates that 49 percent of consumer spending on food is expended in the foodservice sector (the balance being food bought in grocery stores and consumed at home). This compares to only 25 percent of the consumer spending in 1955. Forty-four percent of consumers say that restaurants are an essential part of their lifestyle, with over 40 percent saying they are more productive eating at restaurants or using take-out or delivery foodservice.

This long-term demographic shift, where consumers are increasingly spending their food dollars in restaurants, presents an opportunity and a threat for the natural gas industry. With less food prepared at the home, there is a threat to natural gas sales to the residential sector and potential for displacement with electro-technologies in the home (e.g., microwaves and radiant or inductive heating). However, if a strong position for natural gas can be retained in restaurants, the net effect should be minimal.

The lifestyle elements of food and eating are evident. Sixty-five percent of consumers say their favorite restaurant foods provide flavor and taste sensations they cannot easily duplicate at home. One element to consider, however, is the growing popularity of at-home cooking shows on television featuring a plethora of celebrity chefs – and a dedicated cable station, The Food Network – along with growing enrollment in culinary schools (which includes those pursuing a career as well as for personal enjoyment and development).

> "At the Culinary Institute of America in Hyde Park, N.Y., administrators increased their five-day, $2,095 "Basic Training" boot camp to 14 classes a year, up from 10 three years ago. The Whole Foods in the Soho neighborhood of New York City saw enrollment in the store's cooking classes increase 46% between 2009 and 2008, says a company spokeswoman."
> **Source: Wall Street Journal, Cutting Costs at Culinary School (Aug, 12, 2009)**

Tying natural gas into the lifestyle elements of culinary arts is an important branding consideration for the natural gas industry. As will be highlighted, natural gas has certain positive branding factors, but can face strong competition from newer electro-technologies that may be perceived as cleaner, more high tech, cleaner, greener, or safer. Tapping into culinary arts schools or collaborating with celebrity chefs to expose them to the latest natural gas commercial foodservice products could be an effective marketing approach.

Generally, natural gas has a strong position in the commercial foodservice segment. Table 5 and Figure 3 provide a snapshot view of natural gas and electric product sales. In several product categories – for example, ranges, convection ovens, and conveyor ovens – natural gas is the clear market leader. Leading electric product categories include: fryers, convection ovens, combi-ovens, and free-standing steamers. There are two categories where electric products have over 50 percent market share – counter-top steamers and combi-ovens. The rightmost column highlights product categories that are currently being addressed by UTD or SMP funded R&D efforts.

**Table 5: Commercial Foodservice Product Sales (2006, Source: Fryett)**

| Equipment Category | Total Sales ($MM) | Gas Sales ($MM) | Gas Share (%) | Electric Sales ($MM) | UTD/SMP/ Projects |
|---|---|---|---|---|---|
| Underfired Broilers | $9.8 | $9.8 | 100% | $- | |
| Pizza / Deck Ovens | $18.0 | $18.0 | 100% | $- | ☑ |
| Wok Ranges | $30.0 | $30.0 | 100% | $- | ☑ |
| Steamers - Pressure | $9.0 | $8.0 | 89% | $1.0 | |
| Charbroilers | $17.4 | $15.0 | 86% | $2.4 | |
| Ranges | $175.6 | **$146.5** | 83% | $29.1 | ☑ |
| Conveyor Broilers | $35.0 | $29.0 | 83% | $6.0 | |
| Conventional Ovens | $15.0 | $12.0 | 80% | $3.0 | |
| Conveyer Ovens | $93.9 | **$72.5** | 77% | $21.4 | ☑ |
| Rotisserie Ovens | $34.4 | $26.5 | 77% | $7.9 | |
| Griddles | $46.5 | $35.0 | 75% | $11.5 | |
| Pressure Fryers | $61.9 | $46.5 | 75% | $15.4 | |
| Fryers | $247.2 | **$175.0** | 71% | **$72.2** | ☑ |
| Over-fired Broilers | $36.8 | $24.1 | 65% | $12.7 | ☑ |
| Convection Ovens | $135.9 | **$77.4** | 57% | **$58.5** | ☑ |
| Steamers - Free-Standing | $68.0 | $38.0 | 56% | **$30.0** | |
| Tilting Skillets | $46.3 | $24.0 | 52% | $22.3 | |
| Combi Ovens | $100.0 | $46.0 | 46% | **$54.0** | |
| Steamers - Counter-Top | $39.5 | $9.9 | 25% | $29.6 | |
| **Total** | **$1,220.2** | **$843.2** | | **$377.0** | |
| **% of Total** | | **69.1%** | | **30.9%** | |

Fryers are a key market retention product for the natural gas industry due to the size of the market. While holding a 71 percent market share in 2006, this segment is threatened by electric products – especially with the recent shift to low oil volume fryers. This segment represents the highest dollar volume sales category for electric products. Also, for low oil volume fryers, electric units were developed and field tested one year before gas-fired models because of the extra development time required to design gas-fired burners. This situation places natural gas models of popular natural gas foodservice equipment at risk in terms of timing of commercial introduction or – in the most extreme cases – may be dropped from the product line-up if manufacturers do not see the benefit/cost of investing in a gas offering.

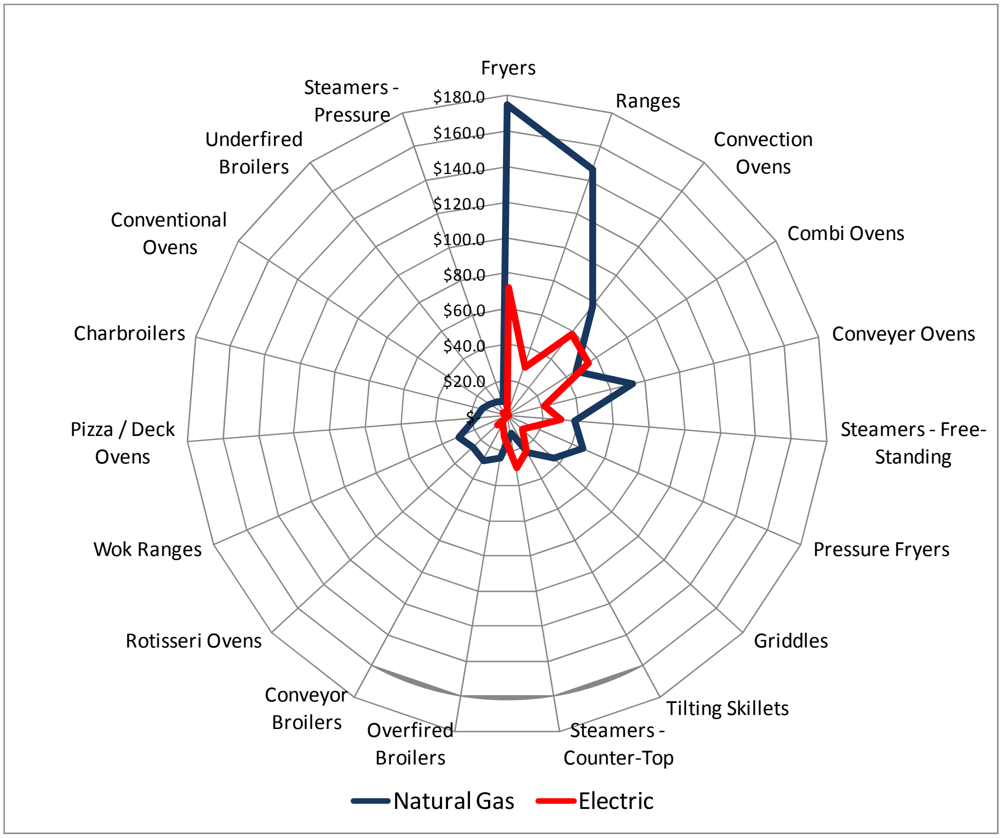



**Figure 3: Commercial Food Service Equipment Sales by Category (2006, $millions)**

## Product Drivers

Historically, the demand for new or healthy food products has driven the foodservice industry to develop new and innovative technologies and equipment. An example is what could be called the "Boston Market" effect during the early 1990's. The popularity of roasted chicken grew tremendously with the initial Boston Market restaurants, leading several other restaurants – including existing chains – to add roasted chicken to their menus. This also led several manufacturers to develop rotisserie ovens for cooking chicken. Another example is the rapid increase in bagel preparation equipment that was spawned by the increasing popularity of bagels several years ago.

A current driver in the foodservice industry is the removing or banning of trans-fat oils by several restaurant chains or metropolitan areas. Trans-fats, present in many deep-frying oils, are linked to unhealthy levels of cholesterol levels -- a fact that has received considerable media exposure. For this reason, partially hydrogenated oils and trans-fat oils are the subject of growing scrutiny from public health officials and health-conscious consumers. By mid 2008, cities such as New York and others passed legislation to ban or tightly control the use of trans-fat oils in any public restaurant. Restaurant chains including McDonald's, Arbys and KFC have either discussed or are eliminating trans-fat oil from their menu items. The main issue with using trans-fat free oils is not availability; they are widely available, but cost more and have a different taste. In response to this, restaurants looked to the foodservice industry and manufacturers for solutions. One result was the development of low oil volume fryers by manufacturers including Frymaster, Pitco and Henny Penny. Low oil volume fryers address the increased cost of the non trans-fat oils by using less oil than standard fryers, 30 to 35 pounds of oil compared to over 50 pounds. The savings is realized by throwing away less oil during each oil change. Oil savings are also realized by improved filtering methods in some of the low oil volume fryers that increase the useful life of the oil.

Rethermalization is an area of potential market change. The concept behind rethermalizing is to use either vendor-prepared or commissary-made food products in place of "from scratch" cooking. In addition to helping restaurants address high demand periods, this can result in labor savings, energy savings, improved consistency, and potentially improved food safety.

In this process, large batch cooking is employed to make a product (e.g., soup) that is quickly chilled and placed into multiple vacuum-sealed bags of food. This is also referred to as the *sous vide* process. Vacuum sealing helps to keep out harmful pathogens while retaining flavor and aroma.

The rethermalization process at the restaurant involves reheating the product – typically with lower temperatures and considerably less time than would be required by cooking from scratch. As noted earlier, labor is a major cost and operations issue for restaurants. Using rethermlized food can reduce restaurant labor costs and – to some extent – the quality of labor needed (compared to cooking from scratch).

"From the standpoint of equipment, in some cases we may be headed for the **fireless kitchen** without pots or pans. This also would reduce, or in some cases even eliminate, exhaust requirements of many professional kitchens."
**Source: "Rethermalize it," Nation's Restaurant News, Oct. 8, 2007.**

Rethermalizing is an area that could represent a threat or opportunity for the natural gas industry. A shift towards a "fireless" kitchen – one that mainly uses electricity for reheating pre-cooked products – is clearly a potential threat.

Ventilation is both an area of opportunity and concern for the restaurant operator and the natural gas industry. Employee turnover is very high in the restaurant industry; in some segments, the turnover rate is 200 percent. This puts additional costs on the restaurant through training and absenteeism costs.

By making the kitchen a more comfortable workplace through advanced ventilation practices and safer cooler equipment surfaces, employee turnover rates may be reduced. Ventilation issues also impact energy use (heating, cooling, fan power, etc) and indoor air quality in the kitchen environment. There are also fire safety consideration with ventilation systems and cleaning of grease to prevent fires.

Kitchen ventilation is an opportunity for improved comfort and energy savings. In most kitchens, exhaust fans will run at a constant speed throughout the day. This can impact space conditioning loads along with fan energy requirements. Opportunities for improvement include using demand ventilation approaches that can modulate fan speed depending on work conditions.

New emission standards have driven the development of new appliances in the residential/commercial markets at different times in the past few decades. Lower emissions requirements in California on residential water heaters led to the development of new combustion systems for all water heaters currently sold in the state. Establishing $NO_x$ emission levels on residential furnaces by the South Coast Air Quality Management District led to the development of new furnace designs and combustion systems. While new emissions legislation is usually more focused on residential appliances, new $NO_x$ emission standards are being considered for commercial cooking equipment in California. Agencies in California are also proposing new limits on the particulate emissions from charbroilers. Particulate emissions and grease build-up in ventilation systems is a serious issue for restaurants. GTI is currently working with the gas industry and manufacturers to explore options to address these environmental and restaurant workplace issues.

## Energy Use and Natural Gas v. Electric Positioning

Table 6 provides a breakdown of typical costs and pre-tax profits in the restaurant business. The dominant cost factors are food and beverage, followed by salaries and benefits. Labor-related issues – controlling labor costs, employee retention, increasing productivity – are key concerns for restaurant operators (as noted in Table 4). The other item of note is that most restaurants have relatively modest income before taxes – around 4 percent. Reducing costs even one percent can translate into a 20-30 percent relative increase in profits.

**Table 6: Typical Restaurant Cost Stack**

| | |
|---|---|
| **Food & Beverage** | 32% |
| **Salaries & Benefits** | 34% |
| **Occupancy** | 7% |
| **General & Administrative** | 3% |
| **Other** | 20% |
| **Income Before Taxes** | 4% |
| **Total:** | **100%** |

Source: NRA and Deloitte, Restaurant Industry Operations Report (2006/2007 Edition)

Generally, restaurants are a tight margin business with many competitors, as evidenced by the substantial number of outlets across the U.S. (525,000). Restaurants typically go through dynamic cycles of birth and death for a variety of reasons. Statistics indicate that one in four restaurants fail in the first year, with nearly 60 percent failing within three years.

The "other" category in Table 6 includes energy and other "utility" costs such as water. The importance of energy and other utility costs will vary depending on the restaurant type and sales volume. Table 7 illustrates the relative importance of utility costs depending on the restaurant type (using average check size as a differentiator). The relative impact of energy costs generally increases as the average check size goes down.

**Table 7: Restaurant Energy & Utility Costs by Restaurant Type (% of revenue)**

| | Average Check <$15 | Average Check $15-25 | Average Check >$25 |
|---|---|---|---|
| **Lower Quartile** | 2.7% | 2.5% | 1.9% |
| **Median** | 3.7% | 3.4% | 2.7% |
| **Upper Quartile** | 4.9% | 4.5% | 3.8% |

Source: NRA and Deloitte, Restaurant Industry Operations Report (2006/2007 Edition)

Table 8 provides an estimate of annual energy costs for an example restaurant as a function of annual sales and the percent of total sales allocated for energy and related utility costs. Using a typical restaurant sale volume of $1-1.5 million annually and energy costs of 3.4 percent of sales, annual energy costs for a nominal restaurant is in the range of $34-50,000. This value will likely be in the range of $50,000-$100,000 for higher sales volume stores.

**Table 8: Energy Costs By Sales Volume and Energy Costs Percent of Sales**

| Energy Cost % Sales ➔ Annual Sales ⬇ | 2.5% | 3.0% | 3.5% | 4.0% | 4.5% |
|---|---|---|---|---|---|
| **$500,000** | $12,500 | $15,000 | $17,500 | $20,000 | $22,500 |
| **$1,000,000** | $25,000 | $30,000 | $35,000 | $40,000 | $45,000 |
| **$1,500,000** | $37,500 | $45,000 | $52,500 | $60,000 | $67,500 |
| **$2,500,000** | $62,500 | $75,000 | $87,500 | $100,000 | $112,500 |

As noted, commercial food service establishments are attractive because they use considerably more energy (per square foot) than other commercial buildings and tend to contribute more to natural gas profits. The higher energy intensity is due to their process activities such as food storage (e.g., refrigeration), food preparation (e.g., cooking), and sanitation (e.g., cleaning dinnerware).

Figure 4 and Table 9 show DOE-EIA estimates of site electric and natural gas use in all foodservice buildings in the U.S. (based on the 2003 Commercial Buildings Energy Consumption Survey). Electricity and natural gas are the primary energy options used in the commercial food service sector, with electricity being about 70 percent of total energy costs. Equivalent electric use is about 217 trillion Btu (63 billion kWh) and 203 trillion Btu for natural gas.

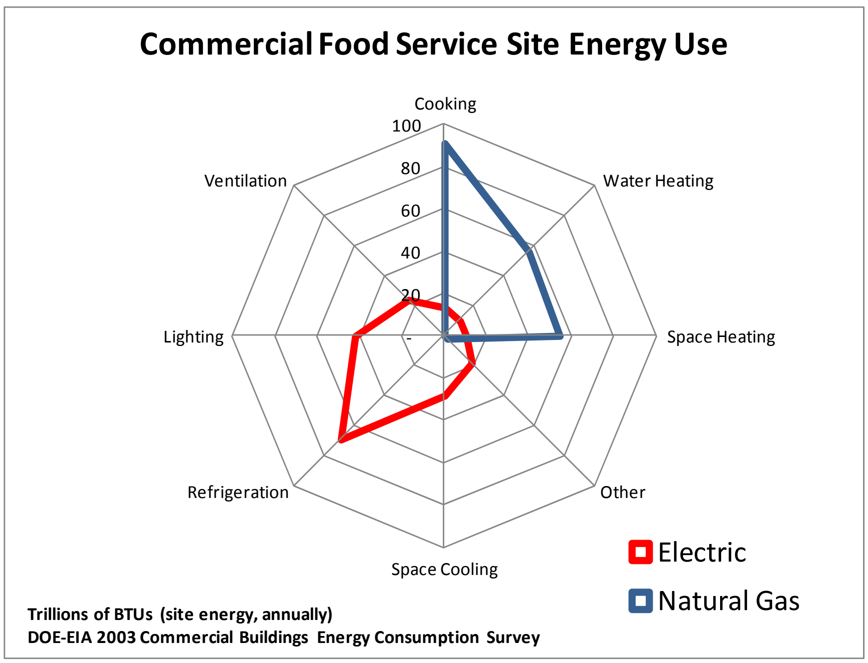



**Figure 4: Commercial Food Service Site Energy Use – Electric and Natural Gas**

The use of each of these two energy choices is highly differentiated, with most electricity used for refrigeration, space conditioning, lighting and ventilation. Natural gas is predominantly used for cooking, water heating, and space heating – holding over 80 percent share across the market. Retaining this market position against electric technologies should be a primary consideration for the natural gas industry.

**Table 9: National Electric and Gas Site Energy Use for Commercial Food Service**

| | Electric | Natural Gas | % Gas |
|---|---|---|---|
| Cooking | 13.6 | 91.0 | 87% |
| Water Heating | 10.2 | 56.0 | 85% |
| Space Heating | 10.2 | 54.0 | 84% |
| Other | 18.1 | 2.0 | N/A |
| Space Cooling | 28.2 | - | N/A |
| Refrigeration | 69.5 | - | N/A |
| Lighting | 42.4 | - | N/A |
| Ventilation | 24.3 | - | N/A |

Source: DOE-EIA 2003 Commercial Buildings Energy Consumption Survey (Trillion Btu)

There is a substantial amount of energy consumed to produce and deliver electricity. The total source to site energy lost is often more than twice the amount of electric energy used onsite. DOE-EIA data indicate that total energy consumption for electricity in commercial foodservice is about 650 trillion on a complete source to use basis (compared to about 215 trillion Btu on a site-only basis). Figure 5 illustrates the substantial differences in total source energy use compared to a site-only basis. For example, refrigeration loads use slightly less energy on a site basis, but are more than two times more in energy consumption on a source basis.

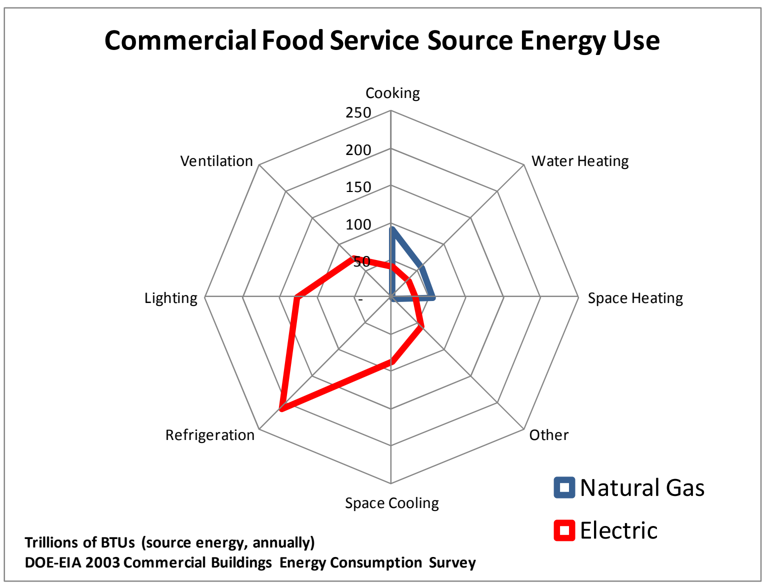



**Figure 5: Commercial Food Service Source Energy Use – Electric and Natural Gas**

The substantial differences in site versus source energy values can be an important factor when companies look at “green building” issues such as LEED compliance. Unfortunately, there has been a reluctance in some of these codes to recognize total source energy as a more complete and responsible measurement of national energy use.

Natural gas and electricity -- and the industries that represent them – have perceived strengths and weaknesses. The following table highlights some of these considerations.

**Table 10: Natural Gas and Electric Strengths and Weaknesses**

| | Strengths | Weaknesses |
|---|---|---|
| **Natural Gas** | • Perceived as lowest life-cycle and operating cost options for end users<br>• High energy rates with rapid response to changes in burner setting<br>• High delivered energy density compared to electric.<br>• Source energy and carbon emission advantages over electricity | • Less technologically advanced (e.g., manual controls, pilot lights)<br>• Perception in some cases as being less safe than electric products<br>• Manufacturers lack gas expertise or motivation to invest in state-of-the-art gas technology (e.g., indifferent on gas vs electric)<br>• Perceived limited gas industry marketing focus in this segment<br>• Lack of gas combustion engineers and burner design experts. Old designs tend to be reused |
| **Electric** | • Seen as cleaner, more technologically advanced<br>• Perceived as safer than natural gas<br>• Products are viewed as more reliable<br>• Typically lower first cost equipment<br>• Many 'green' building codes based upon site rather than total source energy | • Higher electric operating costs (energy and power demand)<br>• Utility pressure to manage peak demand, control costs, ensure reliability<br>• Typically higher source energy and emission factors (on a full-fuel-cycle basis)<br>• Limited availability in some locations to add amperage or install higher voltage outlets needed for resistance heating |

Operating costs are an important factor in the commercial food service sector. Survey data indicates that users perceive natural gas as a better value in terms of annual energy costs. The following table compares typical commercial natural gas and electricity prices in New York and Boston for commercial customers (Source: DOE-EIA, Oct. 2009 data).

**Table 11: Comparison of Energy Costs in New York and Massachusetts**

| | Natural Gas | Electric | Electric/Gas Ratio |
|---|---|---|---|
| **New York** | \$10.46/mcf<br>(\$10.25/MMBtu) | \$0.1568/kWh<br>(\$45.93/MMBtu) | 4.5:1 |
| **Massachusetts** | \$11.38/mcf<br>(\$11.16/MMBtu) | \$0.1912/kWh<br>(\$56.00/MMBtu) | 5.0:1 |

Using information from GTI's Building Energy Analyzer, the following table breaks down annual energy characteristics and energy costs for a typical 5,000 sq. ft. national chain casual full-service restaurant. This highlights the energy value provided by natural gas relative to electricity. Commercial food service establishments are paying monthly bills for electricity that are more than double their natural gas bills. This disparity likely helps underscore the consumer perceptions of natural gas being a better value – or, conversely, they are paying too much for electricity.

**Table 12: Restaurant Energy Cost and Consumption Comparisons in New York City and Boston**

| | Natural Gas | Electric | Electric/Gas Energy Ratio | Electric/Gas $ Sales Ratio |
|---|---|---|---|---|
| **New York, NY** | Site Energy<br>3,087 MMBtu<br>Source Energy<br>3,358 MMBtu<br>Cost: $31,640 | Site Energy<br>427,000 kWh; 89 kW<br>Source Energy<br>4,239 MMBtu<br>Cost: $66,950 | 0.47:1<br>(site)<br>1.26:1 (source) | 2.1:1 |
| **Boston, MA** | Site Energy<br>3,238 MMBtu<br>Source Energy<br>3,552 MMBtu<br>Cost: $36,140 | Site Energy<br>420,000 kWh; 87 kW<br>Source Energy<br>4,383 MMBtu<br>Cost: $80,300 | 0.44:1<br>(site)<br>1.23:1 (source) | 2.2:1 |

Note: Source emission factor of 2.91 for NY electricity, 3.06 for MA electricity, 1.088 for natural gas (Source: GTI)

The Northeast market may see further absolute and relative improvement in natural gas prices and electric/gas price ratios due to the substantial new natural gas supplies being developed in the Marcellus Shale region in Pennsylvania, New York. **The combined impact of expanding supplies coupled with market proximity (i.e., reduced transmission costs) is likely to further enhance the competitive position of natural gas in this market sector**.

As noted, there can be substantial differences between natural gas and electricity from an environmental perspective depending on whether you compare site or source (total) emissions. This is a relevant factor to highlight with respect to consumer awareness of energy, environmental, and sustainability concerns. Surveys indicate that consumers perceive electricity as being “more green” than natural gas (Figure 6) – even though natural gas emits lower greenhouse gases than electricity on a total energy basis.

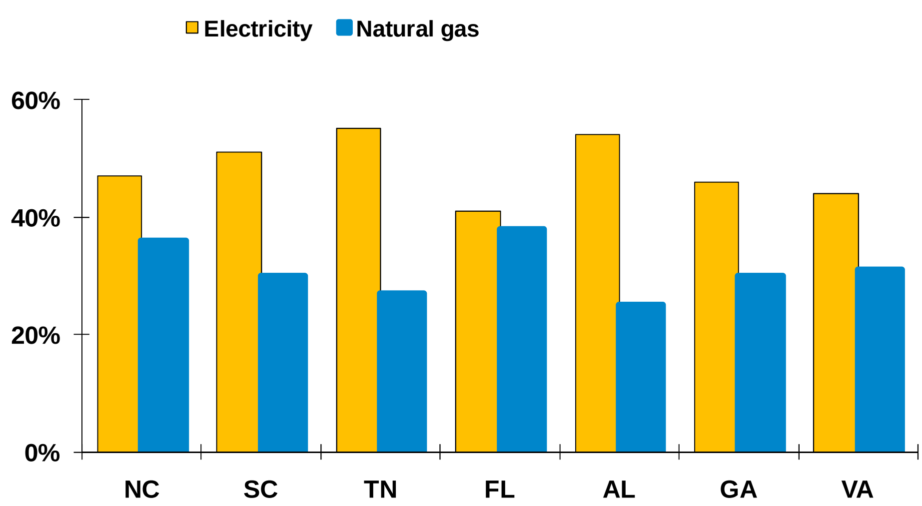



**Figure 6: Consumer Perceptions of Environmental Friendliness**

(Source: Council for Responsible Energy, 2007 data)

The natural gas industry is striving to elevate the source-to-site (or full fuel cycle) energy and environmental benefits of natural gas compared to electricity. Conveying this message to various stakeholders – individual consumers, businesses, and policymakers – is important. Decision makers in the commercial foodservice industry can also include architects, consulting engineers, and others – particularly those who are positioned in areas associated with "green buildings" (e.g., LEED-certified personnel).

There are market factors – opportunities and threats in the competitive marketplace -- that can influence the relative strengths and weaknesses of natural gas and electric now and in the future. The following is a summary of some of these factors that may impact natural gas and electric products and the customer's willingness to continue using or when purchasing new commercial food service products.

**Table 13: Natural Gas and Electric Opportunities and Threats**

| | Opportunities | Threats |
|---|---|---|
| Natural Gas | • Developing state-of the-art natural gas products (e.g., pilotless ignition, new sensors and controls,<br>• Smart technology that enhances control and communications<br>• Features that increase productivity, product quality<br>• Expanding the number of products recognized as Energy Star compliant<br>• Utility marketing, outreach and incentive programs (e.g., test kitchens, live cooking demonstrations, incentives for high-efficiency products)<br>• Marketing outdoor cooking and outdoor seating with gas heating to restaurants<br>• Potential improved positioning of natural gas prices relative to electricity<br>• Enhancing customer and policymaker awareness of source energy and environmental benefits | • Lower number of Energy Star appliances compared to electric<br>• Reduced opportunity for customers to benefit from energy efficiency incentives (and potential switching to electric)<br>• Larger and/or more aggressive electric utility marketing and incentive programs (7-10:1 greater energy efficiency funding)<br>• Reduced level of skill and expertise among small to medium manufacturers – particularly with respect to natural gas technology<br>• Tightening emission standards (e.g., NOx, particulates)<br>• Higher cost and complexity of ventilation and interior piping systems<br>• Bias in certain Green Building Codes towards site energy and "clean" electric |
| Electric | • Rethermalizing and similar trends that could reduce kitchen energy intensity and potentially favor all-electric kitchens<br>• Advanced cooking techniques such as induction cooking<br>• Smart technology that enhances controls and communications Leveraging green building codes that favor site energy | • Increasing electricity prices due to increasing cost of new power plants and added environmental costs to reduce carbon emissions<br>• Concerns over peak electric demand and electricity supply reliability<br>• Use of source energy in place of site energy for green building codes and energy efficiency metrics |

## Energy Efficiency Programs and Energy Star

Energy efficiency and sustainability are key concepts that resonate with restaurant and food service operators. Their tight operating margins provide an incentive to reduce fixed and variable energy costs. The following table from the NRA 2010 Restaurant Industry Forecast outlines steps taken in 2009 and plans for 2010 relative to energy savings and other resource conservation investments. These data indicate a higher inclination towards electricity savings steps (e.g., lights, air conditioning, refrigeration) followed by investments in energy-saving kitchen equipment. Water savings are generally lower priority resource conservation steps.

**Table 14: NRA Sustainability Survey – Planned Actions**

**Sustainability steps**

*Proportion of restaurant operators, by type of operation, who took the following energy-saving actions in 2009 or who plan to in 2010*

| | Family dining | | Casual dining | | Fine dining | | Quickservice | |
|---|---|---|---|---|---|---|---|---|
| | Did in 2009 | Plan to in 2010 | Did in 2009 | Plan to in 2010 | Did in 2009 | Plan to in 2010 | Did in 2009 | Plan to in 2010 |
| Purchased energy-saving light fixtures | 69% | 41% | 66% | 46% | 52% | 38% | 43% | 32% |
| Purchased energy-saving kitchen equipment | 45% | 34% | 41% | 34% | 28% | 32% | 34% | 31% |
| Purchased energy-saving refrigeration, air conditioning or heating systems | 50% | 32% | 40% | 28% | 34% | 27% | 32% | 30% |
| Installed water-saving equipment and/or fixtures | 27% | 26% | 27% | 23% | 27% | 24% | 23% | 23% |

The somewhat greater leaning toward electric savings may reflect the reality that annual electricity costs are likely to be twice as high as natural gas costs – that is, electricity provides greater opportunity for savings.

Other factors to consider are:

- The availability of Energy Star and other high-efficiency equipment
- The availability of rebates, tax credits, and other incentives that may enhance the buying decision process for the consumer

For example, electric and natural gas energy efficiency programs have grown considerably in recent years. These programs can provide meaningful incentives for the purchase of new high-efficiency equipment. Historically, this funding has primarily been directed at electricity consumers, with a more recent trend of funding for natural gas.

According to the Consortium for Energy Efficiency, in 2009 approximately $4.4 billion million was invested in electric energy efficiency and $930 million in natural gas energy efficiency programs across the US. The following table breaks down state-level natural gas and electric energy efficiency program funds (including demand response) directed at the commercial and industrial sector in 2009 by CEE.

**Table 15: Energy Efficiency Funding Comparison (Source: CEE, 2009 data)**

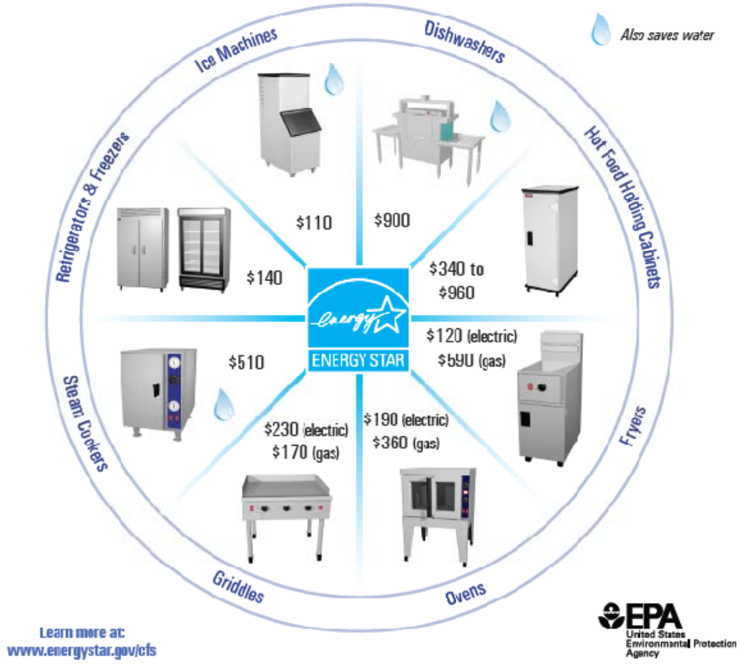
| | Natural Gas | Electric | Electric/Gas Ratio |
|---|---|---|---|
| **U.S. Total** | $930.0 million | $4,400.0 million | 4.7:1 |
| **New York** | $42.9 million | $393.2 million | **9.2:1** |
| **Massachusetts** | $32.5 million | $176.1 million | **5.4:1** |
| **New Hampshire** | $3.0 million | $16.3 million | 5.4:1 |
| **Rhode Island** | $7.6 million | $30.7 million | 4.0:1 |

Substantially greater funds are potentially available to commercial food service establishments for electric energy efficiency incentives and rebates compared to natural gas (by a factor of 4-9:1). Notably, the energy efficiency funding ratio is considerably higher than the national average in New York – that is, greater funds are available to incentivize the purchase of high-efficiency electric equipment. This underscores the potential threat to the natural gas industry of consumers switching to electric technologies based on the incentives provided by energy efficiency program funding.

A complementary issue is the availability of products that can qualify for energy efficiency funding. Energy Star is an international standard for energy efficient consumer products. It was first created as a United States government program by the Clinton Administration in 1992, but Australia, Canada, Japan, New Zealand, Taiwan and the European Union have also adopted the program. Devices carrying the Energy Star logo, such as computer products and peripherals, kitchen appliances, buildings and other products, generally use 20%–30% less energy than required by federal standards. There is considerable online information that can be found at www.energystar.gov – including product availability and other helpful information from consumers.

Initiated as a voluntary labeling program designed to identify and promote energy efficient products, Energy Star began with labels for computer products. In 1995 the program was significantly expanded, introducing labels for residential heating and cooling systems and new homes. As of 2006, more than 40,000 Energy Star products are available in a wide range of items including major appliances, office equipment, lighting, home electronics, and more. In addition, the label can also be found on new homes and commercial and industrial buildings. In 2006, about 12 percent of new housing in the United States was labeled Energy Star. The EPA estimates that it saved about $14 billion in energy costs in 2006 alone. The Energy Star program has helped spread the use of LED traffic lights, efficient fluorescent lighting, power management systems for office equipment, and low standby energy use.

There are eight types of commercial food service (CFS) appliances that can earn EPA's Energy Star. Qualified equipment models use less energy and less water than conventional CFS models. The following images from www.energystar.gov/cfs shows the potential annual savings of using Energy Star qualified compared to conventional appliances.




Energy Star appliances require sufficient information and usage data to determine the baseline energy consumption – a necessary pre-condition to establish an Energy Star performance level. There are limited categories for Energy Star products suitable to the commercial foodservice sector because the data either does not exist or has not been compiled into a useful set to establish Energy Star guidelines.

Current drivers within the foodservice industry are pushing the need to establish new categories of Energy Star appliances. Because of increasing energy and water utility costs and interest in being more sustainable, operators in the commercial foodservice industry are expressing increased interest in appliances and systems that are more energy efficient to replace older, less efficient units. Recent market surveys conducted by both GTI and the National Restaurant Association have shown a greater interest on the part of operators to invest in energy-efficient equipment. GTI surveys have shown that consumers within the past two years are more willing to spend extra on the first cost of new appliances if the units are significantly more efficient or Energy Star rated. Manufacturers also have expressed to GTI that concerns over energy efficiency and the environment have become major drivers in the foodservice industry compared to two years ago.

There is an ongoing challenge facing the natural gas industry to ensure there is a broad array of Energy Star-approved natural gas appliances available. Many utility energy efficiency programs use Energy Star as a product qualifying step for energy efficiency funds. Unfortunately, due to a variety of factors, there are numerous product categories in the commercial food service sector where there are no Energy Star-approved products available – either because the products do not exist or because there are no approved standards for that product category. Table 16 lists the current Consortium for Energy Efficiency "qualifying product" list. Only two categories tie with natural gas equipment – fryers and steamers; all product categories tie into electricity use. The lack of approved energy efficient product standards can stymie or inhibit:

- The development of new, high-efficiency equipment by manufacturers
- The ability of natural gas energy efficiency to incentivize the purchase of new high-efficiency natural gas equipment

**Table 16: CEE Qualifying Commercial Foodservice Products (2010)**

| | | |
|---|---|---|
| Dishwashers | **Fryers** | Ice machines |
| Hot food holding cabinets | **Steamers** | Refrigerators & freezers |
| Pre-rinse sprayers | | |

Table 17 outlines the major commercial food service products with GTI-developed rating criteria on Energy Star status. In nine equipment categories there is an impediment due to the lack of any current standard or standard development process underway. In three categories, a standard is in development. In total, twelve of the nineteen equipment categories (63 percent) of commercial foodservice products are lacking in a qualified Energy Star standard.

**Table 17: Energy Star Availability Ratings for Commercial Food Service Equipment**

| Equipment Category | Energy Star Status* |
|---|---|
| Underfired Broilers/Charbroilers | 1 |
| Pizza / Deck Ovens | 2 |
| Wok Ranges | 1 |
| Steamers - Pressure | 4 |
| Ranges | 1 |
| Conveyor Broilers | 1 |
| Conventional Ovens | 1 |
| Conveyer Ovens | 2 |
| Rotisserie Ovens | 1 |
| Griddles | 4 |
| Pressure Fryers | 1 |
| Fryers | 5 |
| Over-fired Broilers | 1 |
| Convection Ovens | 4.5 |
| Steamers - Free-Standing | 4 |
| Tilting Skillets | 1 |
| Combi Ovens | 2 |
| Steamers - Counter-Top | 3 |
| Warewashers | 3 |

* Energy Star Status Rating Key

5 = Standard Issued - Robust Qualified Gas Equipment
4 = Standard Issued - Some Qualified Gas Equipment
3 = Standard Issued - Electric Equipment Dominates
2 = Standard In Process
1 = No Standard

Taken together, these data on state-level energy efficiency programs, availability of industry recognized "qualified products" by CEE, and a substantial deficiency in Energy Star-approved standards and qualified equipment underscores the need for natural gas industry attention. Specifically:

- In selected Northeast states, such as New York and Massachusetts, there is a need to evaluate the relative availability of natural gas energy efficiency funds relative to those for electric in the commercial sector.
- A concerted natural gas industry effort is required to:
  - Substantially enhance the availability of Energy Star standards for various commercial food service equipment.
  - Expand efforts with CEE and other organizations to document and support an expanded list of energy efficiency commercial foodservice products.
  - Substantially expand the number of qualified Energy Star and CEE-recognized natural gas commercial food service products that are developed and available to consumers.

## Gas Industry RD&D and Commercialization

Based on these results, GTI sees the following as fertile areas in the foodservice industry for National Grid's territory:

Area 1. **Development of higher efficiency and Energy Star-compliant natural gas appliances, coupled with support of new energy efficiency standards and protocols**
Benefits: Energy savings, lower emissions and gas appliance positioning with the "green" and sustainability movement. Increased availability of "qualified products" for natural gas energy efficiency program incentives. Avoiding market erosion to electric equipment.

Area 2. **Improved space conditioning and ventilation in the work area for a healthier work environment**
Benefits: Improved workplace comfort, lower employee turnover, and energy cost savings.

Area 3. **Development and marketing of equipment that is easier to operate and maintain**
Benefits: Improved productivity, improved product quality, and lower energy costs for restaurant and commercial foodservice operators. Avoiding market erosion to electric equipment.

Area 4. **Expanded marketing and outreach programs: Test Kitchens and Live Cooking Demonstrations, increased use of rebates and incentives for natural gas energy efficient products**
Benefits: Greater customer and trade ally recognition of the availability and benefits of new natural gas products.

When assessing the needs, opportunities, and threats within the commercial food service sector, it is important to explore the spectrum of the product development and commercialization stages.

Figure 7 outlines an example of the steps required in the product development and commercialization process.

### Natural gas R&D

The natural gas industry has two primary collaborative R&D programs – the GTI Sustaining Membership Program (SMP) and Utilization Technology Development (UTD, an independent industry-driven non-profit RD&D organization). These organizations primarily span RD&D activities up to Stage 6, demonstration and deployment.

Leading towards commercialization, the roles of SMP and UTD are complemented by the Energy Solutions Center (ESC) as well as an expanding number of natural gas energy efficiency programs that support Stage 6, 7 and 8 efforts through marketing programs and outreach as well as incentives that help support new technology acceptance in the market. A part of the ESC includes the Gas Food Equipment Network, or GFEN. Utility energy efficiency programs also have a national organization called the Consortium for Energy Efficiency (CEE).

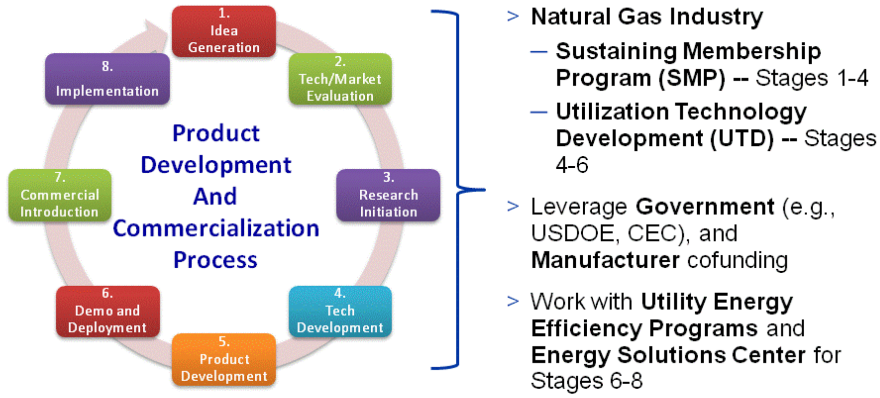



**Figure 7: Product Development and Commercialization Process**

For the reasons outlined in this report – notably, the energy intensity of commercial foodservice operations – GTI and UTD natural gas industry partners have maintained a focused concentration on product development for commercial foodservice customers. The research, development, and demonstration (RD&D) efforts of UTD has led to several successful commercial foodservice products (Table 18).

**Table 18: Example UTD-Supported Commercial Foodservice Products**

| | | |
|---|---|---|
|  | **Low-Oil-Volume Fryers**<br>A new commercial foodservice low-oil-volume fryer unit, marketed by Frymaster as Protector® fryers, increases energy efficiency while also extending cooking oil quality and life to provide significant customer savings. | **Contact: Linda Brugler**<br>Frymaster<br>318-866-2488<br>lbrugler@frymaster.com<br>www.frymaster.com |
|  | **Stellar Countertop Steamer**<br>This compact gas-fired countertop steamer for commercial food service offers enhanced cooking rates while providing users with added savings of energy and water consumption. The unit is the first gas-fired boilerless steamer with an ENERGY STAR rating. | **Contact: Market Forge Industries/Stellar Steam**<br>617-387-4100<br>866-698-3188<br>custserv@mfii.com<br>www.mfii.com<br>www.stellarsteam.com |
|  | **Avantec Combi-Oven**<br>The combination oven uses a patented technology for improving cooking performance, quality, and efficiency. Able to operate in various cooking modes, the oven provides enhanced uniformity when compared to similar-sized ovens. | **Contact: Dave Goble**<br>Avantec Food Service Equipment<br>800-322-4374<br>dave@twomarket.com<br>www.avantecequipment.com |

The UTD Foodservice Working Group is composed of representatives from UTD member gas utilities with expertise in the foodservice arena. The group holds regular conference calls to discuss issues and potential solutions for the foodservice industry and how the utilities can participate in this process. The development and maintenance of quality foodservice equipment is important to both the gas industry and the foodservice manufacturers.

During the past few meetings, several issues have been brought to the group for discussion. The biggest topic has been the need for more efficient gas-fired appliances to be introduced to the market. Specifically, utilities are looking for an expanded list of Energy Star eligible appliances that would qualify for rebates from the utilities. This expansion includes both increasing the number of efficient appliances in existing Energy Star categories and expanding the number of Energy Star categories to include more appliance types. Specific appliances discussed for investigation of improved energy efficiency include: convection ovens, conveyor ovens, and ranges. Specific energy efficiency issues for each appliance are discussed below:

- **Convection Ovens**
  Typical gas-fired full-sized convection ovens have heavy load efficiencies in the mid 30 percent range. The best gas-fired models that have been tested at the Foodservice Technology Center attain near 45 percent heavy load efficiency. The currently proposed standard for Energy Star rating will be 44 percent, meaning only a few models of existing convections ovens will receive an Energy Star Rating. Design elements that may contribute to the lower efficiency include: door gasket material, method of firing the burner (direct vs. indirect heating), construction seals and door design (split vs. one piece). There are an estimated 15,000 gas-fired convection ovens operating in National Grid Service territory, with an associated gas load of 9 million therms annually. Improving the stock efficiency of gas-fried convection has the potential to reduce the commercial gas load by 3 million therms per year. The associated carbon savings is 39 million pounds of $CO_2$ produced per year.
- **Conveyor Ovens**
  Over the past 30+ years, conveyor ovens have taken over the majority of baking pizzas in restaurants. Because of several factors in the design of conveyor ovens, the efficiencies tend to be low compared to other foodservice appliances, about 40 percent for large conveyor ovens and 20 percent for small ovens. A large majority of the larger ovens are gas; however, for the smaller ovens, there are more electric than gas models. More progress has been made to improve the efficiency of the larger ovens than the smaller ovens by improving stand-by losses in the ovens. However, other design issues tend to keep the efficiency of the smaller ovens lower than the large ovens. These include the open ends of the conveyor, cooking tunnel design/dimensions and air flow distribution. There are an estimated 3,000 gas-fired conveyor ovens operating in National Grid Service territory, with an associated gas load of 6.5 million therms annually. Improving the stock efficiency of gas-fried convection has the potential to reduce the commercial gas load by 2 million therms per year. The associated carbon savings is 26 million pounds of $CO_2$ produced per year.
- **Ranges**
  Commercial ranges are one of the most common appliances in the foodservice industry and 90

percent of ranges are gas fired, resulting in a significant gas load. Gas fired commercial ranges currently have very low efficiencies due to three main issues:

- Pilot lights – While most residential gas-fired ranges feature pilotless ignition, a very high percentage of commercial ranges have pilots. Some manufacturers have offered pilotless ignition, but the market has not embraced this feature.
- The ASTM water-boil efficiency is in the low 30 percent range.
- Some operators leave burners operating when there is no load in place on the burner.

Another issue is that there are new hood interlock rules from both the international mechanical code and the international fuel gas code that require gas to be shut off to cooking equipment when the kitchen hoods are not in operation. This forces the restaurant to either run a separate gas line for pilot operation or re-light their pilots every morning. The new hood interlock rules are forcing the industry to consider using ranges without pilots so they will not have to worry about relighting the pilot each morning. There are an estimated 21,000 gas-fired commercial range tops operating in the National Grid Service territory. These are broken into heavy-duty ranges, restaurant ranges and stock pot ranges. The estimated gas-load for the three subcategories of ranges is 20 million therms per year. Estimating 200 new ranges produced per year with 50 percent energy savings provides 1 hundred thousand therms of energy savings in the first full year of deployment alone.

The members also expressed interest in participating in the process of establishing Energy Star ratings and providing information to the customers on rebates and the advantages of using Energy Star appliances.

Another issue growing within the foodservice industry is the concept of “green” appliances and environmental benefits in term of carbon footprint of gas vs. electric. The group expressed the need to understand and define terms that apply to the “greenness” of an appliance and how information can be conveyed to the utilities and its customers.

The current RD&D process for commercial foodservice is reasonably robust, but could benefit from further investment. The following are R&D funded by UTD or SMP::

- Gas-fired wok
- Gas-fired rethermalizer
- Gas-fired conveyor oven
- Gas-fired convection oven
- Gas-fired commercial range
- Gas-fired warewasher

Beyond these readily identifiable products suited to the kitchen environment, there are several cross-cutting technology development initiatives that can benefit the commercial food service sector, such as:

- Early-stage cross-cutting technologies:

  - Advanced flat-panel radiant burner and controls (could be applied to various foodservice cooking devices)
  - Low $NO_x$ burners
- Hybrid tankless hot water technologies
- High-efficiency rooftop packaged gas heating units
- Desiccant-based dehumidification systems
- Commercial hybrid solar thermal/natural gas systems

One area of note is a UTD project that is addressing a growing trend in the foodservice industry: preparing certain food products in larger quantities at a centralized location and delivering those to restaurants for reconstituting or rethermalizing. The main driving factors for this are productivity and labor savings from centralized large-scale production, speedier in-restaurant preparation, and energy savings. Products like soups, gravies, vegetable side dishes and sauces have been shown to be prepared in this method and served in restaurants without any perceived sacrifice in flavor or texture. Data suggests that significant energy and labor savings can be realized by preparing these items in bulk.

## Commercialization

The Energy Solutions Center is a technology commercialization and market development organization representing energy utilities, municipal energy authorities, and equipment manufacturers and vendors. The mission of the Center is to accelerate the acceptance of and deployment of new energy-efficient, gas-fueled technologies that enhance the operations and productivity of commercial and industrial energy users, and improves comfort and reliability for residential energy users.

The ESC and its members identify, evaluate, and prioritize new market opportunities and then implement market development initiatives designed to move products from R&D success to broad market acceptance.

The Gas Foodservice Equipment Network (GFEN) is an international alliance of utilities, foodservice equipment manufacturers, gas industry associations and foodservice trade allies organized to be a source of gas solutions for the commercial foodservice segment. The objective of GFEN is to maintain and build natural gas load by ensuring that our commercial food service customers have an array of clean, efficient, cost-effective and high performance natural gas products from which to choose and are made aware of these products and their benefits.

There are a select number of utilities that have adopted targeted marketing efforts for the commercial foodservice sector using Test Kitchen facilities. This approach allows restaurant operators, cooks, equipment manufacturers and other stakeholders to test new products, learn about new energy efficient practices, and make side-by-side comparisons of competitive brands – including comparing natural gas and electric products.

Several utilities have invested in foodservice centers and test kitchens, including Southern California Gas, PG&E, Southwest Gas, Piedmont Natural Gas, Alabama Gas, and Centerpoint Energy, . Figure 8 shows a profile on Piedmont's test kitchen from a recent GFEN publication.

PIEDMONT NATURAL GAS
TECHNOLOGY CENTERS

Piedmont's Gas Technology Center in Charlotte has 6,000 square feet of space, two 10-foot sections of kitchen ventilation hood and five gas and electric connections. Both natural gas and electric cooking equipment can be compared in a real-world environment. A data acquisition system provides the capability to measure and calculate equipment performance, energy use and efficiency, and food production. In addition, there are large prep and cleanup areas with both condensing and high-efficiency commercial gas water heaters and a dishwasher with a gas booster heater.

When not used for equipment testing or demonstrations, the Centers have extensive audio/video capabilities and seating for 70 people which make them ideal for sales meetings, customer workshops, and ServSafe training sessions.

**Charlotte, NC · Spartanburg, SC**
**Sandra Minter · 704.731.4014**

**Figure 8: Piedmont Natural Gas Test Kitchen Profile (Source: GFEN, Spring 2009)**

The Consortium for Energy Efficiency (CEE), a nonprofit public benefits corporation, develops initiatives for its North American utility members to promote the manufacture and purchase of energy-efficient products and services. Their goal is to induce lasting structural and behavioral changes in the marketplace, resulting in the increased adoption of energy-efficient technologies. CEE members include utilities, statewide and regional market transformation administrators, environmental groups, research organizations and state energy offices in the U.S. and Canada. Also contributing to the collaborative process are CEE partners – manufacturers, retailers and government agencies. The U.S. Department of Energy and Environmental Protection Agency both provide support through active participation as well as funding.

# Commercial Foodservice Market Channels

## Commercial Foodservice Trade Associations

### National Restaurant Association

The National Restaurant Association represents more than 380,000 commercial food service businesses — from restaurants and suppliers to educators and non-profits. They produce annual reports and information products for their members as well as advocacy. They also network with a variety of state organizations, including:

**New York State Restaurant Association**
409 New Karner Rd
Albany, NY 12205-3883
Phone: (518) 452-4222
Web site: www.nysra.org

**Massachusetts Restaurant Association**
333 Turnpike Rd Ste 102
Southborough Technology Park
Southborough, MA 01772-1755
Phone: (508) 303-9905
Web site: www.marestaurantassoc.org

**New Hampshire Lodging & Restaurant Association**
PO Box 1175
Concord, NH 03302-1175
Phone: (603) 228-9585
Web site: www.nhlra.com

**Rhode Island Hospitality Association**
94 Sabra St
Cranston, RI 02910-1031
Phone: (401) 223-1120
Web site: www.rihospitality.org

The annual National Restaurant Association show is a venue to find the latest ideas, products and educational programs. Attendance can include over 75,000 industry professionals participating in over 60 free seminars.

The NRA also has period webinars to allow members to learn from industry experts and operators. This could be a possible communications channel for energy companies.

### The North American Association of Food Equipment Manufacturers (NAFEM)

NAFEM is a trade association of more than 625 foodservice equipment and supplier manufacturers that provide products for food preparation, cooking, storage and table service. NAFEM's biennial trade show attracts approximately 20,000 foodservice professionals and features more than 600 North American manufacturers.

## Foodservice Equipment Sales and Service Channels

Table 19 shows information from a USEPA document outlining supply channel actors for the commercial foodservice sector. This is a fairly typical multiple channel arrangement – with the added role of *design consultants* who would specialize in the commercial foodservice sector. This role is similar to that provided by architect and engineering firms, consulting engineers, etc.

**Table 19: Supply Channel Actors**

| |
|---|
| **Dealers:**<br>Dealers primarily sell to individual restaurants, which is often the most difficult market to reach. Smaller dealers may join buying groups so they can compete more effectively with larger dealers. Many dealers display their products in showrooms and tend to stock lower-priced, popular models that are usually not energy-efficient. A dealer's main objective is usually to sell the products they have on hand, and they are generally more interested in attracting customers with low prices rather than emphasizing the overall value of higher-end products (e.g., lifetime cost savings). Given that many manufacturers offer sales incentives to move lower-end models, dealer incentives can be an effective strategy to promote stocking and sales of energy-efficient equipment. |
| **Distributors:**<br>Distributors primarily supply bulk quantities of equipment to dealers and sell commodity equipment (e.g., ice machines, fryers) directly to end users. Since distributors usually supply dealers, developing a good working relationship with distributors helps funnel energy-efficient CFS products into dealer showrooms. In addition, some restaurant food distributors sell CFS equipment and should also receive program outreach. |
| **Manufacturers and Reps:**<br>CFS equipment manufacturers generally sell through product reps, although manufacturers may also sell directly to large end users such as national restaurant chains. Though all supply channels gravitate toward inexpensive, fast-moving pieces of equipment, a key value proposition for engaging reps is the up-sell potential of high-value, high-efficiency equipment. Sales of high-quality products earn reps a higher commission and generate long-term value for the customer, often leading to repeat business. |
| **Design Consultants:**<br>Design consultants assist in the planning and design of new or renovated commercial kitchens, typically working with large or chain-owned restaurants, hotels, universities, and hospitals. Conducting targeted outreach to design consultants helps to ensure that energy- and water-efficient CFS equipment is considered in these types of projects. Design consultants are typically focused on the overall design and aesthetics of the space and controlling project costs, and back-of-the-house equipment is often a low priority. In addition, they often have established relationships with buying groups and may receive incentives for selling lower-end equipment. Equipment quality and performance are key selling points for engaging design consultants. |

Source: USEPA Energy Star publication. Energy Star for Commercial Kitchens: Helping Customers Manage Costs, (June 30, 2009).

## Market Channel Participant Interviews

In order to gauge market conditions in National Grid's territory, GTI undertook targeted primary market research by talking to key market channel players in the Northeast commercial foodservice sector. An independent consultant was deployed to conduct phone interviews with foodservice consultants and dealers that operated in the National Grid Service territory.

### Phone Survey

GTI worked with Mr. Richard Topping of RFTopping Consultants to organize and conduct the telephone interviews. This encompassed two major Foodservice Consultant firms (Colburn & Guyette and Clevenger Foster LaVallee) and four foodservice equipment dealers/design houses (Kittredge, Trimark, Perkins and May Foodservice). As a practical matter, there are similarities between these two types of organizations but the consultants tend to work on bigger jobs and may be less brand-biased. The results of the interviews appear quite consistent across all six firms.

The most positive outcome from the survey is that participants felt that natural gas is firmly entrenched in the Northeast and that situation seems to be holding steady. No one sees any serious movement to electric equipment at this time.

The overall status of gas foodservice equipment in National Grid's service territory is good. Generally, responses show that gas provided good value and was a "green fuel." The relatively high electric rates in this area may be a contributor in this area. Several items that stood out as potential areas for improvement are highlighted below:

1. There were strong indications that neither the gas nor the electric utilities were involved in a significant role in the decision process for these marketers selling equipment. It is clear that all of the survey participants would welcome more utility involvement.
2. Venting of gas equipment was identified as an issue for five of the six companies.
3. Several of the respondents stated that electric appliances are perceived by some to generally be safer and more technologically advanced than gas-fired appliances.
4. All six responded that gas-fired booster water heaters face issues with being installed including venting, reliability, cost and efficiency.
5. According to three of surveyed sources, gas-fired warewashers face a disadvantage compared to electric because they require venting[1] (note: electric warewashers also require venting for the steam and steam hoods can also be used to vent flue products).
6. Three respondents expressed the need for pilotless ignition, especially on ranges, to address new hood interlock rules that require gas to be shut off to appliances when the kitchen hoods are not turned on. This forces the restaurant to either run a separate gas line for the pilots or re-light their pilots after each time the hoods are turned off.

Fuel cost is a major issue and natural gas has the advantage relative to electricity. Also, natural gas has a solid history and reputation. Electric is only preferred when deemed absolutely necessary, usually due to the lack of suitable gas service or ventilation issues (kiosks).

Interviewees were spread across the New York and Massachusetts areas. The detailed responses from the participants are included in tabular form in an appendix to this report.

The overall conclusion from this market survey effort is that, generally speaking, natural gas holds a good position in National Grid territory. Dealers and consultants feel that gas is the preferred fuel except when venting issues arise.

Several areas are candidates for some improvement if resources allow:

1. This issue arose when the dealers tried to support a gas booster heater program. The gas booster was not integral to the warewasher and required a separate vent. Since replacement sales are a significant component of the market for these appliances, venting is a big issue. GTI has been working with Jackson MSC to develop a warewasher with integral booster heater that vents through the body of the dish machine and should overcome the venting issue.

- Foodservice appliance manufacturers are relatively small in size and lack resources in engineering. They often need support in their gas designs, both for new product development and for troubleshooting existing designs.
- The surveyed dealer/consultant group did not receive information and support from the utilities that might help them promote gas equipment sales. This is probably a result of the loss of gas utility commercial marketing that has come about in the last few years.
- Energy efficiency and “greenness” are of extreme importance now. Appliances which can bear the Energy Star label are good sellers. At this time there are only a few appliance categories for foodservice where there is energy star. The community is working to expand this list over the next few years.

# Conclusions

The commercial and institutional food service sector represents an important – **and growing** -- market for the natural gas industry. According to the National Restaurant Association (NRA), there are approximately 525,000 commercial food service establishments nationwide with annual sales of $580 billion.

State-level characteristics on four key states – New York, Massachusetts, Rhode Island, and New Hampshire – indicate a market size of 56,900 commercial foodservice locations with annual sales in excess of $43 billion. Using a nominal value of 3.4 percent of sales, annual utility costs (electricity, natural gas, water, etc) exceeds $1.4 billion in these four states (and approaches $20 billion nationally).

According to Energy Information Agency (EIA) survey data, commercial foodservice customers have 2.2 times the energy intensity (Btu/ft$^2$) of the average commercial customer. Audits conducted by Southern California Gas and Piedmont Gas found that natural gas sales to commercial foodservice customers account for 12 percent of the volume of gas sold, but comprised a healthy 19 percent of their profits.

In terms of new equipment, the estimated annual sales of new commercial foodservice equipment totaled about $1.2 billion in 2006. Of this, about 69 percent was natural gas-based products – indicating a strong market position for natural gas relative to electricity. The report provides further analysis of sales by product category and, an important consideration, the availability of Energy Star-rated products.

While a significant and growing market, there are continual threats and opportunities to assess within the commercial food service market segment, including:

- Natural gas market share is currently strong and holding against electric market share. New electric products; perceptions of electric as clean, simple, and reliable; and growing electric energy efficiency programs represent potential threats. There is also a market perception that electric equipment is more advanced or higher end than gas equipment.
- Natural gas is perceived as more cost-effective by users, with current electric-to-natural gas price ratios of 4.5:1 or higher. A typical restaurant is paying over twice as much annually for electricity than natural gas – underscoring the perception of natural gas as being cost effective.
- Rising labor, food, and energy costs are motivating foodservice providers to seek new and innovative equipment designs that could save operating costs through productivity improvements and speedier delivery.
- **Labor issues are a dominanting factor in this sector** – the major issues are obtaining and retaining quality workers, labor costs, and productivity. Increased labor turnover motivates foodservice providers to seek methods or equipment to improve the working environment for employees in terms of comfort, ease of equipment usage, and cleaning.
- Key purchase factors for new equipment include price, efficiency (operating costs), after-sales support, and productivity improvement. Equipment obsolescence and deterioration is typically the main reason to buy new equipment. One of the problems with old gas equipment is that is lasts for many years and restaurants do not tend to replace equipment until is total breaks down

instead of updating to new equipment. Getting information to users about the cost and energy saving associated with new equipment is lacking.

- Trends toward healthier and/or more environmentally responsible eating habits can influence the market, but the economic benefits/effects are not fully understood by the industry.
- The industry is concerned about lower emissions standards (including $NO_x$ and particulates) – especially where such requirements have been imposed on residential appliances.
- The green movement is a threat to natural gas. Consumer surveys show that electric is perceived as being more green, possibly due to the site-based efficiency claims. There is an opportunity to position the new gas equipment as green through consumer education - identifying the financial and environmental benefits.

## References

Czachorski, M. and Leslie, N., "Source Energy and Emission Factors for Building Energy Consumption," Gas Technology Institute for American Gas Foundation, Nov. 2009.

Energy Information Agency, "2003 Commercial Buildings Energy Consumption Survey," www.eia.doe.gov.

Environmental Protection Agency, Energy Star www.energystar.gov.

Frable, F., "Rethermalize it," Nation's Restaurant News, Oct. 8, 2007.

Fryett, D.K., "So, What's Going On Out There In The Food Service Industry That We Need To Know About," Final Report, Gas Food Equipment Network (2008).

Gas Food Equipment Network, "Cooking Up Greener Solutions, Spring 2009 Newsletter.

Melink, S., "Kitchen Hoods Using Demand Ventilation," ASHRAE Journal, Dec. 2003.

National Restaurant Association, "2010 Restaurant Industry Forecast," (2010).

National Restaurant Association and Deloitte, "Restaurant Industry Operations Report (2006/2007 Edition).

Nevius, M., Eldridge, R., and Krouk, J., "The State of the Efficiency Program Industry Budgets, Expenditures, and Impacts 2009," Consortium for Energy Efficiency, March 5, 2010.

USEPA, "Energy Star for Commercial Kitchens: Helping Customers Manage Costs," Energy Star publication (June 30, 2009).

van Straten, G. and Brown, S., "Keeping Cooks in the Kitchen: Solving the Makeup Air Dilemma," ASHRAE Journal, June 2003.

## Appendix A: Market Survey Results

| Key Issues | Issue / Question | Colburn & Guyette response | Clevenger Foster LaVallee response | Trimark response | Kittredge response | Perkins response | May Food Service response |
|---|---|---|---|---|---|---|---|
| | **What type of business is this?** | Colleges, healthcare facilities, institutions. C&G do not design many restaurants; dealers have a foothold and do designs for free to sell equipment. | CFL does big commercial and institutional jobs; also does more chain and restaurant work than typical consultants. | Largest dealer in US; also Trimark conducts engineering for restaurants and hotels. | Full service dealer of commercial kitchen equipment including engineering and sales | Dealer and design firm for restaurants, health care, institutions, etc. | Equipment distributor and design firm for food & beverage operations, institutions, etc. |
| | **What product lines do they have (we only care about cooking and warewashing equipment)?** | C&G does the research and specs equipment for clients by brand and model. They use gas wherever possible (high market share). Gas is more efficient and quicker (higher food output) | N/A | Large selection of equipment and brands | Offer products of most major manufacturers | Perkins specs equipment for their clients. | Full line of commercial foodservice equipment |
| | **Profile sales of gas vs. electric equipment** | | | | | | |
| | What are the actual sales of gas equipment / Actual numbers | N/A | N/A | N/A | N/A | | |
| | Share of market/sales of gas vs. electric | Sees no change in share; still predominantly gas in their market. | Sees no significant change in market share between gas and electric | Predominantly gas in the Northeast | Gas is predominant. | | |
| | Is this share ratio changing, and if so, why? | No | No | No. Electric energy cost is high which limits sales of electric equipment. Also, most chefs prefer gas because of better control and higher output. | No | No change seen; equipment is almost always gas. | No change seen in market share |
| | **Why gas share is what it is** | | | | | | |
| | Who specs fuel type and what are the key criteria (availability, cost, ventilation, reliability, etc.) | C&G uses gas wherever possible. They use electric with recirculating ventilation systems by necessity in limited applications. | CFL specs equipment (make and model) in consultation with the owner. CFL gets information from trade shows, equipment reps, AutoQuotes, etc. Usually specifies gas whenever gas is available. In situations without venting, electric is used. | Trimark works with their clients to spec the optimum equipment; also sells equipment to projects where the design is done by A&E firms and Consultants. | Replacement equipment nearly always utilizes the same fuel; utility changeover is very expensive and a hassle for an operating facility. Gas is usually specified when available; viewed as cheaper. | Perkins specs gas almost exclusively. Small markets are developing for unique electric equipment such as induction cooktops. However, induction currently is offered only in one or two station countertop units, no induction ranges are currently sold in the US (some may be coming from Europe) | May does the site design and specs the equipment by fuel type, make, model, etc. Gas is used almost exclusively in the Northeast except for very limited applications of electric equipment. |
| | What are the respective roles of consultants, dealers, manufacturers, utilities, etc.? | Big jobs use consultants; usually brought in by the A&E firm responsible for the project. Some projects like nursing homes use dealers but this may be changing as well. | Consultants typically are brought in by architects and A&E firms on large jobs (80 – 90% of their business). Dealers tend to do restaurant work in return for the equipment business. However, CFL also markets to the chains and restaurants; they do more of this work than most consultants. | Trimark, because of its size, has test kitchens where customers can prepare their food products with different types of equipment to determine what is best for their needs. | Consultants are hired by A&E's and architects for big jobs. Project subcontractors may include Kittredge who bids on supplying suites of equipment. Restaurants use Kittredge and its showrooms to purchase equipment. Kittredge does engineering for restaurants and offers a rebate on purchased equipment | | Customers rely on May for recommendations on equipment. |
| ! | What is the level of participation of utilities, gas and electric. Is one doing a better job? | Utilities (gas or electric) aren't really involved; would be helpful if they were. C&G gets its information from manufacturers and trade journals | Utilities (gas or electric) provide no assistance to CFL. They could use help, especially in the area of codes and standards. Codes are becoming more varied across the country and restrictive. CFL could use one consistent set of up-to-date data. One specific problem area mentioned was requirements for flex connectors. | Rebates for Energy Star (currently up to $1000 for a fryer) help with the sale of high efficiency equipment. Bob believes the West Coast utilities still support the sale of gas with test kitchens and information; the East Coast utilities never did much and now do less. | GasNetworks does a good job of offering and advertising rebates in New England. The electric utilities have been much slower to offer rebates. However, it is like "pulling teeth" to get any assistance from utilities. | Utilities currently are providing $1000 rebates for high efficiency fryers. | Utilities really are no help at all. May is very disappointed that utilities are not more active in providing assistance and information on programs such as rebates. |
| | Is the current energy situation affecting share? | No | No. The fuel choice decision is based on the availability of gas; not energy cost. | No, electric cost is still higher than gas. | People are forgetting about energy and worrying about the economy | No, fuel cost drives the business and gas remains cheaper than electricity. | No |
| | Is the current world economic crisis impacting sales? | Not yet, but it appears there is a slowdown coming on new construction. | Yes, the current recession is slowing building projects. | Absolutely, the chains are experiencing a significant downturn. Franchisees cannot secure financing. | Yes | Across the board. | Yes, definitely. |
| | What is perception of gas equipment (vs. electric) / Cost | Electric equipment is higher cost | Gas equipment is more expensive in some equipment categories; less expensive in others. | Gas equipment is perceived as less costly, although in reality it is not always so. Electronics have added cost. | Gas is viewed as less expensive. | Gas | Gas equipment costs less. |

| Key Issues | Issue / Question | Colburn & Guyette response | Clevenger Foster LaVallee response | Trimark response | Kittredge response | Perkins response | May Food Service response |
|---|---|---|---|---|---|---|---|
| | What is perception of gas equipment (vs. electric) / Reliability | On par with the newer products; electric used to be less reliable | Better in some categories (ranges) and worse in others (kettles, combi-ovens and braising pans). However, the gas equipment manufacturers have done a good job improving equipment reliability | Even | Gas viewed as more reliable | Gas | Gas equipment is more reliable. |
| | What is perception of gas equipment (vs. electric) / Cook Quality | Gas is better | Depends on the application; electric braising was better but gas has improved. Some chefs prefer electric in specialized applications (griddle range and induction) so there is some small penetration of dual fuel kitchens | Gas is better | Gas is viewed as better overall. Some segments, such as bakers, prefer electric deck and convection ovens for better baked product quality. | Gas | Gas is better. |
| | What is perception of gas equipment (vs. electric) / Efficiency | Gas is higher | No perceived difference. | Gasis viewed as higher but because of energy cost. | Dan believes electric products are more efficient at getting the energy to the food but admits most of his customers only are concerned with energy cost which is lower for gas. | Gas | Gas is more efficient. |
| | What is perception of gas equipment (vs. electric) / Output | Gas is better | Same or greater for gas. | Even | Gas is better | Gas | Gas is higher |
| ! | What is perception of gas equipment (vs. electric) / Other issues including Venting | Electric is used if ventless systems are required | Venting is a major issue. For example, it prevents the use of gas booster heaters for warewashing in many applications. Without adequate venting, electric equipment is specified to prevent any potential problems. | Gas requires more ventilation and this is an issue. To expand, some facilities will add electric equipment to the current suite of gas products to eliminate the need to add more hood space. | Venting is a growing issue for all types and applications. Code officials and fire inspectors are requiring similar venting regardless of fuel type. Hoods are expensive. Even table top cooktops (bottled gas or induction) now need ventilation. Electric ignition is required in Massachusetts (though subject to fire inspector interpretation) | There is virtually no call for electric equipment other than small products (toasters) and induction cooktops which is desired by some sophisticated chefs. | Ventilation is not really an issue for the vast majority of applications since cooking requires venting regardless of fuel type. |
| ! | For costumers that prefer electric, why? | Can avoid ventilation cost. Also, certain applications use specialized cooking equipment (induction). New microwave/convection ovens are ventless and cook well; they fill a niche. | Regulations, safety (important in schools), desire for induction. Electric speed ovens (TurboChef) are impinging on gas in settings such as Dunkin Donuts for sandwich preparation. 20 years ago, a gas grill and hood would have been used. Codes and regulations could accelerate this trend – a potential dark cloud for gas. | Electric technology has improved more than gas lately. Speed-cook ovens and induction ranges are impressive and have potential to grow electric market share. | See above; also some churches like electric because of safety. | Applications where gas is not available or ventilation may be an issue. | Kiosk applications may require electric equipment where venting is an issue. |
| | Is there a significant trend in fuel choice by segment? | No | No. | No | No | No | No |
| | Who do users rely on for information before buying equipment | In this segment, on the consultants who rely on manufacturers and trade journals | Consultants and dealers. | Dealers and manufacturers reps. Reps have taken up the slack from utilities and now are much more sophisticated with test kitchens, data, etc. | N/A | | Dealers and designers. Some operators rely on this advice and really do not get involved. Others, like chains, are very much involved in the purchase decision. |
| | **What can be done to grow gas share** | | | | | | |
| | What would cause the decision of gas vs. electric to change in the future | N/A | See above. | N/A | If users start to accept (believe) the efficiency benefit of electric and the fact that electric equipment can be cheaper to operate in some circumstances. | | Large increase in gas cost. |

| Key Issues | Issue / Question | Colburn & Guyette response | Clevenger Foster LaVallee response | Trimark response | Kittredge response | Perkins response | May Food Service response |
|---|---|---|---|---|---|---|---|
| ! | What can manufacturers/utilities do to influence that decision | N/A | Utilities or a national association (AGA, GTI, etc.) could help by providing a national data base on codes and regulations. Foster mentioned a particular problem in New York City where ConEd, the gas supplier, has decided to maintain low pressure service in high rise buildings. This requires a $50K compressor system for food service applications costing $100K, not a cost effective solution. Therefore, electric is being used. Also, the new electronic controls monitor gas pressure and shut the equipment down if the pressure drops below specs. Older equipment used to keep operating at lower output. | N/A | N/A | | |
| ! | Are there opportunities for gas in steamers and warewashing equipment? | C&G uses steamer and kettle combinations that utilize gas-fired boilers. Countertop steamers are electric and have the advantage or being more portable. C&G never specs gas for warewashing equipment; gas-fired boosters are hard to get approved. This is a growth opportunity for gas. | CFL sees an opportunity for large steam generators that can function under a hood and provide steam to several appliances (kettles, booster heater, etc.). Currently, plant steam is used but there is a trend to decentralize steam plants in buildings such as hospitals. Gas booster heaters aren't being widely used because they are hard to vent and restricted by codes. | There are problems with gas boilers in the Northeast because of high iron content in the water. Gas booster heaters for warewashing really are not popular because of the need for venting and the perception that electric is easier to locate, cheaper, and more reliable. | Ventilation and cost restricts the use of gas boosters for warewashing. Dan didn't see any promising additional opportunities for gas boosters or steam generators. | There is an opportunity for gas booster heaters if they can be made more reliable and venting can be more easily accomplished. Electric boosters require very heavy electric service (80 - 100 Amp, 3 Phase). | There are opportunities for booster heaters if gas equipment becomes more reliable, less expensive and more efficient. |
| | Is the Green movement good or bad for gas? | There is a perception that gas is greener. | Good for gas. | Not sure. | Good for gas; as a result, gas companies are aggressively marketing rebates | Not fuel specific; more the desire for higher efficiency. | Don't know. |
| ! | What design improvements are needed for gas equipment (Efficiency, Cleanability, Performance, Price, etc.) | There is a need for electronic ignition in all gas equipment. The new ventilation systems turn off the gas supply when they are shut down. Electronic ignition is now required in some areas (Massachusetts) | The gas industry has done a good job overall with equipment. An additional needed design improvement is auto-shutdown for gas ranges. Currently ranges in many applications are turned on and left on. Also see above suggestion on steam generators | N/A | N/A | Pilotless ignition is being required by some codes. Electronic ignition systems have never been reliable in gas food service equipment; need improvement. | None come to mind. |

## Appendix B: National Restaurant Association Data Sheets

NATIONAL RESTAURANT ASSOCIATION®

2010 Restaurant Industry

# Pocket Factbook

2010 Industry Sales Projection **$580 billion**

| | 2010 Sales (billion $) |
|---|---|
| Commercial | $ 530.4 |
| Eating places | 388.5 |
| Bars and taverns | 18.8 |
| Managed services | 40.9 |
| Lodging place restaurants | 26.9 |
| Retail, vending, recreation, mobile | 55.2 |
| Other | $ 49.7 |

## Restaurants
### An Essential Part of Daily Life

- Restaurants will provide more than 70 billion meal and snack occasions in 2010.
- On a typical day in America in 2010, more than 130 million people will be foodservice patrons.
- 44% of adults say restaurants are an essential part of their lifestyles.
- 65% of adults say their favorite restaurant foods provide flavor and taste sensations that can't easily be duplicated in their home kitchens.

## Restaurants
### Small Businesses with a Large Impact on our Nation's Economy

- Restaurant-industry sales are forecast to advance 2.5% in 2010 and equal 4% of the U.S. gross domestic product.
- The overall economic impact of the restaurant industry is expected to exceed $1.5 trillion in 2010.
- Every dollar spent by consumers in restaurants generates an additional $2.05 spent in the nation's economy.
- Each additional dollar spent in restaurants generates an additional $0.82 in household earnings throughout the economy.
- Every additional $1 million in restaurant sales generates 34 jobs for the economy.
- Eating-and-drinking places are mostly small businesses. Ninety-one percent have fewer than 50 employees.
- More than seven of 10 eating- and drinking-place establishments are single-unit operations.
- Average unit sales in 2007 were $866,000 at fullservice restaurants and $717,000 at quickservice restaurants.

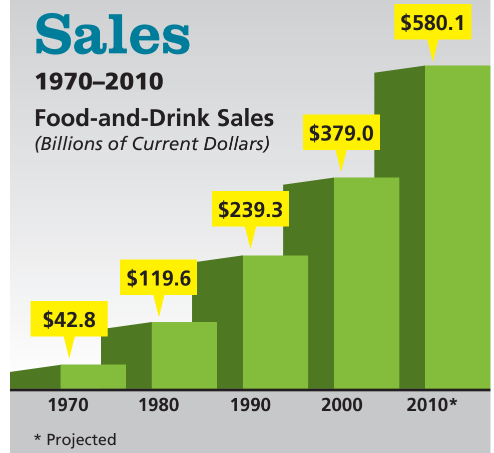
## Restaurants
### Cornerstone of Career Opportunities

- The restaurant industry employs about 12.7 million people, or 9% of the U.S. workforce.
- The restaurant industry is expected to add 1.3 million jobs over the next decade, with employment reaching 14 million by 2020.
- Nearly half of all adults have worked in the restaurant industry at some point in their lives, and more than one in four adults got their first job experience in a restaurant.
- Eating-and-drinking places are extremely labor-intensive — sales per full-time-equivalent non-supervisory employee were $75,826 in 2008. That's much lower than most other industries.
- One-quarter of eating- and drinking-place firms are owned by women, 15% by Asians, 8% by Hispanics and 4% by African-Americans.
- Eating-and-drinking places employ more minority managers than any other industry.
- The number of foodservice managers is projected to increase 8% from 2010 to 2020.
- Fifty-eight percent of first-line supervisors/managers of food preparation and service workers in 2008 were women, 14% were of Hispanic origin and 14% were African-American.

## Restaurant Industry Share of the Food Dollar


## Total Restaurant Industry Employment


## Restaurant Sales
### 1970–2010
Food-and-Drink Sales
*(Billions of Current Dollars)*




## Restaurants by the Numbers

- **$1.6 billion** Restaurant-industry sales on a typical day in 2010.
- **40** Percent of adults who agree that purchasing meals from restaurants and take-out and delivery places makes them more productive in their day-to-day life.
- **73** Percent of adults who say they try to eat healthier now at restaurants than they did two years ago.
- **57** Percent of adults who say they are likely to make a restaurant choice based on how much a restaurant supports charitable activities and the local community.
- **78** Percent of adults who say they would like to receive restaurant gift cards or certificates on gift occasions.
- **59** Percent of adults who say there are more restaurants they enjoy going to now than there were two years ago.
- **52** Percent of adults who say they would be more likely to patronize a restaurant if it offered a customer loyalty and reward program.
- **$2,698** Average household expenditure for food away from home in 2008.
- **29** Percent of adults who say purchasing take-out food is essential to the way they live.
- **54** Percent of adults who say they would be likely to use an option of delivery directly to their home or office if offered by a fullservice restaurant.
- **78** Percent of adults who agree that going out to a restaurant with family or friends gives them an opportunity to socialize and is a better way to make use of their leisure time than cooking and cleaning up.
- **63** Percent of adults who say the quality of restaurant meals is better than it was two years ago.
- **56** Percent of adults who say they are more likely to visit a restaurant that offers food grown or raised in an organic or environmentally friendly way.
- **70** Percent of adults who say they are more likely to visit a restaurant that offers locally produced food items.

1200 17th St. NW, Washington, DC 20036 | (202) 331-5900 | E-mail: askus@restaurant.org | www.restaurant.org

NATIONAL RESTAURANT ASSOCIATION® www.restaurant.org/research

# New York
## Restaurant Industry at a Glance

**New York's restaurants are an increasingly important part of the state's economy.** Restaurants are a key driver of employment in New York, and their sales generate tremendous tax revenues for the state.

The contribution of New York's restaurants extends far beyond the jobs they create, the careers they build and the revenues they generate. America's restaurants today are leaders in nutrition and healthy living, sustainability and social responsibility, and entrepreneurship and business opportunities.

For more information visit www.restaurant.org.

## New York Restaurants by the Numbers

### LOCATIONS

In 2007, there were **37,354** eating-and-drinking places in New York.

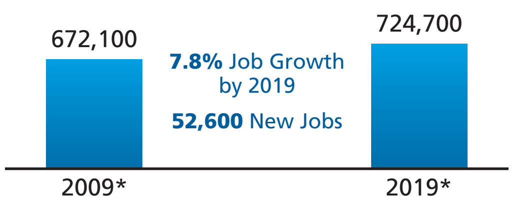
### STATE ECONOMY

Every $1 spent in New York's restaurants generates an additional **$.98 in sales** for New York's economy.

Each additional $1 million spent in New York's eating-and-drinking places generates an additional **23.4 jobs** in New York.

### JOBS

Restaurant and Foodservice **Employment**




Restaurant jobs represent **8 percent** of total employment in New York.

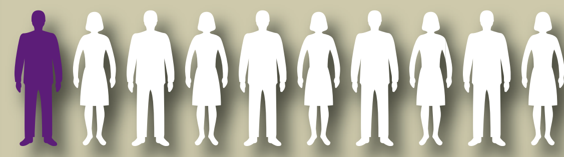
### SALES

In 2009, New York's restaurants will register **$27.8 billion** in sales.*

* projected

## America's Restaurants: By the Numbers

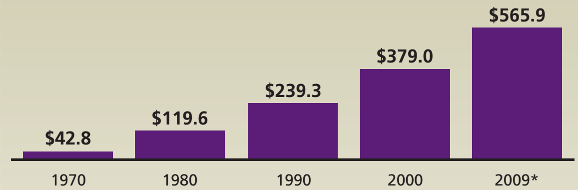
Almost **1 in 10** working Americans are restaurant employees



Restaurants' **share of the food dollar** is rising


Annual industry sales exceed a **half-trillion dollars**

*Restaurant-industry sales, in billions of current dollars*




* projected
**Source:** National Restaurant Association

## Did you know?

- **More than one out of four** American adults got their first job in a restaurant.
- **Nearly half of all Americans** have worked in a restaurant at some point in their working careers.
- America's eating-and-drinking places employ **more minority managers** than any other industry.

**Sources:** Figures are based on National Restaurant Association research and data from federal and state government agencies.

See www.restaurant.org/research/state for more information

NATIONAL RESTAURANT ASSOCIATION® — www.restaurant.org

NEW YORK STATE RESTAURANT ASSOCIATION *We serve you* — www.nysra.org

# New York's Restaurants:
## Impact by Congressional District

| Cong. Dist. | U.S. Representative | Restaurant Establishments* | Restaurant Employees* |
|---|---|---|---|
| 1 | Timothy H. Bishop (D) | 1,350 | 17,431 |
| 2 | Steve Israel (D) | 1,225 | 15,812 |
| 3 | Peter King (R) | 1,357 | 17,513 |
| 4 | Carolyn McCarthy (D) | 1,436 | 18,534 |
| 5 | Gary L. Ackerman (D) | 973 | 12,560 |
| 6 | Gregory W. Meeks (D) | 476 | 6,151 |
| 7 | Joseph Crowley (D) | 919 | 11,866 |
| 8 | Jerrold Nadler (D) | 4,401 | 56,812 |
| 9 | Anthony Weiner (D) | 801 | 10,342 |
| 10 | Edolphus Towns (D) | 453 | 5,851 |
| 11 | Yvette D. Clarke (D) | 525 | 6,777 |
| 12 | Nydia Velazquez (D) | 975 | 12,587 |
| 13 | Michael E. McMahon (D) | 893 | 11,526 |
| 14 | Carolyn Maloney (D) | 2,559 | 33,039 |
| 15 | Charles B. Rangel (D) | 616 | 7,947 |
| 16 | Jose Serrano (D) | 446 | 5,756 |
| 17 | Eliot Engel (D) | 903 | 11,662 |
| 18 | Nita M. Lowey (D) | 1,465 | 18,915 |
| 19 | John J. Hall (D) | 1,129 | 14,574 |
| 20 | *Vacant Seat* | 1,352 | 17,459 |
| 21 | Paul Tonko (D) | 1,602 | 20,684 |
| 22 | Maurice D. Hinchey (D) | 1,722 | 22,235 |
| 23 | John M. McHugh (R) | 1,399 | 18,057 |
| 24 | Michael A. Arcuri (D) | 1,308 | 16,887 |
| 25 | Daniel B. Maffei (D) | 1,365 | 17,622 |
| 26 | Christopher John Lee (R) | 1,325 | 17,105 |
| 27 | Brian Higgins (D) | 1,651 | 21,310 |
| 28 | Louise McIntosh Slaughter (D) | 1,348 | 17,404 |
| 29 | Eric J. J. Massa (D) | 1,378 | 17,785 |
| | **TOTAL** | **37,354** | **482,200** |

***** Estimates are for eating-and-drinking place establishments and employees in 2007. "Eating-and-drinking places" is a Census designation that represents about three-fourths of all restaurant and foodservice employment.

**Source:** National Restaurant Association, based on data from the Bureau of Labor Statistics and U.S. Census Bureau.

NATIONAL RESTAURANT ASSOCIATION®

www.restaurant.org

NEW YORK STATE RESTAURANT ASSOCIATION
We serve you

www.nysra.org

NATIONAL RESTAURANT ASSOCIATION® | www.restaurant.org/research

# Massachusetts

## Restaurant Industry at a Glance

**Massachusetts's restaurants are an increasingly important part of the state's economy.** Restaurants are a key driver of employment in Massachusetts, and their sales generate tremendous tax revenues for the state.

The contribution of Massachusetts's restaurants extends far beyond the jobs they create, the careers they build and the revenues they generate. America's restaurants today are leaders in nutrition and healthy living, sustainability and social responsibility, and entrepreneurship and business opportunities.

For more information visit www.restaurant.org.

## Massachusetts Restaurants by the Numbers

### LOCATIONS

In 2007, there were **14,088** eating-and-drinking places in Massachusetts.

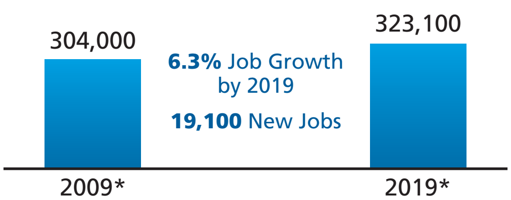
### STATE ECONOMY

Every $1 spent in Massachusetts's restaurants generates an additional **$1.02 in sales** for Massachusetts's economy.

Each additional $1 million spent in Massachusetts's eating-and-drinking places generates an additional **24.1 jobs** in Massachusetts.

### JOBS

Restaurant and Foodservice **Employment**




Restaurant jobs represent **9 percent** of total employment in Massachusetts.

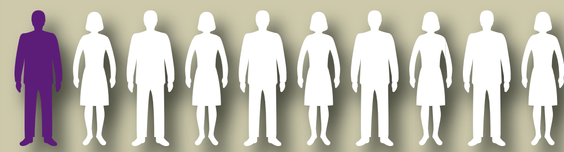
### SALES

In 2009, Massachusetts's restaurants will register **$11.8 billion** in sales.*

* projected

## America's Restaurants: By the Numbers

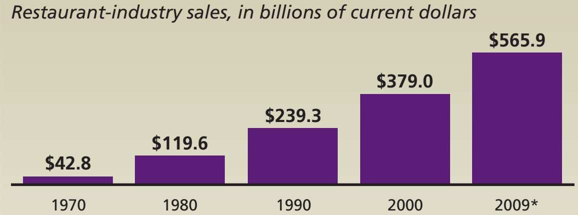
Almost **1 in 10** working Americans are restaurant employees



Restaurants' **share of the food dollar** is rising


Annual industry sales exceed a **half-trillion dollars**

*Restaurant-industry sales, in billions of current dollars*




* projected
**Source:** National Restaurant Association

## Did you know?

- **More than one out of four** American adults got their first job in a restaurant.
- **Nearly half of all Americans** have worked in a restaurant at some point in their working careers.
- America's eating-and-drinking places employ **more minority managers** than any other industry.

**Sources:** Figures are based on National Restaurant Association research and data from federal and state government agencies.

See www.restaurant.org/research/state for more information

NATIONAL RESTAURANT ASSOCIATION® | MRA Massachusetts Restaurant Association

www.restaurant.org | www.marestaurantassoc.org

# Massachusetts's Restaurants:
## Impact by Congressional District

| Cong. Dist. | U.S. Representative | Restaurant Establishments* | Restaurant Employees* |
|---|---|---|---|
| 1 | John W. Olver (D) | 1,449 | 22,613 |
| 2 | Richard E. Neal (D) | 1,307 | 20,399 |
| 3 | James P. McGovern (D) | 1,483 | 23,132 |
| 4 | Barney Frank (D) | 943 | 14,706 |
| 5 | Niki Tsongas (D) | 1,211 | 18,893 |
| 6 | John F. Tierney (D) | 1,537 | 23,980 |
| 7 | Edward J. Markey (D) | 805 | 12,561 |
| 8 | Michael Capuano (D) | 1,926 | 30,053 |
| 9 | Stephen F. Lynch (D) | 1,521 | 23,738 |
| 10 | William Delahunt (D) | 1,905 | 29,724 |
| | **TOTAL** | **14,088** | **219,800** |

***** Estimates are for eating-and-drinking place establishments and employees in 2007. "Eating-and-drinking places" is a Census designation that represents about three-fourths of all restaurant and foodservice employment.

**Source:** National Restaurant Association, based on data from the Bureau of Labor Statistics and U.S. Census Bureau.

NATIONAL RESTAURANT ASSOCIATION®

www.restaurant.org

MRA Massachusetts Restaurant Association

www.marestaurantassoc.org

# Rhode Island

## Restaurant Industry at a Glance

**Rhode Island's restaurants are an increasingly important part of the state's economy.** Restaurants are a key driver of employment in Rhode Island, and their sales generate tremendous tax revenues for the state.

The contribution of Rhode Island's restaurants extends far beyond the jobs they create, the careers they build and the revenues they generate. America's restaurants today are leaders in nutrition and healthy living, sustainability and social responsibility, and entrepreneurship and business opportunities.

For more information visit www.restaurant.org.

## Rhode Island Restaurants by the Numbers

### LOCATIONS

In 2007, there were **2,663** eating-and-drinking places in Rhode Island.

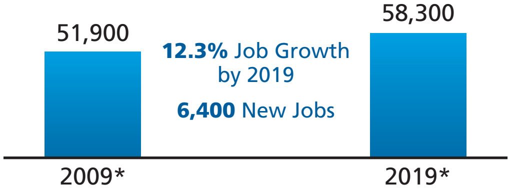
### STATE ECONOMY

Every $1 spent in Rhode Island's restaurants generates an additional **$.85 in sales** for Rhode Island's economy.

Each additional $1 million spent in Rhode Island's eating-and-drinking places generates an additional **24.7 jobs** in Rhode Island.

### JOBS

Restaurant and Foodservice **Employment**




Restaurant jobs represent **11 percent** of total employment in Rhode Island.

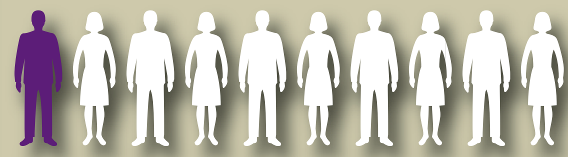
### SALES

In 2009, Rhode Island's restaurants will register **$1.8 billion** in sales.*

* projected

## America's Restaurants: By the Numbers

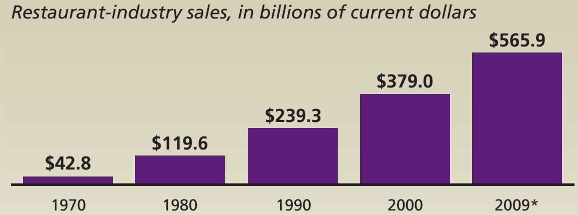
Almost **1 in 10** working Americans are restaurant employees



Restaurants' **share of the food dollar** is rising


Annual industry sales exceed a **half-trillion dollars**

*Restaurant-industry sales, in billions of current dollars*




* projected
**Source:** National Restaurant Association

## Did you know?

- **More than one out of four** American adults got their first job in a restaurant.
- **Nearly half of all Americans** have worked in a restaurant at some point in their working careers.
- America's eating-and-drinking places employ **more minority managers** than any other industry.

**Sources:** Figures are based on National Restaurant Association research and data from federal and state government agencies.

See www.restaurant.org/research/state for more information

NATIONAL RESTAURANT ASSOCIATION® | RI HOSPITALITY ASSOCIATION, RI HOSPITALITY EDUCATION FOUNDATION — Voice of Rhode Island's Lodging, Restaurant and Tourism Industry

www.restaurant.org | www.rihospitality.org

# Rhode Island's Restaurants:
## Impact by Congressional District

| Cong. Dist. | U.S. Representative | Restaurant Establishments* | Restaurant Employees* |
|---|---|---|---|
| 1 | Patrick J. Kennedy (D) | 1,259 | 18,535 |
| 2 | James R. Langevin (D) | 1,404 | 20,665 |
| | **TOTAL** | **2,663** | **39,200** |

***** Estimates are for eating-and-drinking place establishments and employees in 2007. "Eating-and-drinking places" is a Census designation that represents about three-fourths of all restaurant and foodservice employment.

**Source:** National Restaurant Association, based on data from the Bureau of Labor Statistics and U.S. Census Bureau.

NATIONAL RESTAURANT ASSOCIATION®

www.restaurant.org

RI HOSPITALITY ASSOCIATION
RI HOSPITALITY EDUCATION FOUNDATION
Voice of Rhode Island's Lodging, Restaurant and Tourism Industry

www.rihospitality.org

NATIONAL RESTAURANT ASSOCIATION® | www.restaurant.org/research

# New Hampshire

## Restaurant Industry at a Glance

**New Hampshire's restaurants are an increasingly important part of the state's economy.** Restaurants are a key driver of employment in New Hampshire, and their sales generate tremendous tax revenues for the state.

The contribution of New Hampshire's restaurants extends far beyond the jobs they create, the careers they build and the revenues they generate. America's restaurants today are leaders in nutrition and healthy living, sustainability and social responsibility, and entrepreneurship and business opportunities.

For more information visit www.restaurant.org.

## New Hampshire Restaurants by the Numbers

### LOCATIONS

In 2007, there were **2,824** eating-and-drinking places in New Hampshire.

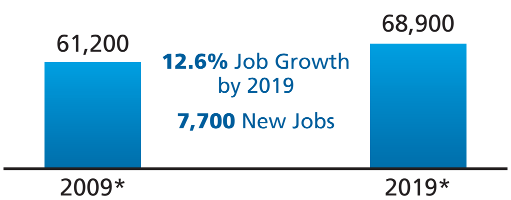
### STATE ECONOMY

Every $1 spent in New Hampshire's restaurants generates an additional **$.84 in sales** for New Hampshire's economy.

Each additional $1 million spent in New Hampshire's eating-and-drinking places generates an additional **22.9 jobs** in New Hampshire.

### JOBS

Restaurant and Foodservice **Employment**




Restaurant jobs represent **9 percent** of total employment in New Hampshire.

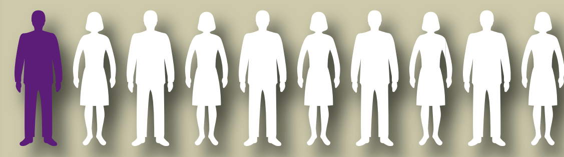
### SALES

In 2009, New Hampshire's restaurants will register **$2.1 billion** in sales.*

* projected

## America's Restaurants: By the Numbers

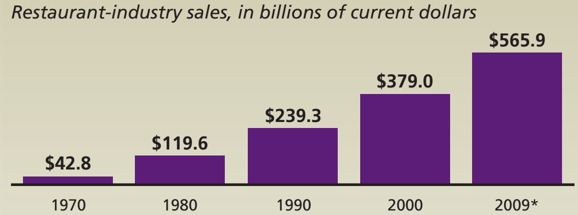
Almost **1 in 10** working Americans are restaurant employees



Restaurants' **share of the food dollar** is rising


Annual industry sales exceed a **half-trillion dollars**

*Restaurant-industry sales, in billions of current dollars*




* projected
**Source:** National Restaurant Association

## Did you know?

- **More than one out of four** American adults got their first job in a restaurant.
- **Nearly half of all Americans** have worked in a restaurant at some point in their working careers.
- America's eating-and-drinking places employ **more minority managers** than any other industry.

**Sources:** Figures are based on National Restaurant Association research and data from federal and state government agencies.

See www.restaurant.org/research/state for more information

NATIONAL RESTAURANT ASSOCIATION®
www.restaurant.org

NHLRA
NEW HAMPSHIRE LODGING & RESTAURANT ASSOCIATION
www.nhlra.com

# New Hampshire's Restaurants:
## Impact by Congressional District

| Cong. Dist. | U.S. Representative | Restaurant Establishments* | Restaurant Employees* |
|---|---|---|---|
| 1 | Carol Shea-Porter (D) | 1,528 | 23,973 |
| 2 | Paul W. Hodes (D) | 1,296 | 20,327 |
| | **TOTAL** | **2,824** | **44,300** |

***** Estimates are for eating-and-drinking place establishments and employees in 2007. "Eating-and-drinking places" is a Census designation that represents about three-fourths of all restaurant and foodservice employment.

**Source:** National Restaurant Association, based on data from the Bureau of Labor Statistics and U.S. Census Bureau.

NATIONAL RESTAURANT ASSOCIATION®
www.restaurant.org

NHLRA
NEW HAMPSHIRE LODGING & RESTAURANT ASSOCIATION
www.nhlra.com

# Appendix C: Commercial Foodservice Publications

ENERGY STAR

# ENERGY STAR® Guide for Restaurants

## Putting Energy into Profit

United States Environmental Protection Agency

LEARN MORE AT energystar.gov

ENERGY STAR®, a U.S. Environmental Protection Agency program, helps us all save money and protect our environment through energy efficient products and practices. For more information, visit www.energystar.gov.

# Contents

Page

Energy Efficiency and Your Restaurant ........ 1
Cooking Appliances ........ 2
Refrigeration Systems and Ice Machines ........ 4
Lamps and Lighting Fixtures ........ 5
Heating, Cooling and Ventilation ........ 6
Water and Waste Management ........ 7
Begin the Process, Learn More and Save! ........ 8

## IN PARTNERSHIP WITH

PG&E Food Service Technology Center is the industry leader in commercial kitchen energy efficiency and appliance-performance testing as well as a leading source of expertise in commercial kitchen ventilation and sustainable building design.

National Restaurant Association's Conserve initiative explores conservation efforts in restaurants around the nation and offers suggestions and resources to help operators reduce their costs and improve their environmental performance.

## ACKNOWLEDGEMENTS

This best-practices guide was created with the assistance of California's four investor-owned utilities (Southern California Gas Company, Pacific Gas and Electric Company, San Diego Gas and Electric Company, and Southern California Edison). These energy suppliers are working together to provide comprehensive energy efficiency resources for California's food service industry, including, but not limited to, the following resources: rebates for cooking and refrigeration equipment, food service specific seminars and workshops, Web tools, energy audits, appliance testing, and energy education centers. The California energy-efficiency research and educational programs are funded by California ratepayers under the auspices of the California Public Utilities Commission and are administered by the four investor-owned utilities.

Southern California Gas Company
A Sempra Energy utility®
*www.socalgas.com/business*

PG&E®
*www.pge.com/fstc*

SDGE
A Sempra Energy utility®
*www.sdge.com/foodservice*

SOUTHERN CALIFORNIA EDISON®
An EDISON INTERNATIONAL® Company
*www.sce.com/CTAC*

*Disclaimer: all energy, water, and monetary savings listed in this document are based upon average savings for end users and are provided for educational purposes only. Actual energy savings might vary based on use and other factors.*

## FIVE EASY STEPS TO SAVE ENERGY AND WATER

**1** *Install compact fluorescent lamps* (CFLs) in your walk-in refrigerators and kitchen ventilation hoods (and throughout your restaurant where appropriate).

**2** *Install a high-efficiency pre-rinse spray valve* in your dishroom and save hundreds of dollars a year!

**3** *Fix water leaks immediately*—especially hot water leaks: wasted water, sewer, and water heating costs can add up to hundreds of dollars a year.

**4** *Perform walk-in refrigerator maintenance:* check and replace door gaskets; clean evaporator and condenser coils; check refrigerant charge.

**5** *Replace worn-out cooking and refrigeration equipment* with ENERGY STAR qualified models!

Get additional easy to implement tips at: http://conserve.restaurant.org

Energy efficiency is a sound business practice that improves profitability, reduces greenhouse gas emissions, and conserves resources. This guide is designed to help your restaurant save energy and water, protect our Earth, and boost your bottom line.

## ENERGY EFFICIENCY AND YOUR RESTAURANT

Restaurants use about 2.5 times more energy per square foot than other commercial buildings.

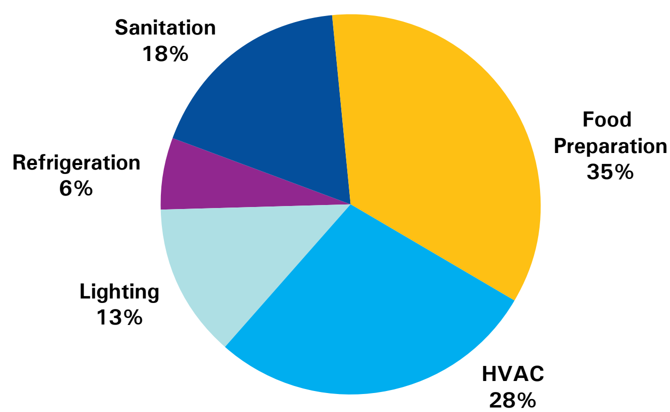
Energy costs have been increasing at a rate of 6 to 8 percent per year. Investing in energy efficiency is the best way to protect your business against rising energy prices.

Most commercial kitchen appliances are energy intensive. For instance, a typical electric deep fat fryer uses more than 11,000 kilowatt-hours (kWh) of energy per year which could cost you more than $1,100 in electricity.

You can reduce your restaurant's energy consumption by following the **Cost Saving Tips** outlined below and throughout this guide:

- Buy ENERGY STAR qualified appliances. If you're in the market for new equipment, think in terms of life-cycle costs, which include purchase price, annual energy costs, and other long-term costs associated with the equipment. High-efficiency appliances could cost more upfront, but significantly lower utility bills can make up for the price difference. Be sure to ask your dealer or kitchen designer to supply you with ENERGY STAR qualified equipment.
- Cut idle time. If you leave your equipment ON when it is not performing useful work, it costs you money. Implement a startup/shutdown plan to make sure you are using only the equipment that you need, when you need it.
- Maintain and repair. Leaky walk-in refrigerator gaskets, freezer doors that do not shut, cooking appliances that have lost their knobs—all these "energy leaks" add up to money wasted each month. Don't let everyday wear and tear drive up your energy bills.

**Example of the Average Energy Consumption in a Full-service Restaurant**
(British Thermal Units [Btu])




- Cook wisely. Ovens tend to be more efficient than rotisseries; griddles tend to be more efficient than broilers. Examine your cooking methods and menu; find ways to rely on your more energy-efficient appliances to cook for your customers.
- Recalibrate to stay efficient. The performance of your kitchen equipment changes over time. Thermostats and control systems can fail, fall out of calibration, or simply become readjusted. Take the time to do a regular thermostat check on your appliances, refrigeration, dish machines, and hot water heaters and reset them to the correct operating temperature.

## COOKING APPLIANCES

When replacing old appliances or buying new ones, look beyond the sticker price. Buying and installing equipment that has earned the ENERGY STAR could trim hundreds of dollars from your annual utility bills. In order to realize the most savings from your ENERGY STAR qualified equipment you must train your staff to use energy wisely by following good operating practices such as those in the **Cost-Saving Tips** that follow.

### Steamers

Steam cookers provide an effective way to batch-cook food but generating steam is an energy-intensive process. ENERGY STAR qualified steamers have a sealed cooking cavity that consumes a fraction of the energy and water required by traditional open systems. In many cases the dollar savings are so great that it makes sense to replace an existing steamer with an ENERGY STAR qualified one.

**Cost-Saving Tips**

- Look for the ENERGY STAR
- Close the door
- Use the timer
- Cut idle time
- Maintain & repair

**Good practices can save:**

$250 to $350 in annual energy costs for a traditional, electric, open-system steamer by eliminating an hour of idle time per day.

**Buy an ENERGY STAR qualified connectionless steamer and save:**

- $680 for water and sewer costs annually
- $510 for electricity annually (electric steamer), or
- $390 for gas annually (gas steamer)

Equating to an average $1,190 total savings for an electric steamer or $1,070 total savings for a gas steamer (some restaurants with high commercial sewer costs can save hundreds of dollars more annually)

### Fryers

Energy-efficient fryers that have earned the ENERGY STAR offer shorter cook times, faster temperature recovery times, and ultimately higher pound-per-hour production rates through advanced burner and heat exchanger designs. Some models also offer an insulated fry pot, which reduces standby losses, giving the fryer a lower idle energy rate.

**Cost-Saving Tips**

- Look for the ENERGY STAR
- Cut idle time & turn off back-up fryers when possible
- Recalibrate

**Good practices can save:**

$250 annually for a gas fryer by cutting four hours of idle time per day.

**Buy an ENERGY STAR qualified fryer and save:**

- $120 for electricity annually (electric fryer), or
- $590 for gas annually (gas fryer)

### Convection Ovens

Convection ovens are the industry standard due to faster cook-times produced by increased hot air movement inside the oven cavity. In addition, convection ovens are now eligible for ENERGY STAR qualification.

**Cost-Saving Tips**

- Look for the ENERGY STAR
- Cut idle time & turn off back-up ovens when possible
- Fully load the oven when cooking
- Replace seals & tighten hinges

**Buy an ENERGY STAR qualified convection oven and save:**

- $190 for electricity annually (electric oven), or
- $360 for gas annually (gas oven)

## Griddles

Griddles are a versatile piece of equipment and a workhorse appliance found on most kitchen lines. Variations in efficiency, production capacity, and temperature uniformity make it important to choose wisely when shopping for a griddle. Many energy-efficient griddles can deliver both high production capacity and excellent temperature uniformity.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Cut idle time
- Recalibrate

**Good practices can save:**

$250 annually from a gas griddle by cutting three hours of idle time per day.

**Buy an ENERGY STAR qualified griddle and save:**

- $190 for electricity annually (electric griddle), or
- $175 for gas annually (gas griddle)

## Holding Cabinets

ENERGY STAR hot food holding cabinets typically feature improved insulation, so heat stays in the cabinet and out of the kitchen. An insulated ENERGY STAR holding cabinet uses about half the energy consumed by an uninsulated cabinet. Other available features that could potentially save energy include magnetic door gaskets, auto-door closers, and dutch doors.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Shut off overnight
- Use the timer
- Replace missing or worn out control knobs

**Good practices can save:**

$500 annually by turning off an uninsulated holding cabinet when the kitchen is closed.

**Buy an ENERGY STAR qualified holding cabinet and save:**

- $340 to $960 annually for electricity

## Combination Ovens

The combination oven is an extrememly versatile cooking platorm with the added bonus of a self-cleaning feature. Operating a combination oven in “steam” or “combination” mode typically uses more energy and water than operating in traditional convection mode. Use the oven’s programming capabilities to properly control different cooking modes to maximize energy efficiency and cost savings. Do your homework when buying a combination oven: the most efficient models will use about half as much energy and water as the inefficient models.

**Good practices can save:**

$400 to $800 annually off an electric combination oven by cutting out two hours of idle time per day.

**If ENERGY STAR qualified models don’t exist for the type of equipment you’re looking for don’t worry: you still have options. Ask distributors and manufacturers for energy use information, and check online for equipment reviews. The California commercial food service incentive program is also a third party resource because, like ENERGY STAR, appliances that qualify must meet designated efficiency standards. The list of qualifying appliances can be found at: www.fishnick.com/saveenergy/rebates.**

## Broilers

Broilers are true kitchen workhorses but their dependability and simplicity come at a price: searing heat requires a great deal of energy and broilers have simple, non-thermostatic controls. This combination can make the broiler the most energy intensive appliance in the kitchen. For example, one gas broiler can use more energy than six gas fryers. A new generation of broilers incorporates better radiant designs, allowing the broiler to get the job done while consuming about 25 percent less energy.

### Cost-Saving Tips

- Cut preheat time
- Turn off unneeded sections
- Reduce idle time
- Replace missing knobs

Good practices can save:
$600 annually by cutting out three hours of idle time per day.

## Ranges

The range top is one of the most widely used pieces of equipment in restaurant kitchens. Ranges are manually controlled and can be energy guzzlers depending on how you operate them. A potential alternative to traditional range tops are induction ranges; they are more expensive but offer very high efficiency, rapid heat up, precise controls, and low maintenance.

### Cost-Saving Tips

- Maintain and adjust burners
- Use a lid
- Cut idle time

# REFRIGERATION SYSTEMS AND ICE MACHINES

## Reach-In Refrigerators and Freezers

Compared to standard models, ENERGY STAR qualified commercial refrigerators and freezers can lead to energy savings of as much as 35 percent with a 1.3 year payback. Glass door refrigerators and freezers can now earn the ENERGY STAR too! Features that could potentially save energy include improved insulation and components such as high-efficiency compressors and motors.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Turn off door heaters when possible
- Clean coils
- Set defrost timers
- Replace worn gaskets

Buy ENERGY STAR qualified equipment and save:
- $200 for electricity annually (per solid door refrigerator)
- $140 for electricity annually (per solid door freezer)

## Walk-In Refrigerators

Walk-in refrigerators are extremely important to any successful restaurant. Improve this equipment's energy performance with a few inexpensive upgrades and good practices, such as:

- Swapping out incandescent light bulbs for low-temperature ENERGY STAR qualified compact fluorescent lamps (CFLs) can reduce the lamps' heat output by 75 percent! (Look for the lowest possible "minimum start temperature" on the CFL box, e.g., zero degrees Fahrenheit.)
- Adding strip curtains and automatic door closers to your walk-in refrigerator: *they are inexpensive and easy-to-install.* Strip curtains can cut outside air infiltration by about 75 percent!
- Installing electronically commutated motors (ECM) on the evaporator and condenser fans reduces fan energy consumption by approximately two-thirds.

### Cost-Saving Tips

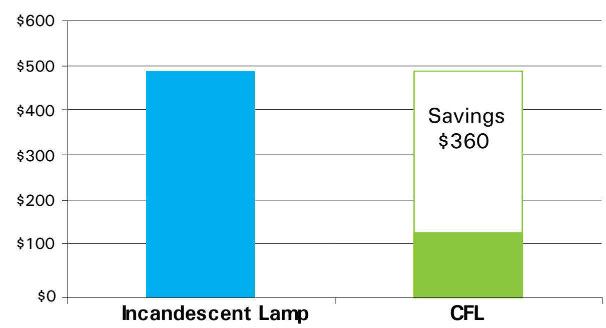
- Allow air circulation
- Insulate suction lines
- Check refrigerant charge
- Repair and realign doors
- Clean coils

## LAMPS AND LIGHTING FIXTURES

In a typical restaurant, lights are usually on for 16 to 20 hours a day. For many areas in your restaurant, high-efficiency ENERGY STAR CFLs and lighting fixtures are your ticket to savings.

- Install ENERGY STAR qualified fixtures and CFLs in your dining area and reduce energy consumption and heat output by 75 percent.
- Install occupancy sensors in closets, storage rooms, break rooms, restrooms, and even walk-in refrigerators. Look for sealed, low-temperature-specific sensors for refrigerated environments.
- If your restaurant features linear fluorescent lighting with T12 lamps and magnetic ballasts it is time to upgrade. Switch to more efficient T8 or T5 lamps with electronic ballasts. Electronic ballasts typically have faster on-times and do not hum or flicker. Look for utility incentives for lighting upgrades in your area.
- Swap your old Open/Closed and EXIT signs with LED technology for electricity savings up to 80 percent.
- Visit www.energystar.gov/lighting for more cost-saving information.

**Annual Savings After Replacing Eight Incandescent Lamps with Eight CFLs**




**CFL vs. Incandescent Light Bulbs**

If each of the 945,000 restaurants in the United States replaced only one incandescent light bulb with a CFL, more than 630 million pounds of $CO_2$ emissions could be avoided each year (the annual greenhouse gas emissions from more than 52,000 passenger vehicles*), and the restaurant industry could save about $42.5 million annually.

*Source: EPA Greenhouse Gas Equivalencies Calculator: www.epa.gov/cleanenergy/energy-resources/calculator.html

### Ice Machines

Commercial ice machines that earn the ENERGY STAR are on average 15 percent more energy efficient and 10 percent more water efficient than standard models.

- Cut down on your daytime electricity demand by installing a timer and shifting ice production to nighttime off-peak hours.
- Bigger ice machines are typically more efficient than smaller ones, yet the price difference is usually not very large. Choose wisely and you could get twice the ice capacity at half the energy cost per pound of ice.
- Avoid water-cooled ice machines because of their high water cost, which make them significantly more expensive to operate. *Note: water-cooled ice machines do not currently qualify for ENERGY STAR.*

**Cost-Saving Tips**

- Look for the ENERGY STAR
- Clean the coils
- Keep the lid closed
- Adjust the purge water timer

Buy an ENERGY STAR qualified ice machine and save:

- $120 for electricity annually

### Mercury and CFLs

**CFLs contain a very small amount of mercury sealed within the glass tubing (approximately 4 milligrams). By comparison, older thermometers contain about 500 milligrams of mercury   an amount equal to the mercury in 125 CFLs. No mercury is released when the bulbs are intact (not broken) or in use. For more information about recycling and disposing of CFLs visit: www.energystar.gov/mercury.**

## HEATING, COOLING AND VENTILATION

Making smart decisions about your restaurant's heating, ventilating, and air conditioning (HVAC) system can have a big effect on your utility bills—and your customers' comfort.

### Heating and Cooling Systems

Heating and cooling systems account for a large portion of your restaurant's annual energy use. For many restaurants, heating and cooling is second only to food preparation in terms of annual energy consumption.

**Cost-Saving Tips**

- Look for the ENERGY STAR
- Clean heat-transfer coils
- Replace air filters
- Consider an Energy Management System
- Repair broken duct work
- Recommission economizers

Energy use falls by 4 to 5 percent for every degree that you raise your cooling thermostat setpoint. Easing back on central cooling by only 3°F could trim air conditioning costs by 12 to 15 percent. Improve customer comfort by using an efficient ENERGY STAR qualified ceiling fan to compensate for the difference in air temperature. Ensure that your heating and cooling equipment is included in the start-up and shut down schedule to save even more.

Don't forget about the restroom! ENERGY STAR qualified ventilating fans use 70 percent less energy than standard models.

**Buy ENERGY STAR qualified equipment and save:**

- $1.70 per square foot over the life of the HVAC equipment ($4,250 for a 2,500 square foot restaurant; the same as $430 annually)
- $17 annually for electricity costs per ceiling fan
- $75 annually for electricity costs for ventilating fans that are run continuously

**According to the Consortium for Energy Efficiency (CEE), at least 25 percent of all rooftop HVAC units are oversized, resulting in increased energy costs and equipment wear. Properly sized equipment dramatically cuts energy costs, increases the life of the equipment, and reduces greenhouse gas emissions.**

### Kitchen Ventilation

An unbalanced or poorly designed kitchen exhaust system can allow heat and smoke to spill into your kitchen, spelling trouble both for your restaurant's air quality and for your utility bills. Spillage leads to a hot, uncomfortable working environment and higher energy bills for air-conditioned kitchens.

- Cut down on spillage by adding inexpensive side panels to hoods.
- Push each cooking appliance as far back against the wall as possible to maximize hood overhang and close the air gap between the appliance and the wall.
- Install a demand-based exhaust control. It uses sensors to monitor your cooking and varies the exhaust fan speed to match your ventilation needs. Demand ventilation controls could reduce your exhaust system costs by anywhere from 30 to 50 percent and can be installed on either new equipment or retrofitted to existing hoods.

**Learning More About Kitchen Ventilation**

If you're getting ready to design a new kitchen or renovate an old one, check out "Improving Commercial Kitchen Ventilation System Performance," a two-part kitchen ventilation design guide written by the experts at PG&E FSTC and available at: www.fishnick.com/equipment/ckv/designguides.

### Windows

Applying a clear, heat rejecting window film will help cut your cooling costs while making your dining room more comfortable. Use only high quality window film installed by a qualified professional.

### Patio Heaters

The best approach to saving money with patio heaters is to cut back their use—both for hours of operation and for the number of patio heaters running at any given time. Patio heaters are radiant devices that heat up quickly so there is no reason to leave them running if a seating area is temporarily empty.

**Good practices can save:**

$530 per heater annually by cutting three hours of use per day

## WATER AND WASTE MANAGEMENT

### Water Use

Using water more efficiently preserves water supplies, saves money, and protects the environment. By conserving hot water you trim not one but two bills: one for the water and sewer and another for the electricity or natural gas used to heat the water used in bathroom faucets, kitchen sinks, and dishwashers.

#### Cost-Saving Tips

- Look for the ENERGY STAR and WaterSense label
- Add aerators
- Install WaterSense labeled toilets
- Repair leaks
- Reduce sink and tap usage

Similar to the ENERGY STAR, the WaterSense® label identifies water-efficient products and programs. WaterSense is a partnership program sponsored by EPA and additional information is available at: www.epa.gov/watersense.

look for WaterSense Meets EPA Criteria

**Good practices can save:**

$1,000 annually by turning down dipper wells and making sure they are OFF when the kitchen is closed

$1,000 annually by fixing leaks in sinks, mop-stations, and dishmachines

**Look for WaterSense labeled equipment and use WaterSense irrigation partners to landscape your restaurant:**

Bathroom faucets are 30 percent more water efficient

Landscaping with WaterSense irrigation partner could save you 15 percent compared to average watering bills

### High-Efficiency Pre-Rinse Spray Valves

A high-efficiency, or low-flow, pre-rinse spray valve is one of the most cost-effective energy saving devices available to the foodservice operator. And it is easy to install! Just unscrew your old spray valve and screw in your new, water-efficient one.

In addition to minimizing hot water consumption, you can reduce both your water-heating and sewer expenditures per month. How? Typical spray valves can release hot water at a rate of three to four gallons of water per minute (gpm), while common high-efficiency units spray only 1.6 gpm or less without sacrificing cleaning power!

**Buy a 1.6 gpm spray valve and save:**

$300 to $350 annually for water, sewer, and natural gas costs annually (used one hour a day and compared to 3 gpm sprayer).

Additional information is available at: www.fishnick.com/equipment/sprayvalves.

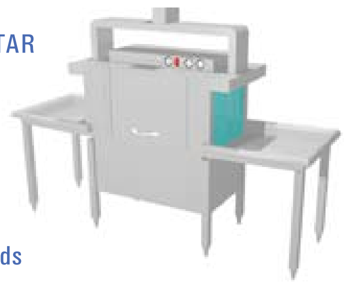
## Dishwashers

From an operational standpoint, dishwashers are one of the most expensive pieces of equipment in your kitchen. Commercial dishwashers that have earned the ENERGY STAR are on average 25 percent more energy and water efficient than standard models.

- Run fully loaded dish racks through the dish machine. Cutting wash cycles could save you hundreds of dollars annually.
- Pay attention to your dishwasher's pressure gauge—if it's showing pressure above 25 psi, there is a good chance you are using much more water than is necessary. Most dishwashers require only around 20 psi.
- If you have a conveyor-style dishwasher, make sure you are using it in auto mode, which saves electricity by running the conveyor motor only when needed.

### Cost-Saving Tips

- Look for the ENERGY STAR
- Turn off at night
- Replace torn wash curtains
- Repair leaks
- Replace worn spray heads



Buy an ENERGY STAR qualified dishwasher and save:

- $975 for electricity annually
- $200 for water annually

## Waste Reduction Is Good Business

Waste reduction leads to increased operating efficiency and cost savings. Decreased solid waste generation reduces collection and disposal costs just as reducing electricity and water consumption reduces utility bills. Waste minimization also may reduce your purchasing costs for restaurant supplies.

Using recycling and composting bins, sustainable take-out containers, and "green" signage are all excellent ways to announce and to demonstrate to your customers your efforts to be more environmentally sustainable and aware.

For help identifying waste reduction opportunities please visit www.epa.gov/wastewise.

## BEGIN THE PROCESS, LEARN MORE AND SAVE!

The best first step is to perform an energy audit on your facility. Energy service providers (utilities), state energy offices, and private sector product and service providers can assist you in identifying a trained professional to conduct your audit. However, comprehensive, affordable energy audits are not available everywhere in the country for commercial food service businesses.

To help address the lack of energy audits in many communities, ENERGY STAR provides free online tools and information to achieve energy savings. ENERGY STAR's basic guidance for self-assessments is part of the Guidelines for Energy Management, "Step 2: Assess Performance," at: www.energystar.gov/guidelines.

In addition, ENERGY STAR's Portfolio Manager software is designed to help businesses "benchmark" and track energy use, costs, and greenhouse gas emissions. Portfolio Manager also offers the option to track water use and renewable energy credits—all in a password protected online file. Portfolio Manager users can track multiple facilities independently or aggregate all the business locations into one file. Your restaurant can generate a Statement of Energy Performance which includes a "weather-normalized" kBtu/ft$^2$ energy use intensity calculation, associated greenhouse gas emissions and a national average for similar building types. Access to the software and free online training in use of Portfolio Manager is available at: www.energystar.gov/benchmark.

Once you have identified the areas of potential energy savings, decide which energy efficiency upgrades you want to install and what practices to initiate. If your finances and operating schedule make it impractical to perform all the upgrades at once, you can take a staged approached and install them as time and money allow.

Remember, having your **restaurant manager** 100 percent on board is absolutely key to saving your restaurant money and protecting the environment! Your best-laid energy-saving plans are only as good as the staff that is implementing them!

## For more information, please consult the following online resources:

- ENERGY STAR Commercial Food Service: www.energystar.gov/cfs
- ENERGY STAR Restaurants: www.energystar.gov/restaurants
- ENERGY STAR Portfolio Manager: www.energystar.gov/benchmark
- PG&E Food Service Technology Center: www.fishnick.com
- National Restaurant Association Conserve: http://conserve.restaurant.org
- EPA WaterSense: www.epa.gov/watersense
- EPA WasteWise: www.epa.gov/wastewise

**Find Monetary Incentives**

ENERGY STAR CFS Incentive Finder: go to www.energystar.gov/cfs and click on "Special Offers" or go to www.energystar.gov/cfsrebate _ locator

December 2009

EPA 430-R-09-030

For more information visit www.energystar.gov.

Food Service Technology Center
*Promoting Energy Efficiency in Food Service*

conserve
solutions for sustainability

NATIONAL RESTAURANT ASSOCIATION®

energy
LEARN MORE AT
energystar.gov

ENERGY STAR

# ENERGY STAR® FOR COMMERCIAL KITCHENS: HELPING CUSTOMERS MANAGE COSTS

Buildings with restaurants and other food service operations are very energy intensive, consuming roughly 2.5 times the energy per square foot as other commercial buildings, or close to 250,000 British thermal units (Btu) of energy per square foot.[1] Energy efficiency program administrators can help these customers rein in operating costs while also reducing energy use, peak demand, and water use by promoting ENERGY STAR qualified commercial food service (CFS) equipment and other best practices. Utility cost savings of 10 to 30 percent are achievable without sacrificing service, quality, style or comfort—all while making significant contributions to a cleaner environment.[2] The U.S. Environmental Protection Agency (EPA) is working with about 50 efficiency program administrators throughout the nation to integrate ENERGY STAR qualified CFS equipment into their program offerings. EPA is providing this fact sheet to introduce more program administrators to ENERGY STAR and the savings opportunities in commercial kitchens, as well as to share best practices for program design, implementation, and evaluation based on the experiences of recent CFS programs.

## DELIVERING SOLUTIONS IN COMMERCIAL KITCHENS

Promoting the installation of energy-efficient equipment in commercial kitchens is an important part of a comprehensive CFS program. It saves significant amounts of energy and offers meaningful financial benefits to the establishment. Utility costs are a major operating expense for the CFS industry, on the level of about one-half to almost parity with their profit margins—which, for a full service restaurant, is around 5 percent of sales.[3] Due to rising energy costs, CFS customers may be increasingly receptive to program administrator assistance for improving energy efficiency and reducing related utility bills. And the savings opportunities are significant: as much as 80 percent of the food service sector's $10 billion annual energy bill is expended on energy that does no useful work and a substantial portion of this waste is related to equipment inefficiencies.[4]

ENERGY STAR provides a comprehensive and cost-effective platform for promoting greater equipment efficiency and related best practices to CFS customers. ENERGY STAR currently identifies efficient products in eight product categories: hot food holding cabinets, solid door refrigerators and freezers, fryers, steam cookers, ice machines, commercial ovens, griddles, and dishwashers.

These energy-efficient products offer energy savings of 10 to 65 percent over standard models, depending upon the product category. Three of the product categories, commercial dishwashers, ice machines, and steam cookers, also offer water savings of up to 90 percent over standard models. Three CFS utility programs have earned ENERGY STAR awards for promoting these energy-saving products and are showing promising early returns. They include:

- California's four investor-owned utilities (IOUs)—Pacific Gas & Electric Company (PG&E), Southern California Edison (SCE), Southern California Gas Company (SCG), and San Diego Gas & Electric Company (SDG&E)—offer a coordinated statewide incentive program with strong early results, achieving annual electric savings of around 20.6 million kilowatt-hours (kWh) and annual natural gas savings of around 526,000 therms.[5]
- The Energy Trust of Oregon's (ETO) CFS program is achieving annual savings of nearly 1.2 million kWh and over 190,000 therms by partnering with dealers that sell CFS equipment directly to restaurants.[6]
- Wisconsin's Focus on Energy offers CFS customers a bonus incentive to encourage the purchase of multiple ENERGY STAR qualified products and is achieving annual electric savings of nearly 350,000 kWh and annual natural gas savings of nearly 22,000 therms.[7]

> Outfitting an entire commercial kitchen with a suite of ENERGY STAR qualified equipment could save around 300 million Btus of energy and about $3,600 per year.

# PROGRAM DESIGN AND IMPLEMENTATION

A key factor in effective program design is understanding the market barriers to greater adoption of energy-efficient equipment and developing strategies to overcome these barriers. Common barriers in the CFS market include:

- ***Hard-to-reach market***—The CFS market is highly fragmented, both in terms of equipment supply channels and end use sectors.
- ***Lack of readily available supply***—CFS equipment suppliers typically compete on low prices and therefore stock only a limited supply of energy-efficient products. This barrier is compounded by customers who make short-term purchasing decisions due to the need to replace equipment quickly when it fails.
- ***Incremental costs***—ENERGY STAR qualified CFS equipment is generally more expensive than standard efficiency equipment and can cost significantly more than refurbished models sold in the used equipment market.
- ***Lack of knowledge***—Equipment suppliers and end users might not be aware of energy-efficient products, might have misperceptions about tradeoffs between energy efficiency and performance, or both.

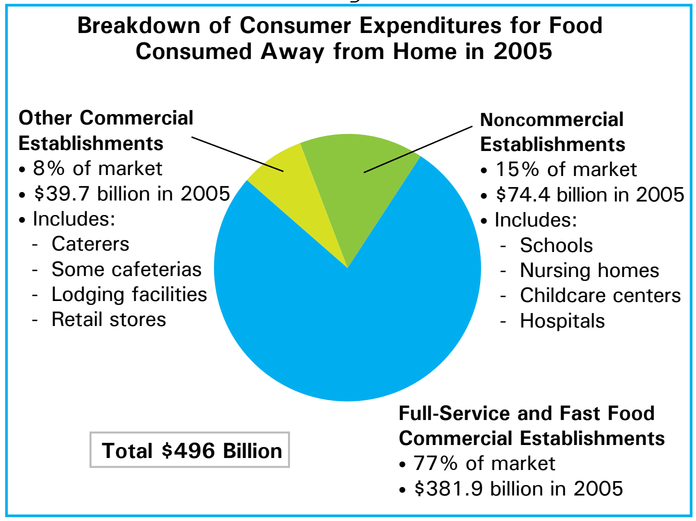
The following sections describe the CFS equipment market in further detail and discuss program strategies for addressing the key barriers listed above.

## Understanding and Engaging the CFS Market

Foodservice establishments include commercial and noncommercial entities, diverse business sectors, and account for approximately $500 billion in expenditures for food consumed away from the home (e.g., meals and snacks for on-premise or immediate consumption). Commercial establishments—including full service restaurants, fast food outlets, caterers, some cafeterias, lodging facilities, and retail stores—account for about 85 percent of this total with full-service restaurants and fast food restaurants representing the two largest industry segments, accounting for 77 percent of expenditures for food consumed away from the home. Noncommercial foodservice operators—those that prepare and serve food as an adjunct service in institutional settings (e.g., schools, nursing homes, childcare centers, and hospitals)—account for the remaining 15 percent.[8]

In addition to the diverse business sectors that comprise the foodservice industry, the CFS equipment market is complicated by multiple equipment distribution channels including:

- Dealers that primarily sell to individual restaurants.
- Distributors that primarily supply bulk quantities to equipment dealers and sell commodity equipment (e.g., ice machines, counter-top fryers) directly to end users.




Source: *Adapted from U.S. Department of Agriculture Economic Research Service, Briefing Room: Food Marketing System in the United States.*

- Manufacturers that sell through manufacturer representatives (reps) but may also sell directly to large end users such as national restaurant chains.
- Consultants that assist in either designing new or renovating existing commercial kitchens, typically working with restaurant chains, hotels, hospitals, and universities.

(Additional information on supply channel actors and strategies for influencing them can be found in the text box on page 3).

Due to the complexity of the CFS market and potential for widespread variability between service territories, program administrators should consider conducting a market assessment to: 1) understand the major sectors and primary distribution channels influencing the CFS equipment market in their territory, 2) develop estimates of likely program uptake for each sector

### ITW Food Equipment Group

2008 and 2009 ENERGY STAR Partner of the Year, ITW Food Equipment Group (ITW FEG)—the parent organization of independent companies such as Hobart, Stero, Vulcan, Traulsen, and Wittco—understands the importance of supporting customers in their drive to cut costs, use less water and consume less electricity, and has responded by offering 381 ENERGY STAR qualified CFS products.

> "ENERGY STAR plays an important role in helping foodservice operators and food retailers design a sustainable kitchen that's good for the environment and good for business in terms of efficiency, productivity and quality...Our partnership with ENERGY STAR enables us to emphasize the value of selecting equipment engineered for high efficiency and low water consumption."
>
> —*John McDonough, President of ITW FEG*

taking into account the uniqueness of each sector (e.g., while restaurants are often the largest segment, they are often the hardest segment to influence), and 3) establish program baseline conditions (e.g., what is the current market share for an efficient product, and what is the best estimate of market share over time absent a program). See related discussion under Measurement and Verification, page 7.

Another key best practice is to engage equipment suppliers and other key stakeholders, such as large and small restaurant customers and their trade associations, during program design. Engaging stakeholders early in the planning process can help program administrators better understand stakeholder business models and gauge receptivity to potential education, marketing, and incentive strategies.

Continuing this dialogue during program launch, particularly with supply-side market actors, is essential to ensuring that manufacturer reps, distributors, dealers, and businesses are familiar with program incentives, policies and procedures, and are able to effectively communicate the key benefits and features of qualified energy-efficient equipment to their customers. During these meetings, it is important to communicate both the mechanics of how the CFS program works and the business benefits of program participation.

An ENERGY STAR qualified commercial refrigerator can save a restaurant around $200 on energy costs per year. This may not seem like much until one considers the slim profit margins in the restaurant industry. If a restaurant operates with a profit margin of around 5 percent (the industry average), it will need to make roughly $4,000 in sales to earn $200 in profit.

## Improving Availability of ENERGY STAR® Qualified Equipment

In the retrofit market, purchasing often occurs when existing equipment fails, and the top priority is getting new equipment online quickly. Decisions on product selection and purchase are usually driven by product availability, price, and advice from the equipment supplier. Unfortunately, many suppliers do not stock or promote efficient equipment due to price premiums that range from 10 to 85 percent, depending on product category.

The following are important strategies for motivating suppliers to sell and stock ENERGY STAR qualified equipment:

**Make the business case—**It is important to educate suppliers on the value proposition for promoting ENERGY STAR qualified CFS equipment to their customers. While efficient equipment may have

## Supply Channel Actors

**Dealers**—Dealers primarily sell to individual restaurants, which is often the most difficult market to reach. Smaller dealers may join buying groups so they can compete more effectively with larger dealers. Many dealers display their products in showrooms and tend to stock lower-priced, popular models that are usually not energy-efficient. A dealer's main objective is usually to sell the products they have on hand, and they are generally more interested in attracting customers with low prices rather than emphasizing the overall value of higher-end products (e.g., lifetime cost savings). Given that many manufacturers offer sales incentives to move lower-end models, dealer incentives can be an effective strategy to promote stocking and sales of energy-efficient equipment.

**Distributors**—Distributors primarily supply bulk quantities of equipment to dealers and sell commodity equipment (e.g., ice machines, fryers) directly to end users. Since distributors usually supply dealers, developing a good working relationship with distributors helps funnel energy-efficient CFS products into dealer showrooms. In addition, some restaurant food distributors sell CFS equipment and should also receive program outreach.

**Manufacturers and Reps**—CFS equipment manufacturers generally sell through product reps, although manufacturers may also sell directly to large end users such as national restaurant chains. Though all supply channels gravitate toward inexpensive, fast-moving pieces of equipment, a key value proposition for engaging reps is the up-sell potential of high-value, high-efficiency equipment. Sales of high-quality products earn reps a higher commission and generate long-term value for the customer, often leading to repeat business.

**Design Consultants**—Design consultants assist in the planning and design of new or renovated commercial kitchens, typically working with large or chain-owned restaurants, hotels, universities, and hospitals. Conducting targeted outreach to design consultants helps to ensure that energy- and water-efficient CFS equipment is considered in these types of projects. Design consultants are typically focused on the overall design and aesthetics of the space and controlling project costs, and back-of-the-house equipment is often a low priority. In addition, they often have established relationships with buying groups and may receive incentives for selling lower-end equipment. Equipment quality and performance are key selling points for engaging design consultants.

a higher first cost, it costs less to operate. With today's rising energy costs, efficient equipment will continue delivering dividends through lower utility bills for years to come. It is also important to highlight non-energy benefits of efficient products such as water savings, reduced noise, reduced waste heat, and other quality and performance features. Businesses that can effectively up-sell higher-end equipment can increase their bottom line.

**Sales incentives—**Upstream incentives, including salesperson incentives or "spiffs," can be effective at motivating equipment suppliers to promote the multiple benefits of energy-efficient products, rather than steering customers to low-cost products, which is the norm. Puget Sound Energy (PSE) offers a $30 "spiff" for each completed incentive application submitted by an equipment supplier; San Diego Gas & Electric Company (SDG&E) offers a $25 spiff.

### Program Highlight

**Puget Sound Energy's** $30 spiff rewards equipment suppliers for submitting completed incentive applications to the utility for processing on behalf of the customer. The supplier discounts the purchase price by the amount of PSE's customer rebate, so the customer receives an incentive at the point-of-purchase. Suppliers are reimbursed for the amount of the customer rebate, and get the $30 reward for their time and effort. This approach has led to higher turn-in rates for incentive applications, and fewer paperwork errors.

**Provide program information—**Providing easy access to up-to-date information about program offerings and procedures is essential to engaging and maintaining effective trade ally relationships. Initial kick-off workshops provide an opportunity to discuss the benefits of ENERGY STAR qualified CFS equipment and to inform participants of program requirements and incentive offerings. Conducting regular visits to trade ally showrooms/offices to discuss the program and distribute educational literature, point-of-purchase marketing materials, and incentive applications are also highly effective strategies for keeping trade allies informed. Other best practices include establishing a dedicated Web site and distributing electronic newsletters to keep equipment suppliers updated on program activities.

## Offering Customer Incentives to Overcome First-Cost Barriers

The incremental cost of some ENERGY STAR qualified equipment can be a significant barrier to purchasing products. In general, the incremental cost is highest for fryers and hot food holding cabinets; moderately high for commercial dishwashers, refrigerators and freezers, and ice machines; and lowest for steam cookers.

**Equipment rebates—**To overcome the significant barrier of incremental cost, the majority of CFS programs offer prescriptive rebates for the purchase of qualified equipment. Program administrators typically set incentive levels at 50 percent or less of the incremental cost of purchasing the ENERGY STAR qualified model versus a standard efficiency model. There is, however, no set formula for success when choosing equipment rebate levels, and CFS programs are achieving success with a range of levels. As of August 2008, the following incentive ranges were available from the online ENERGY STAR CFS equipment incentive finder tool.

**Table 1: Range of Incentives Offered by Program Sponsors (as of 5/09)***

| Product | Incentive Range |
|---|---|
| Fryers | $150–$1,000 |
| Hot food holding cabinets | $200–$500 |
| Refrigerators and freezers | $50–$500 |
| Steam cookers | $200–$1,500 |
| Ice machines | $50–$600 |
| Commercial dishwashers | $200–$2,000 |

Some programs, like Wisconsin's Focus on Energy, promote comprehensive kitchen efficiency upgrades by offering bonus incentives for the purchase of two or more pieces of qualified equipment. The customer is eligible for the usual per-unit equipment incentive, plus an additional $100 if they purchase two or more pieces of qualifying equipment, or $300 if they purchase three or more pieces of eligible equipment at a time. This strategy can be particularly effective when targeting commercial kitchen renovation and new construction opportunities.

The following are common best practices related to incentives:

- Tie incentive levels to ENERGY STAR specifications whenever possible to help customers easily identify products that qualify for rebates and to take advantage of the growing consumer awareness, market momentum, and supporting infrastructure provided by the program.
- Keep incentive application processes simple and straightforward.
- Maintain relatively consistent incentive levels from year to year, trending downward as market penetration increases.
- Ensure suppliers and buyers have easy access to a list of qualified models and related incentive levels. ENERGY STAR qualified product lists are available on each of the specific

* Note: *data include some programs offering incentives for equipment achieving higher efficiency levels than ENERGY STAR.*

product pages at *www.energystar.gov/cfs*. The California IOUs, which offer incentives for CFS equipment beyond ENERGY STAR qualified products, provide an online list of qualified equipment through PG&E's Food Service Technology Center (FSTC).

- Promote program and incentives through the online ENERGY STAR CFS equipment incentive finder tool (*www.energystar.gov/CFSrebate _ locator*).
- Educate customer call centers about program offerings, procedures, and where to direct customers for additional information.

**Audits—**Offering free or reduced-cost audits for commercial kitchen facilities is another form of incentive that can be useful for helping customers, particularly regional and national franchise chains, identify and correct operational inefficiencies, and for encouraging customers to take advantage of program rebate offerings when equipment purchases are needed. Customers are more likely to make smart decisions about CFS appliances if they have time to research options and secure the necessary capital to purchase new equipment. Many utilities offer audits to national restaurant chains as part of the menu of services they receive as managed accounts, and offer a higher level of support in helping such customers specify efficient equipment options for their facilities.

Audits can be offered for a nominal fee or at no cost to the customer. Some programs make a free audit contingent upon implementation of a minimum number of energy- and water-saving recommendations. Immediate energy savings benefits can be achieved by conducting direct installation of low-cost measures (e.g., high-efficiency pre-rinse spray valves, gaskets on refrigeration equipment, or compact fluorescent light bulbs).

### Program Highlight

To effectively serve the diverse set of CFS market participants, the programs sponsored by the **California IOUs** offer an array of services, including site audits, equipment testing, and new restaurant plan review, as well as regular energy efficiency seminars for food service professionals.

Audits help to develop the customer relationship, increasing the likelihood that the customer will take advantage of program offerings when it comes time to replace equipment or conduct comprehensive facility upgrades. To ensure that the program is viewed as a credible resource, it is critical that auditors be knowledgeable about the unique challenges and business realities of CFS operations, and deliver realistic recommendations. A recent evaluation of the PG&E's FSTC found that in order to deliver the most value to food service operators, audit reports should include detailed information on costs and savings associated with the recommended improvements.[9]

## Educating the Marketplace

Lack of knowledge about efficiency opportunities among end users and equipment suppliers, as well as misperceptions about tradeoffs between efficiency and performance, continue to inhibit greater adoption of energy-efficient equipment in the CFS market, despite improvements in this area since EPA introduced ENERGY STAR specifications for a variety of CFS products—as of May 2009, there are more than 98 ENERGY STAR CFS manufacturing partners and 2,600 qualified CFS products on the market.

The following strategies have been effective for getting information to end users to overcome these barriers:

**Target marketing—**Program information needs to be timely and relevant in order to motivate consumers to take action. For this reason, program administrators often develop targeted marketing strategies and messaging for each major market segment they are trying to reach—restaurants, hotels, schools, hospitals, etc.—taking into account business cycles and major industry events in timing promotions and outreach.

**Training and equipment demos—**Equipment suppliers may have little experience selling energy-efficient equipment, and they and their customers may be confused by different efficiency claims in the market or think energy efficiency comes with a tradeoff in productivity or product features. Equipment demonstrations and hands-on training can be particularly effective for persuading consumers that ENERGY STAR qualified CFS equipment comes with no tradeoffs in features or performance. Some programs have dedicated demonstration facilities for this purpose, while others work to assist suppliers in developing their own equipment demonstrations.

- PG&E's FSTC evaluation found that training seminars were a good way to build relationships with food service operators, leading to energy savings impacts over time.[10]
- New York State Energy Research and Development Authority's (NYSERDA) Small Commercial Kitchen Pilot successfully used cooperative marketing dollars to assist suppliers in developing their own equipment demonstrations (see text box on page 6).
- ETO gives an annual 45 minute sales training to CFS dealers to ensure sales staff understand the energy, monetary, and ancillary benefits of ENERGY STAR qualified CFS equipment.

**Cooperative marketing—**CFS programs create opportunities for cooperative advertising, showroom promotions and other collaborative marketing efforts with equipment suppliers. Programs often provide collateral marketing materials such as point-of-purchase banners, tags or stickers to identify rebate-eligible equipment, and informational flyers and brochures. Providing cooperative advertising funds is also an effective approach as it allows businesses the flexibility to market and advertise their ENERGY STAR qualified products in a way that is best aligned with their business model. For example, equipment suppliers that join

### Program Highlight

ETO developed a highly successful document modeled after CFS dealers' handbooks (folders with equipment specification and sell sheets) that dealers take with them on the road. The handbooks contain all the relevant information that a dealer would need to sell ENERGY STAR equipment, such as:

- What is energy efficiency
- What is ENERGY STAR
- List of incentives available in Oregon
- A territory map showing where incentives are available
- Qualified product lists
- Tables listing the energy, water, and monetary savings for energy-efficient equipment (e.g., fryers, ice machines, refrigerators)
- Ancillary benefits of ENERGY STAR equipment
- Incentive application forms

Alliant Energy's trade ally network can be reimbursed for up to 50 percent of the cost of cooperative advertising, subject to utility pre-approval and other minimum requirements. For CFS products that save energy and water—commercial dishwashers, ice machines, and steam cookers—a growing number of energy and water utilities are pursuing opportunities for cooperative marketing, joint program implementation, or both.

**Trade association outreach—**CFS programs can leverage existing trade association networks to raise awareness of program opportunities and boost participation by customers and suppliers. Program administrators should consider joining the local restaurant association and trade associations serving food service equipment suppliers, as well as state restaurant associations. Membership in these organizations will keep program managers abreast of developments in the industry and alert them to outreach opportunities available through trade shows, meetings, and monthly publications. Informational seminars, industry conferences, and well-crafted articles are excellent ways of reaching service decision-makers. At these events, program administrators can also conduct informational seminars and display information and materials to publicize CFS program offerings.

**Communications and outreach—**A robust communications plan utilizing multiple channels including newsletters, targeted mailings, personal contact, seminars, and electronic communications increases awareness of program opportunities. Personal contact (i.e., "face time") is extremely important for implementing a successful program. Energy efficiency is a new concept in the CFS market and supply channel actors often need additional support from utilities before stocking, promoting, and selling energy-efficient CFS equipment. Program administrators can contact ENERGY STAR for assistance in identifying trade allies and developing outreach materials.

### Program Highlights

1) **CenterPoint Energy** (MN) uses its Commercial Food Service Learning Center in Minnesota to provide hands-on education to trade allies about the benefits of high-efficiency equipment. CenterPoint is also a member of several food service trade associations and regularly attends the **Upper Midwest Restaurant Show.**

2) Distributor **Saratoga Restaurant Equipment Sales** (SRES) leveraged cooperative marketing opportunities through **NYSERDA's Small Commercial Kitchen Pilot** and increased sales of qualified equipment by 50 to 900%, depending on the product. Promotional efforts included a showroom event and equipment demonstration, hang tags on qualified equipment, and direct mail. SRES also streamlined the application process by filling out rebate paperwork on the customer's behalf.

3) As part of their program outreach activities, the four **California IOUs** attend the annual **Western Food Service and Hospitality Expo** in Los Angeles. The show is a great way for California program sponsors to engage with trade allies and to reach their key audience: restaurants.

## Motivating Behavior Change and Continuous Energy Performance Improvement

In addition to purchasing energy and water efficient equipment, there are a number of operational best practices that program administrators can share with food service operators. The ENERGY STAR Restaurant Guide provides both short- and long-term recommendations for saving energy in commercial kitchens, equipment use and maintenance tips, and general energy savings tips, in addition to outlining the benefits of energy-efficient equipment installation. Program administrators can use this guide as part of education efforts with commercial kitchen customers to promote additional savings. EPA's Portfolio Manager tool can also be used to obtain a weather-normalized energy performance benchmarks for buildings, assisting food service operators in tracking their building's energy use and reducing it over time.

EPA also works cooperatively with the Consortium for Energy Efficiency (CEE) Commercial Kitchens Initiative. CEE is a nonprofit corporation whose membership includes utility, state, and nonprofit administrators of energy efficiency programming. The goal of the initiative is to define a high performance commercial kitchen package that CEE members can deliver to customers in targeted CFS sectors. A bundled whole-kitchen approach may be particularly appropriate for new construction or major renovation projects. For more information, please visit: *www.cee1.org/com/com-kit/com-kit-main.php3*

### Program Highlight

**PG&E** has developed a Food Service Edition of the Smart Business Rebate Booklet identifying over $6,000 in rebates for the food service industry. The booklet provides information on nearly two dozen ways that PG&E can help customers save energy in commercial kitchens. The booklet tells customers how to apply for rebates, how to access education and training through PG&E's Food Service Technology Center, and how to develop an energy management plan using PG&E's online tool, SmartEnergy AnalyzerTM.


## MEASUREMENT AND VERIFICATION

Measurement and verification (M&V) are central to the success of energy efficiency programs, and are used to assess the market during program design, monitor program performance during program implementation, validate program impacts, and justify continued investment in a program.

During the program planning and design phase it is important to establish a baseline and capture important data before it is lost.

### Baseline Assessment

During the program planning process, it is useful to develop a baseline market assessment of the energy savings potential from commercial kitchens. This baseline will allow program managers to set realistic savings goals and design programs that are well-suited for the target market. Understanding market potential and the market penetration of energy-efficient CFS equipment is well worth the effort, providing valuable insights into how the program should be delivered, and what incentive levels would be cost-effective and successful at moving the market.

Many program administrators quantify kWh savings potential by customer segment. Some market assessments employ a survey process to develop baseline assumptions. At a minimum, a market assessment will identify the number of independently owned and franchised restaurants, hospitality businesses, and large institutional users of CFS equipment (e.g., hospitals, schools, prisons) within the service territory, and provide general information on the baseline equipment installed in such facilities. Growth projections for key end-use sectors and annual run time for qualified equipment are also useful metrics to include.

### Program Tracking

Developing and maintaining a program tracking system is important for measuring program progress and tracking energy savings. Program administrators have found the following indicators useful in tracking program performance over time: energy savings (kWh and kW) from approved incentive applications; level of rebate activity by product type; level of rebate activity by customer type (restaurant, hospitality, etc.); trade ally participation; and program costs.

Incentive applications are an important source of information for collecting basic information not only to justify rebate payment, but also to inform future program impact evaluation. The following are commonly required inputs:

- Customer contact information
- Type of facility (restaurant, hotel, etc.)
- Equipment type
- Manufacturer
- Model number
- Equipment cost
- Number of qualified units installed
- New installation or retrofit
- Proof of purchase (including serial number)
- Trade ally contact information (if trade ally incentives are offered)

It is important to keep in mind the significant lag time between implementing a program and achieving program results. According to PG&E, CFS incentive programs take approximately 12 months to demonstrate changes in equipment stocking, selling, and purchasing behavior.

### Process and Impact Evaluation

CFS programs are typically subject to two types of evaluations: process evaluation and impact evaluation. Process evaluations review program design and implementation to assess what elements of the program are working well and identify opportunities for improvement. Impact evaluations estimate the energy and demand savings that directly result from a program. The Model Energy Efficiency Program Impact Evaluation Guide, a resource of the National Action Plan for Energy Efficiency, is a useful resource for learning more and is available at *www.epa.gov/cleanenergy/documents/evaluation _ guide.pdf*

## PROGRAM COST EFFECTIVENESS

ENERGY STAR qualified CFS equipment provides substantial savings opportunities for program administrators. While CFS programs can be operational within a two to four month period, given the diffuse nature of the distribution and purchasing patterns associated with this equipment, seeing significant progress in terms of program participation may take as long as one year.

Measure-level cost-effectiveness analysis, conducted during program planning, requires data on incremental measure cost, per-unit savings (kW, kWh, therms), annual hours of operation, and measure life. Program administrators typically base hours of operation assumptions on the type of facility where the equipment is installed (e.g., full service restaurant, quick service restaurant, hospital, school). As refrigeration measures are weather-sensitive,

**Figure 1: Example of Co-Branded Marketing Document**


ENERGY STAR supports development of co-branded marketing materials, like this flyer from **Wisconsin's Focus on Energy** highlighting the benefits of ENERGY STAR qualified equipment.

savings assumptions may vary based on the climate zone where the equipment is installed.

Measure-level data are available from a number of public sources, including the following:

- The Database for Energy-efficient Resources (DEER), maintained by the California Energy Commission and California Public Utilities Commission: *www.energy.ca.gov/deer*
- Program work papers filed by the California IOUs, available through the Energy Efficiency Groupware Application: *http://eega2006.cpuc.ca.gov*
- PG&E's FSTC Web site: *www.fishnick.com*
- NYSERDA also has a Deemed Savings Database, available by request

Table 2 presents program administrator cost (PAC) effectiveness results for three existing programs that provide incentives for ENERGY STAR qualified CFS equipment. These calculations only include the equipment incentive and administrative costs, but are estimated for the useful life of the equipment and discounted to net present value using 7 and 9 percent discount rates.

Program administrator costs are different, and usually lower than, total resource cost (TRC), which include the end users' marginal cost for purchasing energy-efficient equipment. For example, PG&E's PAC cost per kWh is estimated at $0.04 for both 7 and 9 percent discount rates; TRC is estimated

**Table 2: Estimated Program Cost Effectiveness for Three Utilities***

| | Pacific Gas & Electric Company[11] (PG&E) | Southern Minnesota Municipal Power Agency[12] (SMMPA) | Energy Trust of Oregon[13] (ETO) |
|---|---|---|---|
| Implementation Period (years) | 2.75 | 2.00 | 4.00 |
| Implementation Dates | 01/06 to 09/08 | 05/06 to 05/09 | 05/05 to 04/09 |
| Total Rebated Units | 3,026 | 60 | 4,757 |
| Gas | 858 | 7 | 2,601† |
| Electric | 2,168 | 53 | 2,156 |
| Total Therms Saved | 490,625 | 1,402 | 458,970 |
| Total KWh Saved | 13.3 million | 183,147 | 3.4 million |
| Levelized CCE - Natural Gas ($/Therm)° | $1.06 –1.18 | $1.54 – 1.70◊ | $0.44 – 0.47◊,† |
| Levelized CCE - Electricity ($/kWh)° | 0.04 | $0.01◊ | $0.10 – 0.11◊ |

* Levelized Cost of Conserved of Conserved Energy (CCE) estimates using the Program Administrator Cost Test (also known as the Utility Cost Test).

° Levelized CCE is presented using a range for discount rates of 7% and 9%.

◊ Administrative costs: for ETO and SMMPA an administrative cost of 11% was used in calculating CCE based on a published cap on administrative costs from the Oregon Public Utility Commission (www.energytrust.org/who/090323_Facts_EnergyTrust.pdf). PG&E data includes administrative costs supplied by the utility in program files and imbedded in measure level estimates.

† Includes 2,202 low-flow pre-rinse spray valves (PRSVs) provided free of charge to restaurants by ETO.

between $0.12 and $0.13 per kWh for the same discount rates (9 and 11 present respectively).11 The difference between these two estimates is the end users' added costs for purchasing the equipment. Utilities should analyze both PAC and TRC when deciding what types of equipment to incentivize.

## ENERGY STAR SUPPORT FOR CFS PROGRAMS

In order to take full advantage of the ENERGY STAR platform for CFS programs, program administrators sign an ENERGY STAR Partnership Agreement with the government. The ENERGY STAR Program has an established national network of program administrators, equipment manufacturers, and marketing support firms that can provide advice and technical assistance during program start-up and implementation. Examples of support and resources include:

- **Specifications**—ENERGY STAR specifications currently cover six CFS equipment types, with new product categories evaluated every year. Information on new specifications and revisions to existing specifications is available at *www.energystar.gov/productdevelopment*.

**Figure 2: Example of Co-Branded Incentive Booklet**


Be creative when publicizing your programs! Southern Minnesota Municipal Power Agency created the Food Service Equipment Rebate booklet to showcase the comprehensive incentive program they developed for their 18 Member utilities. The booklet includes information on the utility's CFS equipment rebates, emphasizes ENERGY STAR's role in CFS market transformation, and provides product- and market-specific information for end users.

The Food Service Equipment Rebate booklet is available at: *http://www.SaveEnergyInBloomingPrairie.com/Upload/FoodServiceBooklet.pdf*

- **Marketing tools and resources**—Downloadable logos, equipment-related information, and educational tools like the ENERGY STAR Guide for Restaurants allow program administrators to customize a variety of marketing and informational materials, while using high-quality ENERGY STAR graphics and language that effectively describes how ENERGY STAR works in commercial kitchens (see figure 1 and 2).
- **Training resources**—A variety of materials are available to support program training activities, including customizable train-the-trainer presentations and opportunities for online or in-person training conducted by PG&E's FSTC (minimum participation requirements apply).
- **Partner matchmaking**—ENERGY STAR facilitates contacts between energy efficiency program administrators and manufacturers, equipment suppliers, and restaurant associations to support program marketing and outreach.
- **Savings calculators**—Spreadsheet tools estimate lifecycle energy, water, and cost savings for each category of ENERGY STAR qualified CFS equipment and are available at *www.energystar.gov/cfs* by clicking on the relevant product page.
- **Manufacturer and product lists**—Regularly-updated lists of equipment models that have earned the ENERGY STAR support rebate verification activities and are available at *www.energystar.gov/cfs* by clicking on the relevant product page.
- **Best practices tools**—Spreadsheet tools for quick service restaurants and full service restaurants estimate lifecycle energy and cost savings from additional energy-efficient food service equipment categories not currently covered by ENERGY STAR, and are available at *www.energystar.gov/cfs*.
- **CFS Equipment Incentive Finder**—Online database of available rebates for qualified equipment is searchable by zip code or by product type and is available at *www.energystar.gov/CFSrebate _ locator*.
- **CFS Program Guide**—Regularly-updated publication informs food service equipment suppliers about cross-promotional opportunities available through efficiency programs.
- **CFS newsletter**—Bimonthly electronic publication is distributed to industry associations, equipment suppliers, and efficiency program administrators highlighting efforts to promote ENERGY STAR qualified CFS equipment.
- **Case studies**—Success stories highlight commercial kitchens saving energy and money by leveraging energy efficiency programs and purchasing ENERGY STAR qualified equipment.

## RESOURCES FOR ADDITIONAL INFORMATION

The following links are useful resources for energy efficiency program administrators that would like to learn more.

- ENERGY STAR for Commercial Food Service: *www.energystar.gov/cfs*

- ENERGY STAR for Restaurants: *www.energystar.gov/restaurants*
- ENERGY STAR Purchasing and Procurement with Product Savings Calculators: *www.energystar.gov/purchasing*
- ENERGY STAR Small Business Network: *www.energystar.gov/smallbiz*
- CEE Commercial Kitchens Initiative: *www.cee1.org/com/com-kit/com-kit-main.php3*
- PG&E's FSTC: *www.fishnick.com*
- GasNetworks: *www.gasnetworks.com/efficiency/pdf/Fryer_Rebate_Form_07_08.pdf*
- Green Restaurant Association: *www.dinegreen.com*
- National Restaurant Association: *www.restaurant.org*
- National Restaurant Association Conserve Initiative: *www.conserve.restaurant.org*
- North American Association of Food Equipment Manufacturers (NAFEM): *www.nafem.org*

## PROGRAMS PROMOTING ENERGY STAR QUALIFIED CFS EQUIPMENT

Selected efficiency programs offering rebates for ENERGY STAR qualified CFS equipment include:

- Avista Utilities: *www.avistautilities.com/business/rebates/washington_idaho/Pages/incentive_7.aspx*
- The Energy Trust of Oregon: *www.energytrust.org/buildingefficiency/restaurants.html*
- MidAmerican Energy: *www.midamericanenergy.com/kitchen*
- New York State (NYSERDA): *www.nyserda.org/Commercial_Industrial/CommercialKitchens/default.asp*
- Pacific Gas & Electric Company: *www.pge.com/mybusiness/energysavingsrebates/incentivesbyindustry/hospitality*
- Puget Sound Energy: *www.pse.com/solutions/forbusiness/pages/comRebates.aspx?tab=4&chapter=4*
- San Diego Gas & Electric Company: *www.sdge.com/foodservice*
- Southern California Edison: *www.sce.com/RebatesandSavings/SmallBusiness/ExpressEfficiency/FoodServiceEquipment*
- Southern Minnesota Municipal Power Agency (SMMPA): *www.smmpa.org/members.asp?utility=59&service=326*
- Wisconsin's Focus on Energy: *www.focusonenergy.com/foodserviceincentives*

## SOURCES


1 Consortium for Energy Efficiency. Commercial Kitchens Fact Sheet. Available at: *www.cee1.org/resrc/facts/comkit-fx.pdf*

2 PG&E Food Service Technology Center.

3 National Restaurant Association (2008). 2007/2008 Restaurant Industry Operations Report, as cited in National Restaurant Association, 2008 Restaurant Industry Forecast.

4 PG&E Food Service Technology Center.

5 California Public Utilities Commission (CPUC) (2008). Energy Efficiency Groupware Application, 4th Quarter 2007 E3 Calculators. Available at: *http://eega2006.cpuc.ca.gov*

6 Personal communication, Energy Trust of Oregon, July 9, 2008.

7 Personal communication, Wisconsin's Focus on Energy, July 16, 2008.

8 U.S. Department of Agriculture Economic Research Service. Briefing Room: Food Marketing System in the United States. Available at: *www.ers.usda.gov/Briefing/FoodMarketingSystem/foodservice.htm*

9 PA Consulting Group (2008). Pacific Gas & Electric: Process Evaluation and Strategic Assessment of the Food Service Technology Center. Available at: *www.calmac.org/publications/PGE_FSTC_Eval__Report_-_Final_Feb_14_2008.pdf*

10 PA Consulting Group (2008). Pacific Gas & Electric: Process Evaluation and Strategic Assessment of the Food Service Technology Center. Available at: *www.calmac.org/publications/PGE_FSTC_Eval__Report_-_Final_Feb_14_2008.pdf*

11 Pacific Gas and Electric Company. E-mail communication and data sharing, January 2009.

12 Southern Minnesota Municipal Power Agency. E-mail communication and data sharing, April 2009.

13 Energy Trust of Oregon. E-mail communication and data sharing, April 2009.


ENERGY STAR®, a program sponsored by the U.S. EPA and DOE, helps us all save money and protect our environment through energy-efficient products and practices. Learn more. Visit www.energystar.gov.

ENERGY STAR

Date of Request: April 13, 2016 DPS Request No. DPS-426 JL-5
Due Date: April 25, 2016 KEDNY/ KEDLI Req. No. BULI-462

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, James Lyons

TO: National Grid, Sean Mongan

SUBJECT: **SALES PROMOTION EXPENSE - KEDLI**

Request:

Provide the following:

1. Identify and explain what sales promotion activities were performed by the Company (KEDLI) during the historic test year for the $1,040,000? Provide the cost breakdown in the same format as the information provided by the Company in Exhibit____(SPM-2).

2. What additional activities, if any, will be performed in the Rate Year and Data Years with the additional $950,000? Provide an updated Exhibit____SPM-2 with a breakdown of the sales promotion activities to reflect the total dollars to be spent by the Company for sales promotion activities in the Rate Year and Data Years, combining the historic sales promotion expenses of $1,040,000 and the requested sales promotion expenses of $950,000.

3. How will the additional sales promotion expense dollars requested by the Company help achieve the load reflected in the Company's sales forecast? Specifically, identify the level of customer additions and load growth expected if sales promotion expenses were cut to $0, left at the existing $1,040,000, and increased to $1,990,600 as requested by the Company. For each of these scenarios, identify the number of customers and additional load, anticipated to be added resulting from these sales promotion expenditures.

4. On p. 5 you state that sales promotion activities will promote cost effective load growth through incremental conversion and the retention of existing load. Explain how sales promotion expenses will contribute to net load growth through retention of existing load and identify which customer classes will directly benefit from these expenditures

5. The Neighborhood Expansion Program, case 14-G-0214, is set to expire on December 31, 2016. KEDLI requests a three-year extension of this successful program. Provide an explanation and examples of the metrics used by KEDLI to label the program as a success. Identify and explain what metrics does the Company propose be used to support this program as a successful program and provide any analysis of the costs/benefits of this program?

6. For the proposed residential rebate program, historically $46,000 and with a proposed incremental increase of $200,000, explain what does the Company propose to do with any unspent rebate dollars at the conclusion of the Rate Year and Data Years?

7. Provide the work papers supporting the $750 savings and the $210 incremental margin associated with a service line extension at the time of main replacement.

8. Provide the reports and data points the Company uses to monitor the success of its sales promotion payback over a nine-year period (*see*, KEDLI testimony p. 12).

Response:

1. Please see the following chart describing sales promotion activities in the Historic Test Year:

| Channel | Description | KEDLI |
|---|---|---|
| Direct Mail* | Initial Direct Mail campaigns and follow-up initiatives | $595,419 |
| Television | :10 TV Billboards on News 12 Long Island | $116,192 |
| Co-Op Advertising | Plumber outreach postcards | $86,254 |
| Digital/Mobile Ads | Digital and mobile ads to target people to convert on LI | $83,956 |
| Sales Promotion | Residential Rebate Program-Sales Promotion | $46,800 |
| Email | Email campaigns | $40,234 |
| Outbound Telemarketing | Outbound Telemarketing for additional outreach/follow-up | $21,863 |
| Construction Support | Marketing materials to support main replacement efforts | $8,325 |
| Events | Tabling and Collateral material | $7,700 |
| Plumber Outreach | Outreach materials for plumbers | $7,472 |
| Sales Materials | Collateral material to help support Sales team | $6,874 |
| Social Media | Full year of SEM and Facebook posts | $2,000 |
| Website Content | Develop content on the website to drive conversions | $5,257 |
| Door hangers | Door hangers to targeted areas to get them to convert | $4,895 |
| Community meetings | Direct Mail and Collateral material | $3,968 |
| Services not burning letters | Letters to Services not burning | $2,587 |
| Employee Notifications | At-a Glance communications to employees | $850 |
| **Total Cost:** | | **$1,040,647** |

**Cost includes the printing and postage.*

2. Please see the following chart showing total spending of $1,990,646 for the Rate Year and Data Years:

| Channel | Description | KEDLI | Additional Spend | Total |
|---|---|---|---|---|
| Direct Mail* | Initial Direct Mail campaigns and follow-up initiatives | $595,419 | $115,000 | $710,419 |
| Sales Promotion | Residential Rebates | $46,800 | $450,000 | $496,800 |
| Television | :10 TV Billboards on News 12 Long Island | $116,192 | $125,000 | $241,192 |
| Email | Email campaigns | $40,234 | $103,000 | $143,234 |
| Outbound Telemarketing | Outbound Telemarketing for additional outreach | $21,863 | $92,000 | $113,863 |
| Co-Op Advertising | Plumber outreach postcards | $86,254 | $0 | $86,254 |
| Digital/Mobile Ads | Digital and mobile ads to target people to convert on LI | $83,956 | $0 | $83,956 |
| Website Content | Develop content on the website to drive conversions | $5,257 | $29,100 | $34,357 |
| Sales Materials | Collateral material to help support Sales team | $6,874 | $14,200 | $21,074 |
| Construction Support | Marketing materials to support main replacement efforts | $8,325 | 4000 | $12,325 |
| Events | Tabling and Collateral material | $7,700 | $3,700 | $11,400 |
| Plumber Outreach | Outreach materials for plumbers | $7,472 | $3,000 | $10,472 |
| Community meetings | Direct Mail and Collateral material | $3,968 | $5,000 | $8,968 |
| Social Media | Full year of SEM and Facebook posts | $2,000 | $6,000 | $8,000 |
| Door hangers | Door hangers to targeted areas to get them to convert | $4,895 | $0 | $4,895 |
| Services not burning | Letters to Services not burning | $2,587 | $0 | $2,587 |
| Employee Notifications | At-a Glance communications to employees | $850 | $0 | $850 |

**Cost includes the printing and postage.*

3. The sales promotion expense promotes awareness, generates new leads and provides incentives to achieve the sales forecast. The level of additions associated with the identified levels of spending cannot be accurately forecast as the price difference between oil and natural gas and general economic conditions are larger drivers of added load and impact the outcome of the sales promotion expense.

4. Sales promotion activities help to promote the overall awareness of the value of natural gas service for both current and prospective customers. Although retention of existing customers is not presently a large issue, there are options for customers as their equipment breaks down or comes to the end of its useful life. The overall market messages that promote the value of gas help to keep a new gas appliance as a customer's first choice and may help to offset any messaging about new non-gas fired products. This messaging has a greater impact in the residential market based on volume of equipment turnover and number of alternatives.

5. The program is a success as it has provided access to natural gas to previously un-served areas that meet the density and initial connection requirements of the program. The program's metric for success is achieved when the Company is able to connect to an un-served area because a sufficient number of customers (as set forth in the program's guidelines) have chosen to connect for service. Longer term success will be based on the overall program portfolio achieving results that are consistent with tariff requirements. This will be supported with ongoing promotion and education of customers along the route of a Neighborhood Expansion main extension.

6. If a multi-year rate plan is adopted, any unspent funds will carry forward during the term of the rate plan and, upon conclusion of the plan, be refunded to customers if they are not used to provide rebates. If a one year case results, the Company would be willing to defer any unspent amount.

7. The estimated savings of $750 expected from the installation of a new service when a road or street is already open were derived from a comparison of contractor bids for both scenarios. The anticipated revenue of $210 from new residential non- heating customers is derived from a weighted average of the expected types of appliance and the Company's adjusted annual revenue net of fuel for each of those applications. It is projected that 75% of the new non-heat customer usage would be from either a new stove or dryer at $183 of annual New Delivery Revenue (NDR) each and 25% to be water heating at $279 NDR each. The weighted average NDR as shown in the testimony is derived as follows:

   (($183*75%) + ($279*25%)) = $207

   There are no workpapers associated with these calculations.

8. No specific reports are prepared or maintained to show the success of the sales promotional payback over the past nine years. However, in the response to question 8 of DPS-289, the Company provided the methodology and support for determining the payback for the Historic Test Year and Rate Year based on costs and expected revenue.

<u>Name of Respondent</u>:
Keith Sperling, Christine Kivia/Chris Cavanagh

<u>Date of Reply</u>:
April 25, 2016

Date of Request: April 13, 2016 DPS Request No. DPS-427 JL-6
Due Date: April 25, 2016 KEDNY/ KEDLI Req. No. BULI-463

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, James Lyons

TO: National Grid, Sean Mongan

SUBJECT: **SALES PROMOTION EXPENSE – KEDNY**

Request:

Provide the following:

1. Identify and explain what sales promotion activities were performed by the Company (KEDNY) during the historic test year for the cost of $557,081? Provide the cost breakdown in the same format as the information provided by the Company in Exhibit____(SPM-2)

2. Explain why sales promotion expenses beyond the historic level of $557,081 will not increase and describe whether this is consistent with your request for KEDLI?

3. How will the sales promotion expense dollars requested by the Company help achieve the load reflected in Company's sales forecast? Specifically, identify the level of customer additions and load growth expected if sales promotion expenses were cut to $0, left at the existing $557,081, increased beyond the requested level, and equivalent to those sales promotion dollars requested for KEDLI? For each of these scenarios, identify the number of customers and additional load, anticipated to be added resulting from these sales promotion expenditures.

4. You state that sales promotion activities will promote cost effective load growth through incremental conversion and the retention of existing load. Explain how sales promotion expenses will contribute to net load growth through retention of existing load and identify which customer classes will directly benefit from these expenditures?

5. Explain why the Company is not proposing a Neighborhood Expansion Program for KEDNY and provide any analysis or supporting documentation underlying the decision not to propose a Neighborhood Expansion Program.

6. On p. 9 of your KEDLI testimony you identified an approximate savings of $750 associated with a service line extension if it is done at the same time as a planned main replacement with a $210 incremental margin. Explain why the Company has not requested a similar customer rebate for customers located in the KEDNY service territory. What would the savings and additional margin be for customers converting from non-firm or no heat service classes to firm heating classes?

7. Provide the reports and data points the Company uses to monitor the success of its sales promotion payback over a nine-year period (*see*, KEDNY testimony p. 6).

<u>Response</u>:

1. Please see the following chart describing sales promotion activities in the Historic Test Year:

| Channel | Description | KEDNY |
|---|---|---|
| Direct Mail* | Initial Direct Mail campaigns and follow-up initiatives | $390,472 |
| Email | Email campaigns | $31,478 |
| Sales Materials | Collateral material to help support Sales team | $8,743 |
| Web site updates | Updates to the website with any updated forms | $1,880 |
| Plumber Outreach | Outreach materials for plumbers | $67,514 |
| Outbound Telemarketing | Outbound Telemarketing for additional outreach/follow-up | $56,994 |
| **Total Cost:** | | $557,081.00 |

**Cost includes the printing and postage.*

2. The market conditions in KEDNY's service territory are different than those in KEDLI's service territory. Unlike KEDLI, KEDNY's service territory has a high saturation of natural gas and new construction is driving the market. Therefore, KEDNY is not forecasting an incremental increase in sales promotion expense.

   The market conditions driving KEDLI's need for incremental sales promotion expenses are discussed in the testimony of Sean P. Mongan.

3. The sales promotion expense promotes awareness, generates new leads and provides incentives to achieve the sales forecast. The level of additions associated with the identified levels of spending cannot be accurately forecast as the price difference between oil and natural gas and general economic conditions are larger drivers of added load and impact the outcome of the sales promotion expense.

4. Sales promotion activities help to promote the overall awareness of the value of natural gas service for both current and prospective customers. Although retention of existing customers is not presently a large issue, there are options for customers as their equipment breaks down or comes to the end of its useful life. The overall market messages that promote the value of gas help to keep a new gas appliance as a customer's first choice and may help to offset any messaging about new non-gas fired products. This messaging has a greater impact in the residential market based on volume of equipment turnover and number of alternatives.

5. The Company is not proposing a Neighborhood Expansion Program for KEDNY because of the high saturation of natural gas in its service territory.

6. Because of the high saturation of natural gas in KEDNY's service territory, there is minimal opportunity to connect new customers in conjunction with the main replacement program. KEDNY will review the results of KEDLI's main replacement program and, if successful, would consider it at a later date. For the non-heat to heating conversions in KEDNY's residential market, the vast majority of customers do not require a new service. The decoupled revenue associated with a residential non-heat to heating conversion is $396.

7. No specific reports are prepared or maintained to show the success of the sales promotional payback over the past nine years. However, in the response to question 8 of DPS-289, the Company provided the methodology and support for determining the payback for the Historic Test Year and Rate Year based on costs and expected revenue.

<u>Name of Respondent</u>: Keith Sperling/Christine Kiviat/Chris Cavanagh

<u>Date of Reply</u>: April 25, 2016

Date of Request: April 14, 2016 DPS Request No. DPS-435 JL-7
Due Date: April 25, 2016 KEDNY/ KEDLI Req. No. BULI-471

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, James Lyons

TO: National Grid, Sean Mongan

SUBJECT: Natural Gas Vehicles - KEDNY

Request:

1. On p. 17 of your testimony, you identify that the price advantage that compressed natural gas (CNG) has enjoyed over gasoline fuel has declined in the last few years. Provide the average price for a CNG gasoline gallon equivalent and a gallon of gasoline for the past five years (2011 to 2015). Include the gasoline gallon equivalents (GGE) sold, by station, within KEDNYs service territory for the same five year period.

2. Provide information regarding the price advantage that CNG has enjoyed over diesel fuel and changes in that advantage in the last five years. Provide the average price for a CNG diesel gallon equivalent and a gallon of diesel fuel for the past five years (2011 to 2015). Include the diesel gallon equivalents (DGE) sold, by station, within KEDNYs service territory for the same five year period.

3. For the KEDNY service territory, has the Company developed information regarding the numbers and types of vehicles with the potential to convert from gasoline and /or diesel to CNG within its service territory? Has the Company developed or does it have access to information regarding the numbers and types of vehicles that have converted from gasoline or diesel and the level of displacement or elimination of the associated pollution by fuel type?

4. Identify the total number of individual CNG vehicles that have utilized CNG stations located in KEDNY's service territory. Provide the monthly and annual totals for the past five years (2011 through 2015).

5. On p. 17 of your testimony, you identify that government incentives and grants have been reduced or eliminated. Provide a listing of the individual incentives and grants provided by the government and the amount and timing of these program changes.

6. On p. 19 of your testimony, you identify the cost of the proposed Natural Gas Vehicle (NGV) incentive program would be capped at $475,000 annually to enable the Company to provide up to a $1,200 incentive for approximately 395 new NGVs. Has the Company evaluated the potential for NGV conversions within its service territory and developed a targeted marketing plan to acquire 395 vehicles per year? If so, provide a copy of the analyses developed by the companies. If not, what is the basis for the estimate of 395 NGVs?

7. What is the Company's plan to address unspent monies collected for this rebate program? Explain whether the plan addresses these unspent monies annually or over the term of a multi-year rate plan, were one to be adopted in this case?

<u>Response</u>:

1. Attachment 1 sets forth both the gallon gas equivalent and diesel gas equivalent sold, by station, within KEDNY's service territory for calendar year (CY) 2011 through CY 2015. National Grid does not set the price or have pricing information for Compressed National Gas (CNG) stations, with the exception of the Company-owned fueling station at JFK Airport that operated until March of 2015; that station sold CNG under SC-14 of the Company's tariff. The fuel sold at JFK was a relatively small volume and not representative of the market. The actual pricing at CNG stations is set by the station's operator. The Company has estimated the price differential for uncompressed gas that is compressed, treated and dispensed into vehicles. The second tab of Attachment 1 includes an estimate of the typical cost of fuel supplied to these CNG stations and an estimate of the fuel price differential for natural gas for CY 2011 through CY 2015.

2. Please see the response to question 1 and Attachment 1.

3. Because the Company does not manage retail fueling, it does not have specific information on the types of vehicles being fueled. Most CNG vehicles are now acquired new from original equipment manufacturers or their designated upfitters. The Company does not have specific data on the numbers or types of vehicles that have been converted or have the potential to convert. The types of vehicles being fueled can be inferred from customer information. Referring to the stations identified in Attachment 1, from observation, vehicles that utilize the National Grid-owned stations are typically medium or light-duty trucks, vans and sedans with occasional heavy-duty trucks. The majority of CNG dispensed in KEDNY's service territory is for public transit buses and municipal garbage trucks.

   The Company previously purchased fleet registration data from vendors. One such list, purchased in 2007, indicated that there were at least 98 commercial fleets based in KEDNY's service area each with 50 or more vehicles and more than 500 fleets of all sizes. There are in excess of 3,600 public transit buses in NYC and over 13,000 medallion taxis.

The environmental benefits of natural gas vehicles (NGVs) have been documented in a variety of studies by the USDOE, USEPA and others and will vary by vehicle type.[1] NGVs generally result in a reduction of greenhouse gases by as much as 25% over traditional fuels. NGVs also reduce criteria pollutants such as smog and acid-rain producing emissions (*e.g.,* NOx) by as much as 60%. In addition, NGVs that would otherwise have been fueled with diesel result in the elimination of up to 90% of particulate matter. For additional information on displacement or elimination of pollutants, please refer to Attachment 2, page 9 of the Executive Summary. At the current rate of use, CNG in NYC is estimated to avoid the emission of approximately 48,000 tons per year $CO_2$.

4. The Company does not have specific information on the types and numbers of individual vehicles using CNG stations. The first tab of Attachment 1 includes an estimate of the average numbers of vehicles using these stations based on typical annual usage of commercial vehicles. The average over the past five years is the equivalent of approximately 850 vehicles exclusively using these stations.

5. There have been significant changes in the incentives and grants available in NYS in recent years, including the following;

   a. Fueling equipment for natural gas, installed between January 1, 2015, and December 31, 2016, is eligible for a federal tax credit of 30% of the cost of a fueling station, not to exceed $30,000. This incentive has recently been as low as $1,000 while the original incentive was a tax deduction of $100,000 for an investment in a station and up to $25,000 for each vehicle.

   b. The NYS alternative fuels credit expired on December 31, 2010. As of January 2013, NYS reduced the new credit for each installation of property to the lesser of $5,000 or 50% of the cost of property. The credit previously was 50% of the cost of clean fuel refueling property limited by the Customer's tax. See NY Tax Law section 187-b.

   c. There currently is a federal Volumetric Excise Tax credit for alternative fuels valued at $0.50 per GGE. However, this credit expired three times and has been retroactively reinstated through 12/31/2016.[2]

   d. Federal grant funding is facilitated by the USDOE Clean Cities program. There was significant competitive federal grant funding available for vehicles and stations prior to and through the 2009 American Reinvestment and Recovery Act, but the Company is not aware of any significant federal funding opportunities since.

   e. The 2013 New York City Alternative Fuel Vehicle - Voucher Incentive Fund is managed by NYSERDA and has been extended. It offers up to 80% of the incremental cost of an

[1] See http://www.afdc.energy.gov/vehicles/natural_gas_emissions.html
[2] See http://www.afdc.energy.gov/laws/319

alternative fuel Class 3 to 8 truck or bus operating in NYC that meets certain qualifications. Vehicles operated by public agencies are not eligible. Funds have been awarded on a first-come first served basis. The program has a fixed budget and is expected to permanently close when any remaining funds are committed.[3]

6. A review of NYSERDA and EIA data indicated that CNG market share in NYS is about 0.5%[4] in terms of vehicle fuel. America's Natural Gas Alliance commissioned a detailed study in 2013 that estimated that a realistic potential of 6% market share for CNG was possible by 2035.[5] The Company has not yet developed a new marketing plan but will do so upon approval of the funding proposed in the case in collaboration with NGV developers operating in NYC and through direct interaction of the Company's sales force and the Empire Clean Cities organization.

   The target for the incentive will be to support the fuel equivalent of 395 light-or medium duty vehicles that utilize 1,500 GGE each annually. As the market data show, there is more potential than the incentive could support. Attachment 1 shows that NGV use in NYC has essentially been flat for the past five years. The proposed incentive could restore a growth rate of about 10% over the term of the rate plan in terms of fuel use at existing CNG stations.

7. If a multi-year rate plan is adopted, any unspent funds will carry forward during the term of the rate plan. If a one year case results, the Company would be willing to defer any unspent amount.

Name of Respondent:
Christopher Cavanagh/Keith Sperling

Date of Reply:
April 25, 2016

[3] See https://truck-vip.ny.gov/WhatisNYT-VIP.php
[4] See USEIA & Patterns and Trends New York State Energy Profiles: 1999-2013 Final Report, NYSERDA 2015
[5] See "U.S. and Canadian Natural Gas Vehicle Market Analysis: Natural Gas Vehicle, Industry Overview", p 9. America's Natural Gas Alliance & TIAX Corp. 2013 Included as Attachment 2.

U.S. and Canadian Natural Gas Vehicle Market Analysis:

# Natural Gas Vehicle Industry Overview

## Executive Summary

Published by America's Natural Gas Alliance

The opinions expressed within the Executive Summaries of Modules 1 and 2 of this market assessment are the work product of America's Natural Gas Alliance (ANGA) and participating American Gas Association (AGA) companies based upon data provided by TIAX LLC.

The Final Reports of Modules 1 through 5 are the work of TIAX LLC as a market assessment sponsored by ANGA with the support of participating AGA companies.

# Executive Summary

## Driving Into a Cleaner, Safer Future

### America needs to increase its energy independence now

America urgently needs a new alternative energy solution. We must reduce our dependency on foreign sources of energy and implement an alternative transportation fuel that is reliable, safe, and affordable. The U.S.'s annual import bill approaches $350 billion, more than double what the federal government spends on education.[1] The transportation sector uses the bulk of our imported oil. Vehicles consumed 4.7 billion barrels of petroleum in 2010, even more than the 4.2 billion barrels of petroleum the country imported that year.[2]

Increasing use of domestic natural gas as a clean alternative fuel will help prevent North America from relying on regions of the world whose interests run counter to our own. Given events in the Middle East like the Gulf War and the prolonged conflict in Iraq as well as OPEC's continual control of petroleum supplies, we can practically gauge the health of U.S./Middle East diplomatic relations by the price at the pump.

### Our current transportation portfolio carries societal costs

It's not just the price at the pump that should worry us. It's also the hidden costs we don't see when we slide our credit cards across the magnetic reader. Each time a driver refuels, the indirect cost of energy security adds an additional $0.46 per gallon or an average of $8.31 per vehicle.[3] You can see the costs of this premium in decreased national economic output, loss of national gross product, economic strain and volatility, oil supply shocks, prices spikes, supply disruption, and import costs.

*Each time a driver refuels, the indirect cost of energy security adds an additional $0.46 per gallon or an average of $8.31 per vehicle.*[3]

In addition, every transportation fuel carries a societal cost based on impacts from criteria pollutant emissions. Another societal cost of our transportation fuel results from GHG emissions. Monetization of these societal costs provides a means to assess the societal benefits of the alternative fuels considered. Across multiple vehicle segments, the societal costs for NGVs are lower than those for conventional transportation fuels. The net savings (of direct and societal costs) exceed $50,000 for some high fuel use applications and are comparable to saving 15 percent of lifetime costs. The savings for other applications may be less but are still significant.

The more we increase the use of domestic natural gas, the more these societal costs can be reduced.

1 Brian Riedel, "Federal Spending By the Numbers," June 1, 2010, http://www.heritage.org/research/reports/2010/06/federal-spending-by-the-numbers-2010, (October 12, 2011).
2 Energy Information Administration. "Annual Energy Review." October 19, 2011.
3 U.S. EPA, NHTSA. "Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis." EPA-420-R-10-009, p. 8-16. April 2010.

## ES1 Energy Security Premium

The effect of imported overseas petroleum:

| **Energy Security Premium[4]** $0.46 per gallon transportation fuel |
|---|
| Decreased economic output<br>Loss of national gross product<br>Economic strain and volatility<br>Supply shocks and price spikes<br>Supply disruption<br>Import costs |

## ES2 Criteria Pollutants + GHG Costs

Our current total transportation portfolio bears societal costs:

| **Air Pollution Costs[5,6,7,8]**<br>$9,072 per ton NOx<br>$270 per ton CO<br>$7,401 per ton VOC<br>$283,274 per ton PM2.5 | **GHG Costs[9,10]**<br>$23.13 per ton |
|---|---|
| Impacts from Criteria Pollutants | Impacts from GHG Emissions |

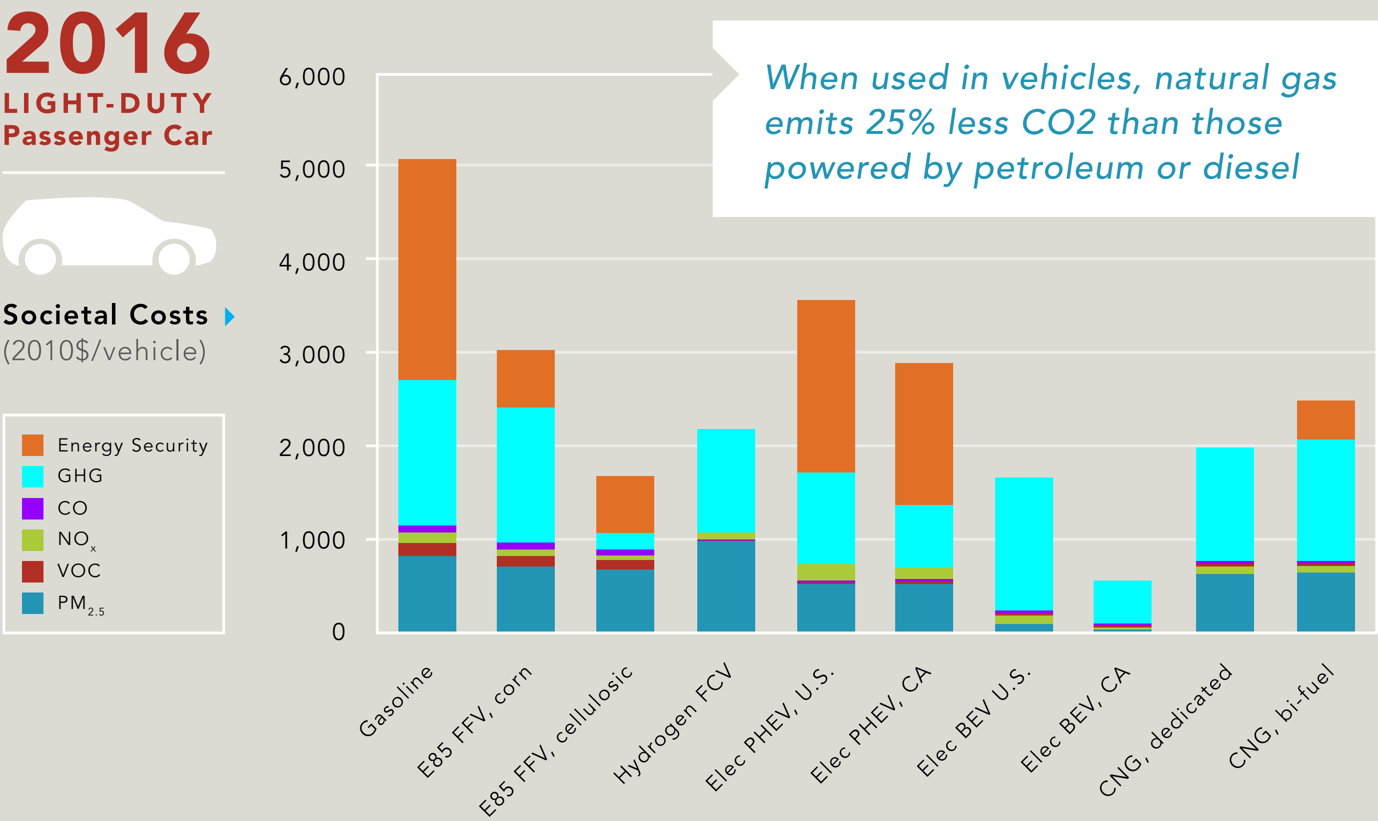
Current societal costs are estimated to add up to $0.99 per day for each 2010 passenger car on the road.[11,12,13,14,15,16] With an on-highway vehicle population of 255 million in the U.S., the costs related to transportation fuel pollution total upwards of $252 million dollars a day.[17]

Natural gas vehicles (NGVs) have less impact on energy and the environment, and the difference is dramatic. Conventionally-powered passenger cars carry a societal cost estimated at $5,100 per vehicle over their lifetime, while NGVs cost $2,000 to $2,500.

For medium-duty vans, hybrid package delivery vans, hybrid beverage trucks, transit buses, refuse haulers, and 18-wheeled tractor-trailers using diesel the societal costs are even greater. Over the lifetime of an 18-wheeler, these costs are estimated at $70,000. In comparison, the costs associated with an 18-wheeler using natural gas are $21,000 to $34,000. Regardless of a vehicle's size, the lifetime societal costs of NGVs will be lower than those of conventional vehicles.

> *Regardless of a vehicle's size, the lifetime societal costs of NGVs will be lower than those of conventional vehicles vehicles.*

4 U.S. EPA, NHTSA. "Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis." EPA-420-R-10-009, p. 8-16. April 2010.
5 Costs for NOx and VOCs include both direct emissions of these pollutants and their indirect emissions (as precursors to PM); all costs are given in 2010 U.S. dollars.
6 U.S. EPA, NHTSA. "Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis." EPA-420-R-10-009, p. 7-118. April 2010.
7 TIAX communication with N. Fann, EPA Office of Air Quality Planning & Standards, August/September 2010.
8 CEC. "Reducing California's Petroleum Dependence, Appendix A: Benefits of Reducing Demand for Gasoline and Diesel (Task 1)." P600-03-005A1, p. 3-27. September 2003.
9 U.S. Government. "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis, Under Executive Order 12866," p. 39. Interagency Working Group. February 2010.
10 U.S. EPA, NHTSA. "Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis." EPA-420-R-10-009, p. 7-128. April 2010.
11 Costs for NOx and VOCs include both direct emissions of these pollutants and their indirect emissions (as precursors to PM); all costs are given in 2010 U.S. dollars.Costs for NOx and VOCs include both direct emissions of these pollutants and their indirect emissions (as precursors to PM); all costs are given in 2010 U.S. dollars.
12 U.S. EPA, NHTSA. "Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis." EPA-420-R-10-009, p. 7-118. April 2010.
13 TIAX communication with N. Fann, EPA Office of Air Quality Planning & Standards, August/September 2010.
14 CEC. "Reducing California's Petroleum Dependence, Appendix A: Benefits of Reducing Demand for Gasoline and Diesel (Task 1)." P600-03-005A1, p. 3-27. September 2003.
15 U.S. Government. "Technical Support Document: Social Cost of Carbon for Regulatory Impact Analysis, Under Executive Order 12866," p. 39. Interagency Working Group. February 2010.
16 U.S. EPA, NHTSA. "Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards: Regulatory Impact Analysis." EPA-420-R-10-009, p. 7-128. April 2010.
17 Research and Innovative Technology Administration, "Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances (2008)," http://www.bts.gov/publications/national_transportation_statistics/html/table_01_11.html (October 6, 2011).




## The advantages and opportunities of alternative fuels

Although driving small vehicles reduces fuel consumption, all vehicles in every class have gotten heavier and more powerful, small and large vehicles alike. However, many Americans want their minivans, SUVs, and trucks. As we continue to use energy in transportation, we need to find alternatives to the way we fuel our cars.

No matter what your political affiliation, we all agree on a basic problem: We must change our energy consumption. Former President George W. Bush explained that affordable energy is the key to our future:

*"Keeping America competitive requires affordable energy. And here we have a serious problem: America is addicted to oil, which is often imported from unstable parts of the world. [...] By applying the talent and technology of America, this country can dramatically improve our environment, move beyond a petroleum-based economy and make our dependence on Middle Eastern oil a thing of the past."* [18]

The Obama Administration shared these sentiments, and President Barack Obama stated:

*"Our dependence on foreign oil threatens our national security, our environment and our economy. We must make the investments in clean energy sources that will put Americans back in control of our energy future, create millions of new jobs, and lay the foundation for long-term economic security."* [19]

Fortunately, our overseas dependency on foreign sources of energy from geopolitically unstable regions of the world is a problem we can solve. We already recycle, tote canvas bags to the grocery store, and try to run our appliances in evening hours. Doesn't it logically follow then that the transportation industry offers consumers an amazing opportunity to impact their country, environment, and wallet with one purchasing decision?

18 President George W. Bush, "State of the Union Address: January 31, 2006," The Washington Post, http://www.washingtonpost.com/wp-dyn/content/article/2006/01/31/AR2006013101468.html, (October 3, 2011).
19 The White House, "Learn: Clean Energy Economy," http://m.whitehouse.gov/issues/energy-and-environment/new-foundation/learn, (October 3, 2011).

## A better source of energy security and economic stability exists inside our borders

North America has a better energy source inside its borders, and the U.S. could pass Saudi Arabia and overtake Russia as the world's largest energy producer.[20] We can accelerate our energy independence by augmenting our petroleum supply with North American natural gas. NGVs and a natural gas fueling infrastructure can be the solution to our energy problems that minimizes damage to the environment. Switching to natural gas will also save North America millions of dollars in security costs related to defending access to international petroleum resources in geopolitically unstable regions of the world.

Natural gas is not a new fuel. We've used it since practically the beginning of time—the Chinese discovered natural gas in 600 BC and, around the first century, the first recorded use of natural gas in the home occurred in Persia (now Iran). In North America, natural gas use dates back as early as 1626.[21] It heats our homes and businesses, has many industrial applications, and generates electricity. Natural gas already accounts for 23.4% of the U.S. energy supply.[22]

Natural gas has served as a transportation fuel for more than six decades. It has mainly been applied to commercial vehicles like school buses and truck fleets that return to a central base at the end of a day. Fleet operators can economically build and maintain fueling stations at these central stations. It's also no coincidence that school buses have been a successful application, given the positive attribute of lower emissions.

*We can accelerate our energy independence by augmenting our petroleum supply with North American natural gas.*

## Natural gas is an economical fuel option

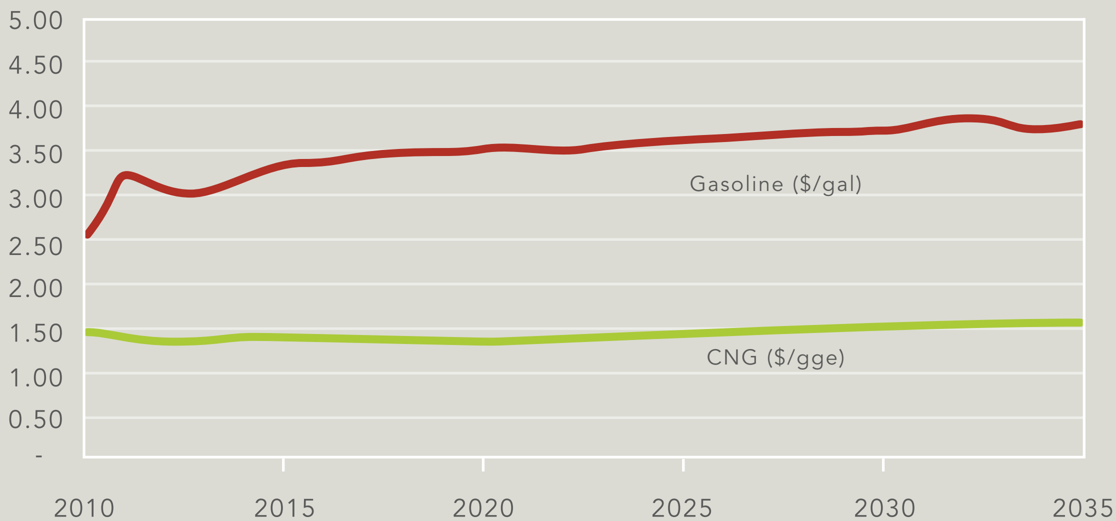
Despite the lack of a large natural gas fueling infrastructure for the public, consumption as a transportation fuel has increased steadily since 1997. During this period, the price of petroleum rose while the price of natural gas fell. As the exhibit below shows, this trend is continuing. Over the next 25 years, natural gas is expected to become even cheaper relative to petroleum.

The fuel cost differential between natural gas and gasoline is expected to reach over $2.00 per gasoline gallon equivalent (GGE) and over $3.00 per diesel gallon equivalent (DGE) between natural gas and diesel. For the average North American, who fills up his or her tank weekly, refueling with natural gas rather than petroleum would save approximately $32 per gas station visit. In a year, that's a $1,664 savings.

## ES4

**GGE Fuel Price At Pump**
(2010$ per GGE)

**Notes**
**1) Fuel prices are derived from the reference case in U.S. EIA "Annual Energy Outlook," 2012**
**2) Prices include federal and state taxes**
**3) Prices are adjusted for vehicle efficiency**



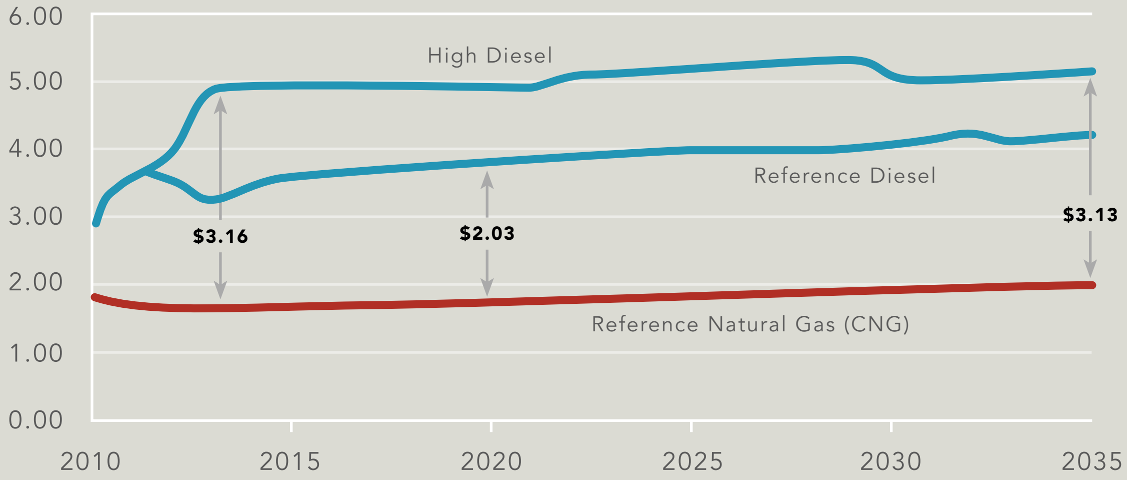

20 "History Zone", Pacific Gas & Electric, http://www.pge.com/microsite/safety_esw_ngsw/ngsw/more/history.html (October 3, 2011).
21 U.S. Energy Information Administration, "U.S. Primary Energy Flow by Source and Sector, 2009," www.eia.gov, http://www.eia.gov/totalenergy/data/annual/pecss_diagram.cfm, (October 3, 2011)
22 Energy Information Administration. "Annual Energy Outlook 2011" assessed at http://www.eia.doe.gov/forecasts/aeo/ on April 28, 2011.

## ES5

**DGE Fuel Price At Pump**
(2010$ per DGE)

**Notes**
**1) Fuel prices are derived from U.S. EIA "Annual Energy Outlook," 2012**
**2) Prices include federal and state taxes**
**3) Prices are adjusted for vehicle efficiency**

**Fuel price differentials at the pump of over $3 per equivalent gallon are possible in the near future.[23]**




Conventional fuel retailers, fleet fueling operators, and average drivers are accustomed to fueling vehicles with liquid fuels. Though natural gas is different from conventional fueling, it's simple to use and is widely used in transportation.

While liquid fuels like gasoline or diesel must be transported to stations via over-the-road trucks, compressed natural gas (CNG) is a natural gas fuel that is typically transported via an underground pipeline and then compressed to a higher pressure. While some investment is required to build a natural gas fueling infrastructure, it can use an already existing network of pipelines to reach stations. Additionally, CNG fueling stations can be designed to accommodate any situation—public or fleet fueling.

## Natural gas is in abundant supply and offers price stability

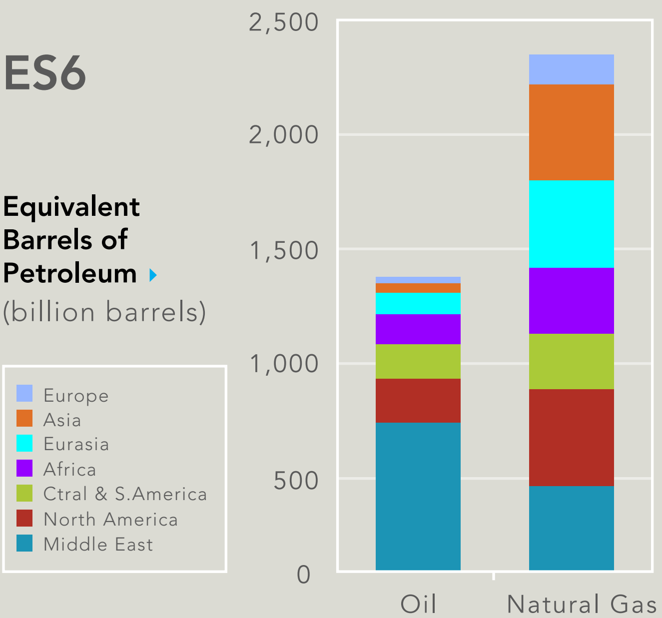
Now is the time for natural gas. Recent explorations for natural gas have found abundant supplies in North America, making natural gas even more plentiful than petroleum. Current global supplies of natural gas could sustain world demand, at current consumption, for 121 years versus 46 years for petroleum.[24]

There is enough natural gas in the U.S. and Canada to supply the current economy-wide uses of 24.3 trillion cubic feet (TCF) per year and support these markets as they expand.[25]

*Current global supplies of natural gas could sustain world demand, at current consumption, for 121 years versus 46 years for petroleum.[24]*

## ES6

**Equivalent Barrels of Petroleum**
(billion barrels)



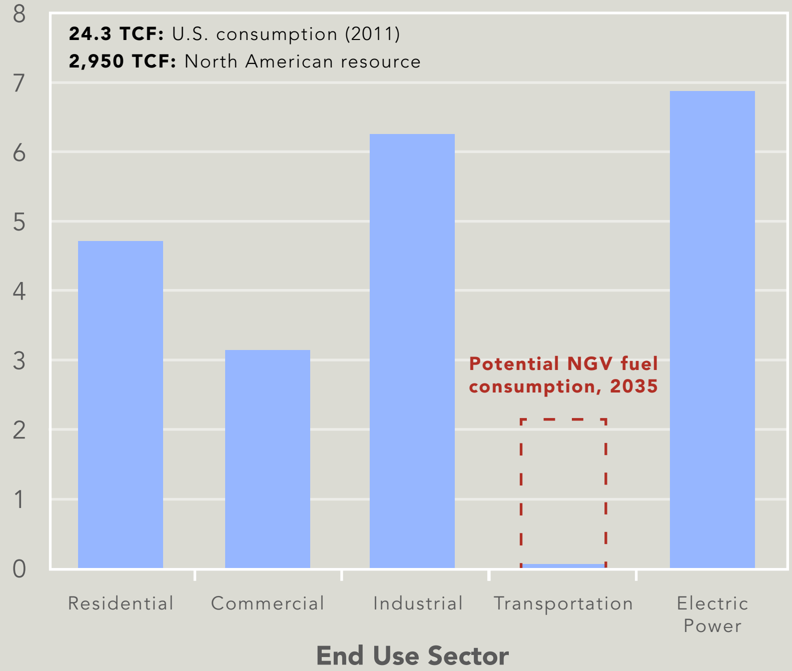

23 Energy Information Administration, "International Energy Outlook 2010-Natural Gas," DOE/EIA-0484(2009), July 27, 2010; http://www.eia.doe.gov/oiaf/ieo/nat_gas.html
24 Energy Information Administration, "World Shale Gas Resources: An Initial Assessment of 14 Regions Outside the United States," Release date: April 5, 2011, http://www.eia.doe.gov/analysis/studies/worldshalegas/
25 Energy Information Administration. "Natural Gas Consumption by End Use." http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm. Accessed January 2011.

## ES7 Natural Gas Transportation Consumption

| | 2008 | 2035 |
|---|---|---|
| Natural Gas Vehicles in U.S. (Millions) | 0.13 | 16 |
| Consumption (Trillion Cubic Feet-TCF) | 0.05 | 2.2 |

## ES8 Natural Gas Consumption (TCF)

Source[27]




The existing U.S. natural gas vehicle population is approximately 130 thousand (.05% of the on-highway vehicle population), and it consumes 364 million DGE of natural gas annually. If we made a commitment to NGVs, by 2035 we could have 16 million vehicles in the U.S. That amounts to 6% of the 2012 on-highway vehicle population, and it would displace 10% of the 2012 on-highway conventional/transportation fuel consumption.[26] At the same time, we could also increase the number of residences, businesses, and industries using natural gas for electricity.

Because North America is subject to changes in foreign energy policy, we constantly wrestle with fluctuating supply and volatile prices for foreign sources of energy from geopolitical unstable regions of the world. However, the abundance of our current and projected natural gas supplies would lead to stable prices for regionally sourced fuel. Price certainty would also allay some of our fears about domestic security. Among other benefits, this would translate into millions of dollars in fuel savings, fewer dollars leaving North America to pay for imports, and a smaller trade imbalance.

*Replacing 6% of the vehicles on the highway with natural gas vehicles would displace 10% of conventional/transportation fuel consumption.*

## Natural gas is a safe, environmentally superior fuel

You might ask, since natural gas is a fuel, doesn't that mean it is harmful to the environment? With natural gas, our clean energy future may be closer than we think. When it's used to generate electricity, natural gas burns cleaner than other fossil fuels and releases fewer pollutants. It is an essential partner to the development of renewables because it provides clean, reliable power when the sun sets in the evening or the wind dies down.

26 See Scenario Analysis report of overall TIAX assessment for details and assumptions
27 See Market Segmentation and Scenario Analysis reports of overall TIAX assessment for NGV population and fuel consumption estimates and projections. Data from Energy Information Administration, "Natural Gas Consumption by End Use," http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm, accessed September 11, 2012; Energy Information Administration, "Natural Gas Year-in-Review 2009," July 2010; Massachusetts Institute of Technology, "The Future of Natural Gas," Interim Report, p. 7. 2010.

Natural gas is the answer that green energy proponents are searching for: it's a high octane, low carbon fuel. From a well to wheels analysis natural gas can emit 23% less $CO_2$ than gasoline passenger cars.[28] But that's just the beginning of its clean-energy profile. Using natural gas results in 46% reduction in $NO_x$ emissions compared to pre 2010 diesel vehicles and virtually no sulfur dioxide, mercury, or particulate pollution. In most cases, natural gas can be a substitute for gasoline or diesel without many of the energy and environmental drawbacks.[29]

But to get an accurate picture of the environmental costs of different fuels, you need to look beyond tailpipe emissions. Using domestically sourced natural gas would mean we wouldn't have to use oil tankers to transport oil thousands of miles from the Middle East to North America.

The U.S. Environmental Protection Agency (EPA) has cited natural gas as a safe transportation fuel for several reasons including reduced flammability relative to petroleum, presence of onboard gas detectors, existence of tank safety valves, and periodic DOT tank inspections. Since it is non-toxic, natural gas poses no threat to land or water. In the event of a release, natural gas disperses rapidly (it is lighter than air) thus reducing ignition risks relative to gasoline.

Similarly, liquefied natural gas (LNG) readily evaporates if it is released in the air. If an LNG vehicle or station were damaged in a way that punctured fuel tanks, any spilled fuel would evaporate into the atmosphere much faster than gasoline or diesel, both of which pool on the ground.

Because natural gas has been used in the North American vehicle fleet for many years, consumers are unlikely to face the specter of dramatic new, unforeseen dangers if market penetration increases.

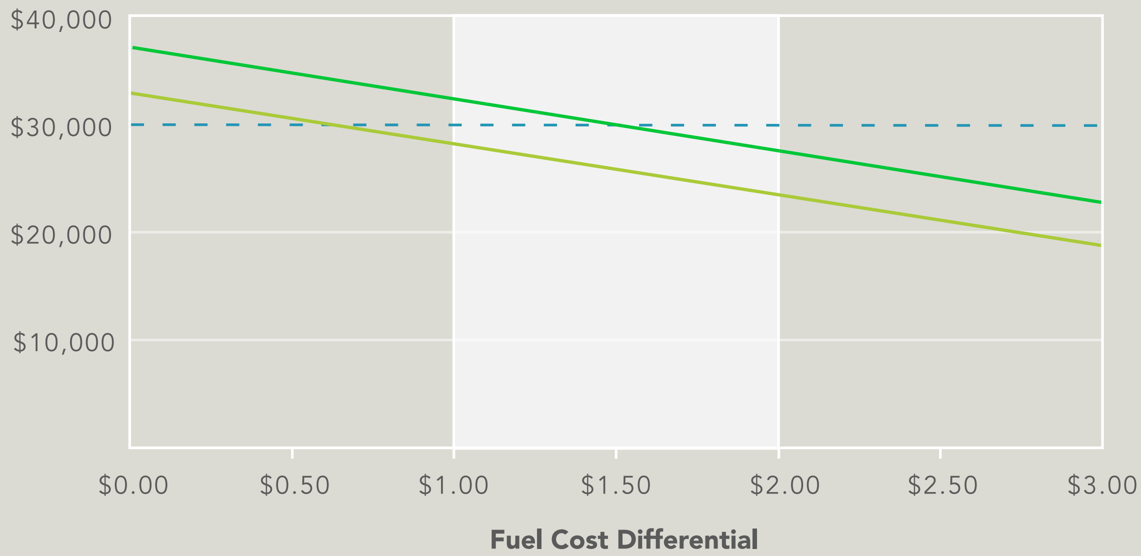
## NGVs have a lower total cost of ownership versus conventional vehicles

Natural gas is an economical and versatile fuel option. Even assuming a conservative fuel price differential at the pump of $1.50 per equivalent gallon, lifetime ownership costs for NGVs are generally lower than those of conventional vehicles. Lower fuel prices offset the higher costs of fuel storage in vehicles, enabling NGV owners to have reasonable payback periods.[30] As demand for petroleum increases, prices do the same. However, because of our vast natural gas supplies, increases in natural gas vehicles on the road will have little impact on the price of natural gas.

## ES9

**Vehicle and Lifetime Fuel Cost Comparison**
(Passenger Car)

CNG (dedicated)
CNG (bi-fuel)
BASELINE-Gasoline




28 U.S. Department of Energy, "Energy Efficiency and Renewable Energy: Alternative Fuels and Advanced Vehicles Data Center," http://www.afdc.energy.gov/afdc/vehicles/natural_gas_emissions.html, (November 17, 2011).ANGA, "Why Natural Gas: Clean," http://anga.us/why-natural-gas/clean, (October 3, 2011).
29 U.S. Environmental Protection Agency. "Clean Alternative Fuels: Compressed Natural Gas." http://eerc.ra.utk.edu/etcfc/docs/EPAFactSheet-cng.pdf. March 2002.
30 Lifetime costs include the cost of fuel over the vehicle's first-owner operating lifetime and reflect the vehicle application's operating characteristics. Hydrogen vehicle and fuels costs are projections only (not yet commercialized). See Comparative Analysis report of overall TIAX assessment for calculation details and assumptions.

## NGV adoption is progressing in the commercial and consumer markets

**Commercial Adoption**
Several corporations and municipalities have already switched their fleets from petroleum to natural gas fuel (CNG in all applications), and they're already seeing savings in transportation costs and a reduction in harmful emissions. Among them:

**UPS:** By switching a portion of its fleet to compressed natural gas (CNG) vehicles and converting existing trucks, UPS reduced its carbon emissions significantly. It started this process in 2000, and its CNG trucks have traveled over 165 million miles since. A study by the National Renewable Energy Laboratory found UPS' CNG trucks yielded much lower emissions than the cleanest operating diesel trucks.[31]

**Kansas City:** In 1996, Kansas City, Missouri instituted a fleet-wide alternative fuel program for the city's large rigs and public transportation. The city started with six CNG-powered vehicles and has expanded to approximately 2,700. By switching much of their fleet to CNG, the city displaces nearly a half a million gallons of foreign oil each year. Kansas City has experienced not only 15% savings in fuel costs, but has also significantly lowered emissions. The EPA estimates the use of CNG in Kansas City will yield 90-97% lower carbon monoxide output, 35-60% lower nitrogen oxides emissions, and reductions in carbon dioxide output of 25%.[32]

**Seattle:** Seattle has quickly expanded its natural gas fleets to include both heavy-duty vehicles—garbage trucks—and light-duty taxis. In 2009, Waste Management of Seattle invested $29 million in 106 new CNG-fueled vehicles to replace diesel-run trucks. An independent environmental review determined Waste Management's equipment upgrade will reduce smog-causing NOx emissions by 97%, diesel particulate matter by 94%, and greenhouse gases by 20%.. It's also good news for residents—natural gas vehicles run cleaner and quieter.[33]

Seattle opened Washington's first large scale, public access CNG fueling station near the Sea-Tac Airport. The station is convenient for the 74 natural gas and hybrid vehicles in use at the airport as well as the fleet of taxis operated by the Seattle-Tacoma International Taxicab Association. All 166 Ford Crown Victoria cabs operated by the association are CNG-fueled. It's estimated that the cabs will produce 149 fewer tons of carbon monoxide and 24 fewer tons of nitrogen oxides each year than comparable petroleum-powered vehicles.[34]

*With respect to NGVs, though the world is changing, the U.S. is not.*

**Consumer Adoption**
Consumers already drive NGVs today, though the limited vehicle choices and uncertainty about refueling options holds many people back. Honda manufactures and sells limited volumes of the Civic Natural Gas, one of the cleanest vehicles in the world, and more manufacturers are re-entering the North American market, including Ford, GM, and Chrysler. As consumer demand increases, the market will expand, just as it has globally. Worldwide, consumers can choose from more than 40 models, and there are more than 12 million NGVs in operation. In the U.S., that number is just 120,000. With respect to NGVs, though the world is changing, the U.S. is not.

## NGVs offer proven benefits and are the new frontier of North American prosperity

Natural gas means domestic jobs. By increasingly using NGVs in transportation, we will foster domestic jobs, create new manufacturing and construction opportunities, and stimulate economy-wide spending through consumer fuel savings.

Expanding North America's fueling infrastructure would add over 3.7 million jobs. Some, though not all, of these jobs would be temporary, but they are just the kinds of opportunities that Americans, specifically unemployed construction workers, need today.

31 ANGA, "Issues and Policies: Case Studies," http://anga.us/issues--policy/transportation/case-studies-, (October 3, 2011).
32 Ibid.
33 Ibid.
34 Ibid.

## ES10 Building the natural gas transportation infrastructure will create jobs

Source [35]

| | Light-Duty CNG | Medium and Heavy-duty CNG | Heavy-Duty LNG |
|---|---|---|---|
| Total number of new stations built by 2035 | 12,800 | 12,100 | 700 |
| **Spending Changes and employment impacts in transportation fuel sectors** | | | |
| Job impacts (Full Time Employees) per station: | 0.81 | 0.24 | 19.78 |
| Overall job impacts (FTEs): | 10,400 | 2,900 | 13,800 |
| **Capital and infrastructure expansion** | | | |
| Job impacts (FTEs) per station built: | 112 | 179 | 166 |
| Overall job impacts (FTEs): | 1,430,000 | 2,170,000 | 116,000 |

During this economic downturn, new shale plays across North America enabled the natural gas community to add jobs. According to IHS Global Insight, an independent research source, natural gas companies directly employed roughly 622,000 Americans in 2008 and indirectly sustained an additional 2.2 million jobs. But the economic benefits of natural gas extend well beyond job creation. In 2008 alone, natural gas contributed $385 billion to the U.S. economy and generated over $70 billion in direct income for workers. Its overall impact on the U.S. economy was $172 billion.[36]

*Natural gas contributed $385 billion to our nation's economy and generated over $70 billion in direct income for workers.*

In Canada, the natural gas industry has had a greater relative impact on the domestic economy. Every province has people whose jobs are related to natural gas. According to IHS Global Insight, nearly 600,000 Canadians worked in jobs supported by natural gas in 2008, contributing $106 billion to the nation's GDP. This economic impact exceeds the total GDP of all but four Canadian provinces that year. It accounts for 3.5% of all Canadian jobs and roughly 6.7% of Canada's overall GDP.[37]

*According to IHS Global Insight, nearly 600,000 Canadians worked in jobs supported by natural gas in 2008, contributing $106 billion to the nation's GDP.*

Natural gas jobs are filling the void left by the manufacturing, management, and technology sectors in Pennsylvania, Louisiana, and Alberta.

**Pennsylvania:** The Marcellus Shale, which is considered by experts to be the second largest shale gas formation in the world, is responsible for much for the state's natural gas job growth. A recent influx of natural gas activity in the state has quickly expanded the number of well-paying employment opportunities, ranging from manual labor to highly technical work. A 2010 Penn State study concluded that the Marcellus Shale could generate over $8 billion in economic value this year, $1 billion in state and local tax revenue and almost 100,000 jobs in 2011, just in Pennsylvania.[38]

35 Employment impacts based on IMPLAN Input-Output model and Jack Faucett Associate estimates. See Overview report of overall TIAX assessment.
36 ANGA, "Why Natural Gas: U.S. Benefits," http://anga.us/why-natural-gas/jobs/us-benefits, (October 3, 2011).
37 ANGA, "Why Natural Gas: Canada Benefits," http://anga.us/why-natural-gas/jobs/canada-benefits, (October 3, 2011).
38 ANGA, "Why Natural Gas: State-by-State," http://anga.us/why-natural-gas/jobs/us-benefits/state-by-state, (October 3, 2011).

**Louisiana:** The Haynesville Shale has helped boost the Louisiana economy during tough economic times. According to Dr. Loren Scott & Associates, which looked at about 70% of the exploration in the state, natural gas activities in the shale generated $10.6 billion in new economic activity and created more than 57,000 new jobs. It also generated $5.7 billion in new household earnings for Louisiana residents.[39]

**Alberta:** Over 16% of Alberta's employment was attributable to natural gas, with British Columbia (4.8%) the second largest beneficiary of Canada's natural gas abundance. Saskatchewan was third (4.5%). Natural gas supports 27.7% of Alberta's GDP, or $80 billion in total economic impact.[40]

## Jump-starting NGV adoption

Even without broad adoption in the commercial transportation market and a minimal presence in the consumer market, natural gas is has made a significant economic impact in North America. Just imagine the opportunity we have to strengthen national security, grow our economy, reduce pollution, and lower greenhouse gas emissions if we make NGVs more widely available and affordable. This challenge will involve all of us but particularly the four major stakeholders in the NGV industry—end users, natural gas supply chain companies, vehicle and engine manufacturers, and government—all working together. There are some challenges to this goal but they are not insurmountable.

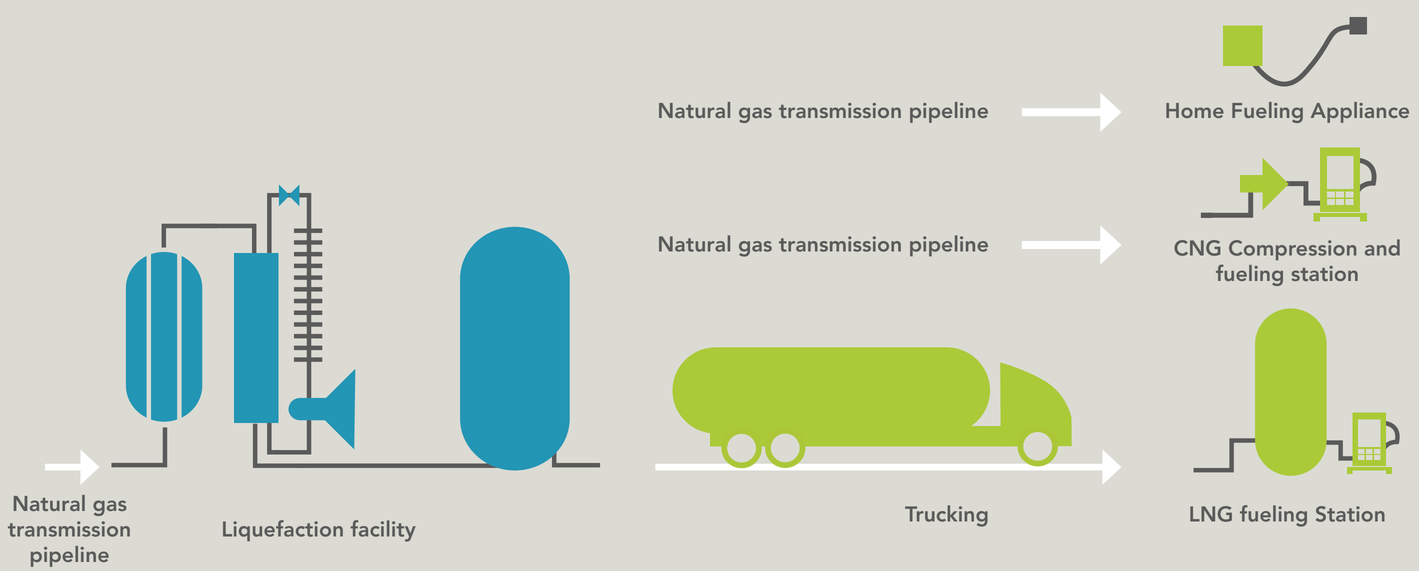
*The average driver in the U.S. drives 29 miles per day, based on this statistic, early localized infrastructure can support this emerging consumer market, but it will take a paradigm shift in the consumer mindset.*[41]

## To drive demand, consumers need to be educated on vehicle and fueling options

Consumers and commercial stakeholders are becoming more interested in natural gas. General consumer interest in alternative vehicles is also growing, but consumers are driven by both price and convenience. NGVs will not become a viable transportation option without an efficient and affordable fueling infrastructure, affordable vehicles, and a level playing field among alternative vehicles if government incentives are necessary.

Uncertainty about the fueling infrastructure is the main concern swaying customer purchase decisions and keeping vehicle manufacturers from building more NGVs. It's a chicken and egg problem: consumers who consider buying an NGV don't see natural gas fueling stations lining the highway or visible at main intersections, so they assume that refueling will be inconvenient. But without a critical mass of NGVs on the road, the need for a fueling infrastructure does not seem critical.

ES11




39 ANGA, "Why Natural Gas: State-by-State," http://anga.us/why-natural-gas/jobs/us-benefits/state-by-state, (October 3, 2011).
40 ANGA, "Why Natural Gas: Canada Benefits," http://anga.us/why-natural-gas/jobs/canada-benefits, (October 3, 2011).
41 U.S. Department of Transportation Federal Highway Administration. "2009 National Household Travel Survey." http://nhts.ornl.gov. Accessed August 2012.

## Building the fueling infrastructure

North America is in the process of establishing an efficient and affordable natural gas fueling infrastructure. Companies like UPS and Seattle Waste Management have been able to transition to natural gas quickly because they have dedicated fleets that return to a base. It's economical for them to develop small or large private fueling facilities for their exclusive use. Accommodating light and medium duty vehicles will require some changes in vehicle fueling systems, like an in-home fueling device—a home-based gas utility or personal fueling device approximately the size of a small chair that sits outside or inside—and accessible public fueling stations.

During this intermediate phase, government will work in partnership with the natural gas industry and fuel providers to begin developing a public natural gas fueling infrastructure that includes corridors connecting stations throughout regions.[42] This partnership is already underway. Through the American Recovery and Reinvestment Act of 2009, the Department of Energy funded 25 different projects for alternative fuel, infrastructure, and advanced technology vehicles, and 19 of these 25 projects included natural gas. These commitments include support for 140 new fueling stations.

## Building the vehicles

When consumers make the decision to buy an NGV, these vehicles need to be readily available on showroom floors. The manufacturing process must begin with engine manufacturers who provide efficient technology for natural gas, develop, and commercialize a wider selection of natural gas engines to meet the increasing demand.

One way to ease into this new era is to design and adopt natural gas passenger cars and light-duty trucks as bi-fuel vehicles—using both natural gas and gasoline. These vehicles do not compromise tailpipe or evaporative emission performance. They are designed to meet daily driving requirements with natural gas and use gasoline for extended driving. Reducing onboard natural gas storage capacity reduces vehicle costs, and ensures a faster payback on initial NGV purchase costs. For the U.S. and Canadian retail consumer market, bi-fuel NGVs coupled with a small home fueling compressor would provide overnight access to natural gas and allow consumers to avoid daily trips to a natural gas fueling station. For heavy-duty trucks, dedicated natural gas systems make the most economic sense, as long as the fuel systems are properly sized to the particular needs of the fleet, thereby minimizing unnecessary incremental cost and weight.

Vehicle manufacturers must be financially motivated to continue to provide high quality NGVs that meet the same reliability and durability standards as gasoline and diesel products.

The newest NGV offerings have focused on the medium-duty market and targeted at the commercial working sector. In the future, we need to offer a wider selection of vehicles for the consumer market.

## Creating a level playing field

The U.S. and Canada both have robust environmental policies to reduce air pollutant and GHG emissions associated with fuel production and vehicle operation. These policies have been marginally effective. Now, we need stronger energy policy or strategy supported by stakeholders to increase the use of natural gas in the transportation sector and reduce North America's dependency on foreign sources of energy from geopolitcally unstable regions of the world.

The integration of both environmental and energy policies can reduce petroleum use and emissions. These policies can also highlight the favorable lifetime economics and environmental aspects of NGVs to increase consumers' interest in alternatives to petroleum. The government can also play a role in leveling the playing field relative to other alternative fuels and vehicles, allowing for more market based adoption and avoidance of picking alternative fuel winners and losers. If policy makers decide to continue to offer purchase incentives for alternative fueled vehicles, they should do so on a level playing field.

The players in the natural gas ecosystem—vehicle manufacturers, government, and fuel suppliers—are ready to work together to make natural gas vehicles widely available, affordable, and simple to maintain. The missing piece is consumer demand and a desire to increase energy security. Now it is your turn; it's time to find out about the natural gas vehicle waiting for you. It's time for natural gas.

---

42 See Compressed Natural Gas Infrastructure and Liquefied Natural Gas Infrastructure reports of overall TIAX assessment for additional discussion of natural gas fueling infrastructure development.

## U.S. and Canadian Natural Gas Vehicle Market Analysis:

# Natural Gas Vehicle Industry Overview

# Legal Disclaimer

This report was prepared by TIAX LLC for America's Natural Gas Alliance on terms specifically limiting TIAX's liability. Our conclusions are the result of the exercise of our best professional judgment based in part upon materials and information provided to us by our subcontractors and others.

TIAX accepts no duty of care or liability of any kind whatsoever to any third party, and no responsibility for damages or loss, if any, suffered by any third party, as a result of decisions made, or not made, or actions taken, or not taken, based on this document.
This report may be reproduced only in its entirety and only with the prior written consent of TIAX.

# Table of Contents

Abbreviations

Lower heating value energy conversion factors

Preface

Introduction

Executive Summary

Chapter 1

What do we pay for our current transportation energy?

The high costs and risks of foreign energy dependency.

Chapter 2

How can NGVs and a supporting NG infrastructure enable energy independence?

A better source of energy security and economic stability exists inside our borders

Natural gas is proven, safe, dependable and affordable and ready now

Chapter 3

Who will benefit from expansion of NGVs?

Natural gas vehicles create thousands of jobs

It's the right choice for our families, our businesses, and North America

Natural gas vehicles offer proven benefits and are the new frontier of North American prosperity

Chapter 4

How can we make NGVs more available and affordable?

We can make natural gas vehicles more available and affordable

Building a foundation for natural gas vehicles

Action plans for key participants in the natural gas ecosystem

Appendix:
Job Impacts Analysis

## Lower heating value energy conversion factors*

| | |
|---|---|
| **Diesel** | 129,488 Btu/gal |
| **Gasoline** | 113,602 Btu/gal |
| **Natural gas** | 113,602 Btu/GGE or 129,488 Btu/DGE (983 Btu/cubic foot) |

*Argonne National Laboratory, “Greenhouse Gas and Regulated Emissions and Energy Use in Transportation,” 1.8c. Note that lower heating values for fuels will vary by refinery. Lower heating value does not include the latent heat of vaporization of water vapor, whereas the higher heating value does. Lower heating value is used to represent the energy available for internal combustion engines, and higher heating value is used to represent energy available for external combustion engines (e.g., gas fired boiler for space heating).

# Abbreviations

| | |
|---|---|
| **AGA** | American Gas Association |
| **ANGA** | America's Natural Gas Alliance |
| **B20** | Blend of 20 percent biodiesel and 80 percent diesel |
| **BCF** | Billion cubic feet |
| **BEV** | Battery electric vehicle |
| **CA** | California |
| **CAFE** | Corporate Average Fuel Economy |
| **CNG** | Compressed natural gas |
| **CO** | Carbon monoxide |
| **DEF** | Diesel exhaust fluid (urea) |
| **DGE** | Diesel gallon equivalent (equals 131.7 cubic feet of natural gas) |
| **DPF** | Diesel particulate filter |
| **E10** | Blend of 10 percent ethanol, 90 percent gasoline |
| **E85** | Blend of 85 percent ethanol, 15 percent gasoline |
| **EIA** | Energy Information Administration |
| **EPAct** | Energy Policy Act |
| **EPA** | Environmental Protection Agency |
| **FCV** | Fuel cell vehicle |
| **FTE** | Full-time equivalent |
| **gal** | Gallon |
| **GGE** | Gasoline gallon equivalent (equals 115.6 cubic feet of natural gas) |
| **H2** | Hydrogen |
| **HEV** | Hybrid electric vehicle |
| **LNG** | Liquefied natural gas (1 gallon LNG equals 0.58 DGE) |
| **LDC** | Local distribution company (gas utility) |
| **LPG** | Liquefied petroleum gas |
| **M85** | Blend of 85 percent methanol, 15 percent gasoline |
| **MPG** | Miles per gallon |
| **NGV** | Natural gas vehicle |
| **NHTSA** | National Highway Safety Transportation Administration |
| **NOx** | Oxides of nitrogen |
| **OEM** | Original equipment manufacturer |
| **OECD** | Organization for Economic Co-operation and Development |
| **OPEC** | Organization of Petroleum Exporting Countries |
| **PHEV** | Plug-in hybrid vehicle |
| **PM** | Particulate matter |
| **RFS** | Renewable Fuel Standard |
| **SCAQMD** | South Coast Air Quality Management District |
| **SCFM** | Standard cubic feet per minute |
| **SCR** | Selective catalytic reduction |
| **TCF** | Trillion cubic feet |
| **U.S.** | United States |
| **VOC** | Volatile organic compound |

# Preface

To identify the most productive and effective means to increase the use of natural gas vehicles (NGVs) in the U.S. and Canada, the TIAX team has conducted a thorough and independent assessment of the NGV market. This assessment examines the key technical, economic, regulatory, social, and political drivers and challenges that shape this market. TIAX has partnered with The CARLAB, Clean Fuels Consulting, the Clean Vehicle Education Foundation, Jack Faucett Associates, the Natural Gas Vehicle Institute, and St. Croix Research to provide perspectives and insights into the development of the future NGV market.

**TIAX's overall approach relies on six key stages:**

- Segmentation of the vehicle market
- Identification of market decision drivers
- Assessment of market development actions
- Analysis of competing technologies
- Analysis of market scenarios
- Integration of overall market development opportunities

The market perspectives, for which decision drivers and opportunities have been identified and assessed are: light-, medium-, and heavy-duty vehicle ownership; light-, medium-, and heavy-duty vehicle manufacturing; compressed and liquefied natural gas infrastructure; and government.

Drawing on the respective expertise of each team member, TIAX presents an integrated assessment of the U.S. and Canadian NGV market in a collection of eight reports. Each report is capable of standing alone while integrating the data, ideas, and themes of the other seven reports. The collection of reports in this TIAX analysis of the NGV market is funded by America's Natural Gas Alliance (ANGA) and further supported by participating members of the American Gas Association (AGA).

# Introduction

The NGV market and its prospects for a long-term, sustainable future are described from the perspectives of four major stakeholders: End Users, Natural Gas Supply Chain Companies, Vehicle and Engine Manufacturers, and Government, all of whom have significant opportunities in the NGV market.

The four major stakeholders that have a key role in bringing about these changes in transportation are: 1) end users, 2) natural gas supply chain companies, 3) vehicle and engine manufacturers, and 4) government.

- **End users** purchase and operate vehicles and provide the market demand for natural gas vehicles (NGVs). Acceptance of NGVs by end users will depend on the value proposition offered by the vehicles, including lifetime economics, attribute tradeoffs, vehicle availability, fueling convenience, and other incentives.

- **Natural gas supply chain companies** include gas producers, pipeline companies, local distribution companies (gas utilities/LDCs), and fueling station operators. Together, they establish and operate the infrastructure needed to supply natural gas to the transportation market. Having the most knowledge of and greatest familiarity with natural gas, these companies may also greatly benefit the NGV market by helping in the education and training of and outreach to other industry players, which aids in the distribution of market risk.

- **Vehicle and engine manufacturers** provide NGV and engine offerings to meet the requirements of the end users. Because these requirements vary by vehicle application, NGVs may be better suited to some applications than others.

- **Government** is entrusted with the general welfare of society and can undertake measures to correct market failures, including the classic example of environmental costs that are not included in full product costs that negatively impact society as a whole.

Other needed stakeholders in the NGV industry include vehicle component and infrastructure equipment suppliers, who enable the four major stakeholders to operate in the NGV market.

# Chapter 1

## What do we pay for our current transportation energy?

## The high cost and risk of foreign energy dependency

### Our transportation system relies on imported fuel

The transportation sector, specifically vehicles that operate using gasoline or diesel, uses mostly foreign sources of energy. In 2010, vehicles consumed a total of 4.7 billion barrels of petroleum, 4.2 billion barrels of which were imported.[1]

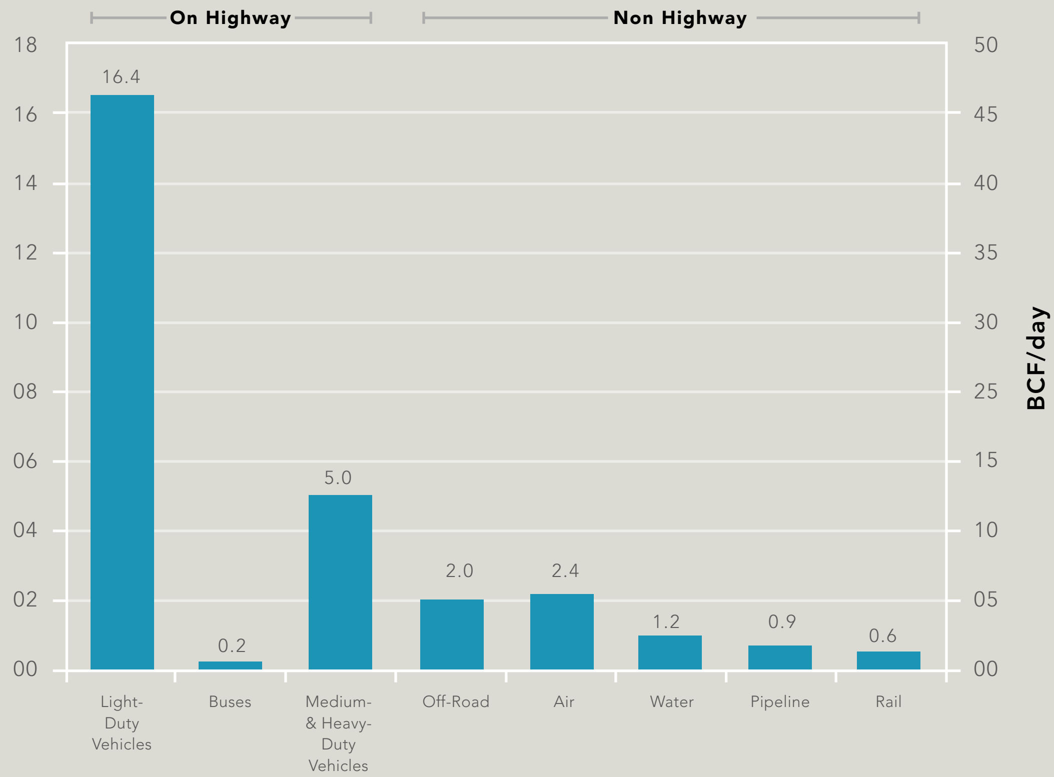
Passenger and light-duty trucks dominate energy use, but off-road and non-highway uses consume significant energy per vehicle. Vehicles vary in their fuel consumption and efficiency. The North American vehicle fleet is very diverse, composed of relatively standardized vehicles such as pickup trucks and passenger cars, as well as highly specialized vehicles such as beverage trucks and refuse haulers. Within the on-road market, the light- and medium-duty vehicle market segments are predominantly composed of mass-produced vehicles in a few common configurations. Heavy-duty, on-road vehicles are built for specific applications and are generally built-to-order for each customer, as is equipment in the off-road and non-highway sectors.

As the graphics below show, in the on-road segment, light-duty vehicles are the most fuel-efficient vehicles and use the least fuel per vehicle on an annual basis. Medium- and heavy-duty vehicles are less fuel efficient and consume more fuel annually per vehicle, especially in specific applications, making their total cost of ownership very sensitive to fuel price. Passenger and light-duty trucks dominate energy use, but off-road and non-highway uses consume significant energy per vehicle/application.[2] Despite increasing fuel efficiency of light, medium, and heavy-duty vehicles, the U.S. transportation system continues to rely significantly on foreign sources of energy from geopolitically unstable regions of the world and cannot be satisfied with domestic sources alone.

1 Energy Information Administration. "Annual Energy Review." October 19, 2011.
2 U.S. Census Bureau Foreign Trade Division. "U.S. Imports of Crude Oil." http://www.census.gov/foreign-trade/statistics/historical/petr.pdf. Accessed October 2010.

## Passenger and light-duty trucks dominate energy use; non-highway uses consume significant energy per vehicle/application[3]

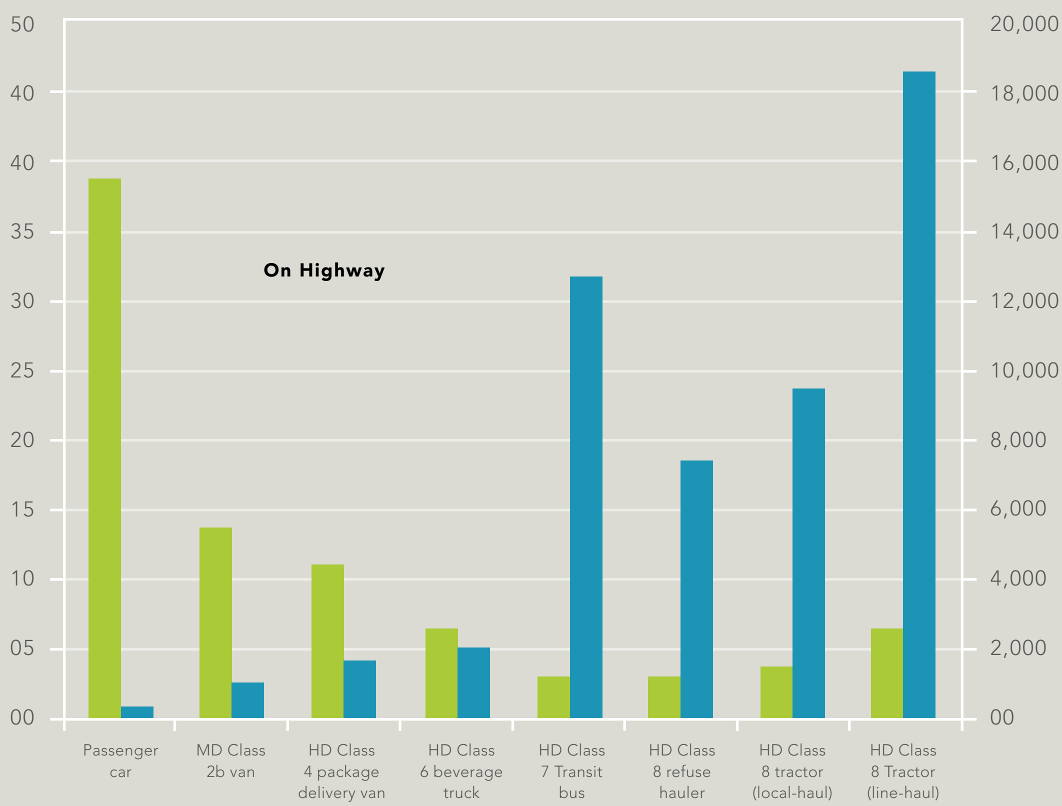
**Annual Fuel Consumption by Sector** (quads)




## Light-duty vehicles have low annual mileage and high fuel economy; heavy-duty vehicles have high annual mileage and lower fuel economy[4]

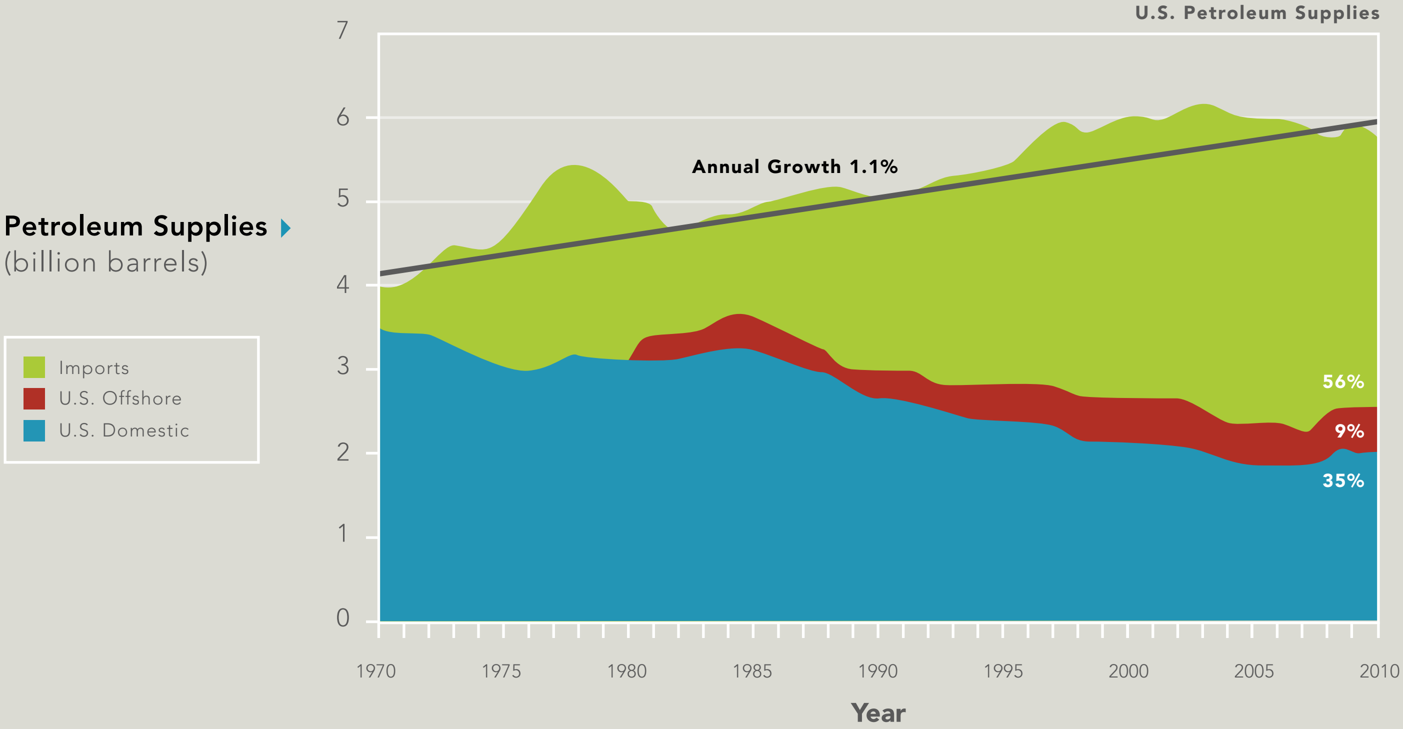
**Fuel Economy** (mpg)

**Average Annual Fuel Consumption** (gal/year/vehicle)




3 2008 data from DOE Transportation Energy Data Book - http://cta.ornl.gov/data/index.shtml
4 See Market Segmentation report of overall TIAX assessment for additional descriptions of these market segments.

## U.S. petroleum supplies[5]




For commercial and fleet vehicle operators, whose total cost of doing business is significantly influenced by small changes in fuel price, both volatility of, and increase in, petroleum prices can have a large negative impact. From the consumer perspective, this cost is reflected in the price per gallon at the retail pump. Because fuel price to date has generally represented a small fraction of total lifetime vehicle costs, private vehicle use has been relatively insensitive to fuel price.

If alternative fuel vehicle technology can be proven economically and become more available, conventional fuel prices will eventually move consumers to lower costs alternatives. Leveraging and communicating the potential of natural gas is a critical component of this shift. With abundant domestic natural gas, proven technology, and overall lower ownership costs, consumers will move natural gas into the marketplace and allow the North American economy to hedge against widespread impacts of unstable sources of foreign energy.

5 Data from Energy Information Administration, "Crude Oil Production," http://www.eia.gov/dnav/pet/pet_crd_crpdn_adc_mbbl_a.htm, accessed September 11, 2012; Energy Information Administration, "U.S. Crude Oil Supply & Disposition," http://www.eia.gov/dnav/pet/pet_sum_crdsnd_k_a.htm, accessed September 11, 2012.

# Chapter 2

## How can NGVs and a supporting natural gas infrastructure enable energy independence?

## A reliable source of energy security and economic stability exists inside our borders

North America can reduce its dependence on imported petroleum by tapping into the supply of natural gas. Several recent developments make this the right time to look at natural gas as a viable and sustainable option for widespread use in transportation. First, recent discoveries of abundant and domestic natural gas supplies have resolved questions relating to supply constraints. Secondly, NGV technologies are maturing. Thirdly, the United States and Canada are experiencing a widespread push for increasing energy security.

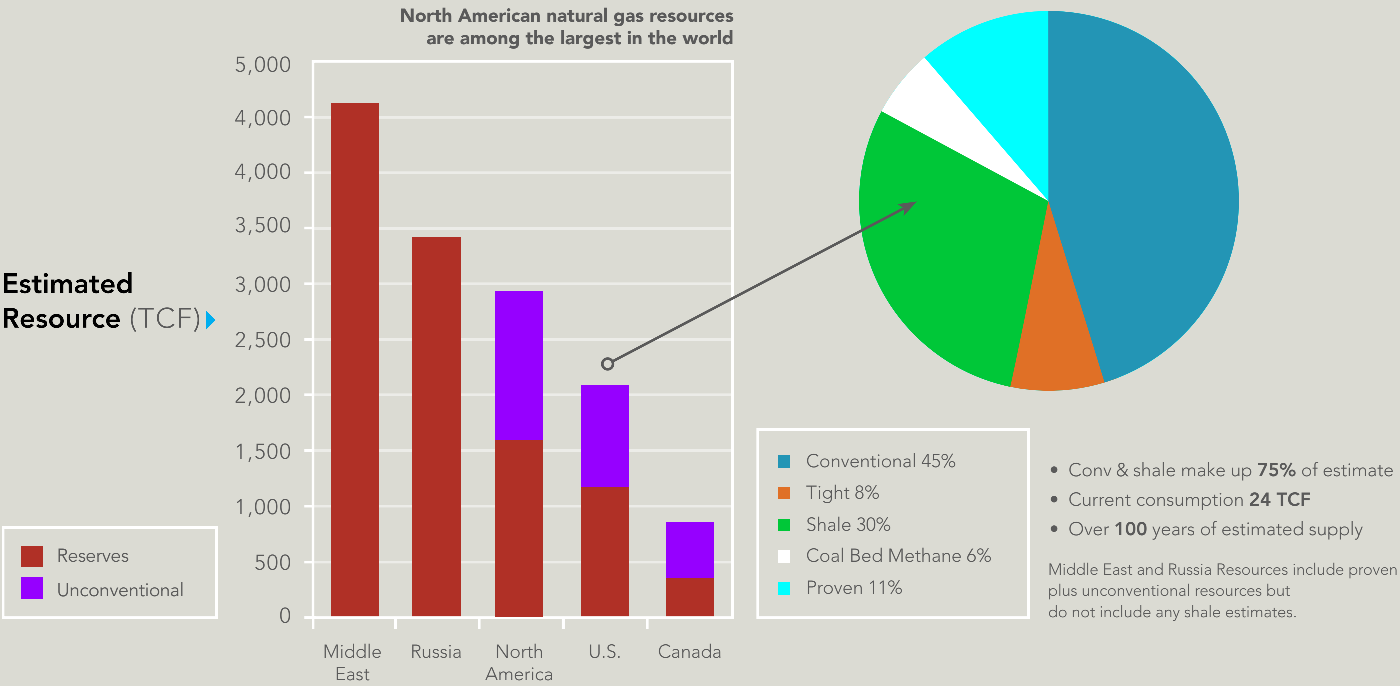
### From mature supply and rising prices to abundance and affordability

Not long ago, it appeared that conventional North American domestic natural gas supplies had begun to reach maturity. This perceived limited supply drove up prices, and demand stagnated as consumers switched to other energy sources. Due to high prices, suppliers (particularly in the U.S.) sought new natural gas sources, including planned liquefied natural gas (LNG) terminals, and increased exploration. This lack of North American supply was seen as a non-starter for considering natural gas as an alternative to foreign petroleum in the transportation sector. At this time, natural gas was being used for residential, commercial, and power generation markets. However, expanding its use in transportation would only take away from using clean natural gas in these segments.

Natural gas supply changed radically beginning in the early 2000s with the introduction of advanced drilling technologies and pressure pumping services that could economically produce natural gas from the vast resources in North America. Overnight, the supply went from projections of shortages to oversupply. This changed the opportunity for using natural gas as a transportation fuel. Currently, North America's natural gas resources are among the largest in the world, approaching 3,000 trillion cubic feet (TCF). Current U.S. consumption is about 24 TCF[6], suggesting over 100 years of supply.

6 Energy Information Administration. "Natural Gas Consumption by End Use." http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm. Accessed September 11, 2012.

## U.S. and Canadian natural gas resources are among the largest in the world[7]




## The abundance of natural gas makes it an attractive transportation fuel option

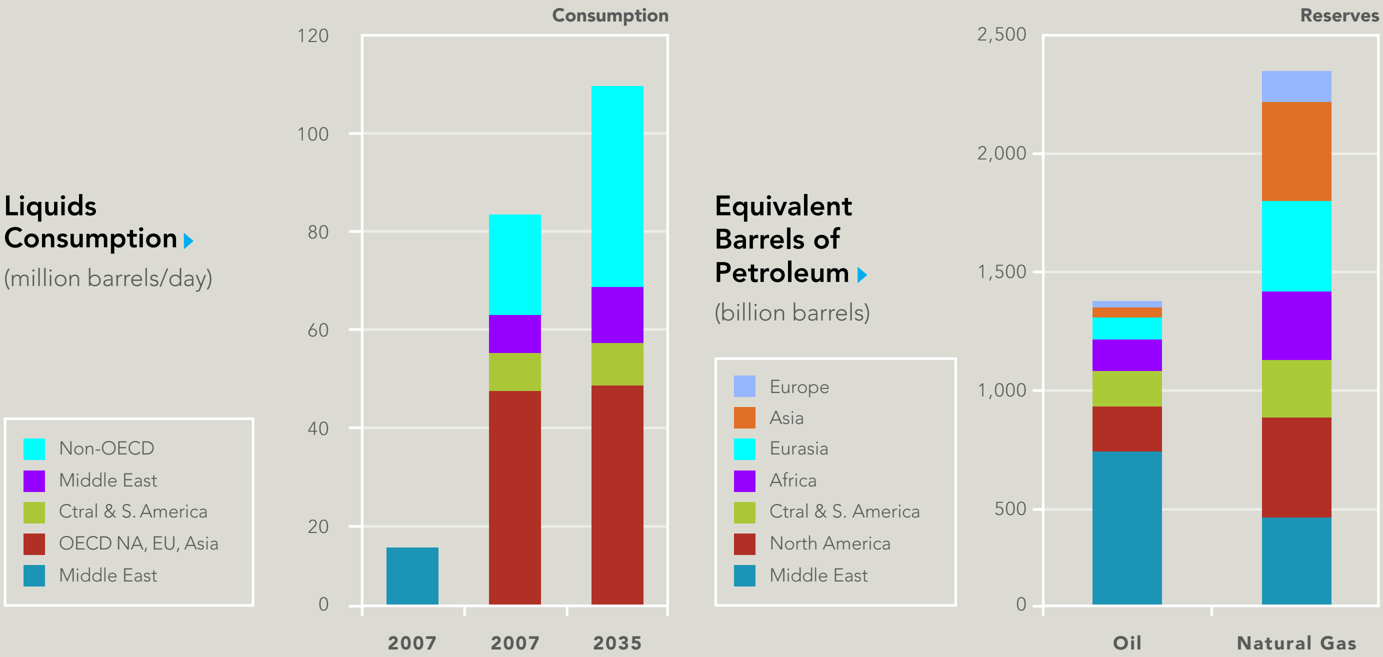
The North American natural gas supply is estimated (on an energy equivalent basis) at 500 billion barrels. The annual U.S. transportation consumption is 14 million barrels per day, compared to world consumption of over 80 million barrels per day. The total U.S. transportation demand is projected to increase to 16.2 million barrels per day in 2035. Little future growth in consumption is from the Organisation for Economic Co-operation and Development (OECD) countries, but significant growth is projected from developing (non-OECD) countries.

## Natural gas can resolve a petroleum supply/demand imbalance

The worldwide supply of natural gas far outweighs the worldwide supply of petroleum. World petroleum resources are estimated at 1,350 billion barrels, and world natural gas resources are estimated (on an energy equivalent basis) at 2,260 billion barrels. At current consumption rates, these resources would last 46 and 121 years, respectively, and fewer years at projected future utilization rates. More importantly, from the perspective of domestically supplied and available fuels, natural gas resources in North America are 2.6 times greater than petroleum resources.

7 Data from Energy Information Administration, DOE/EIA-0484(2009), July 27, 2010; "Worldwide Look at Reserves and Production," Oil & Gas Journal 105(48), December 24, 2009.

## Worldwide petroleum consumption and reserves[8]




As illustrated above, worldwide petroleum consumption is projected to remain relatively flat in North America, Europe, and Asia while increasing substantially in non-OECD countries and the Middle East (left). While petroleum reserves are concentrated in the Middle East, natural gas reserves are more widely distributed and are greater than petroleum (right). Even with fuel efficiency standards, increased demand from other parts of the world will increase pressure on petroleum prices for North American consumers and consumers around the world.

## We have sufficient natural gas supply for both current & projected uses

Expanding natural gas applications can occur without limiting supply to current uses. Today, natural gas in North America is used primarily in sectors other than transportation, specifically, residential and commercial heating, industrial processes, and electric power generation. Combined, all U.S. sectors use 24.3 TCF of natural gas annually[9]. Of that amount, annual natural gas use in the transportation sector is 0.05 TCF. Given the extent of the North American natural gas resource, estimated at over 2,950 TCF[10], the supply of natural gas is sufficient to supply both the transportation and non-transportation sectors even as the NGV market expands.

8 Data from Energy Information Administration, DOE/EIA-0484(2009), July 27, 2010; "Worldwide Look at Reserves and Production," Oil & Gas Journal 105(48), December 24, 2009.
9 Energy Information Administration. "Natural Gas Consumption by End Use." http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm. Accessed September 11, 2012.
10 Massachusetts Institute of Technology. "The Future of Natural Gas." Interim Report, p. 7. 2010.

Current supplies of natural gas are sufficient for future natural gas demands[11]

Source[28]

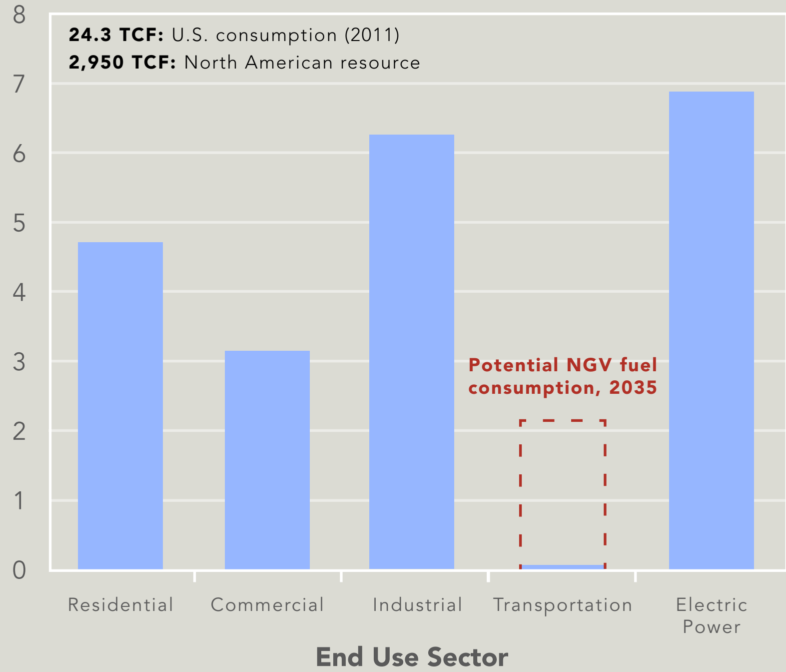
**Natural Gas Consumption**
(TCF)

**Estimated U.S. NGV population, current:**
100,118-154,466 vehicles
(0.04-0.06% of 2012 on-highway vehicle population)

**Estimated annual U.S. NGV fuel consumption, current:**
361-366 million DGE
(0.05 TCF or 0.2% of 2012 on-highway consumption)

**Potential U.S. NGV population, 2035:**
16 million vehicles
(6% of 2012 on-highway vehicle population)

**Potential annual U.S. NGV fuel consumption, 2035:**
17 billion DGE
(2.2 TCF or 10% of 2012 on-highway consumption)

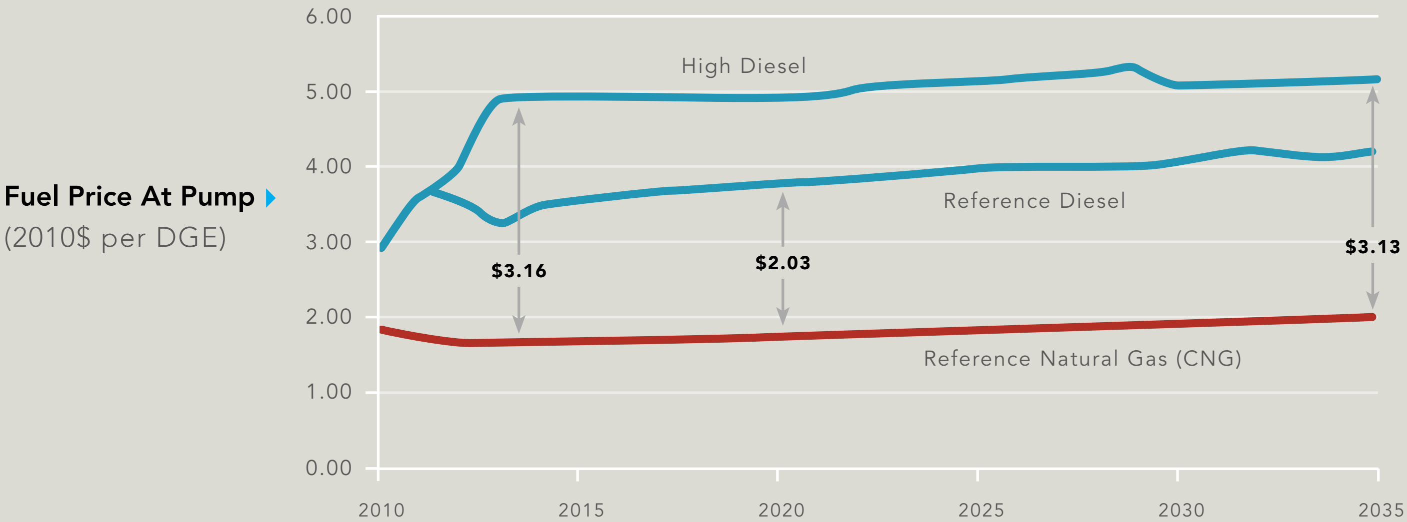



## Natural gas is an economical fuel

Natural gas prices are gradually diverging from petroleum prices, making natural gas use in cars and trucks far more economical than gasoline or diesel fuels. NGVs cost more than conventional vehicles, but these higher costs are usually offset by lower fuel prices. The Energy Information Administration (EIA) projects natural gas pump price differentials of $1.00 to over $3.00 per diesel gallon equivalent (DGE) over the next 25 years. These savings are attributable to increasing petroleum prices, driven by increasing global demand and decreasing global supply, and stable natural gas prices, due to reliable domestic fuel resources. As shown in the following graph, natural gas is less expensive (on an energy basis) than conventional fuels. Fuel price differentials at the pump of over $3.00 per gallon are possible in the near future.

11 See Market Segmentation and Scenario Analysis reports of overall TIAX assessment for NGV population and fuel consumption estimates and projections. Data from Energy Information Administration, "Natural Gas Navigator," http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm, accessed January 2011; Energy Information Administration, "Natural Gas Year-in-Review 2009," July 2010; Massachusetts Institute of Technology, "The Future of Natural Gas," Interim Report, p. 7. 2010

Future natural gas/diesel price differentials[12]

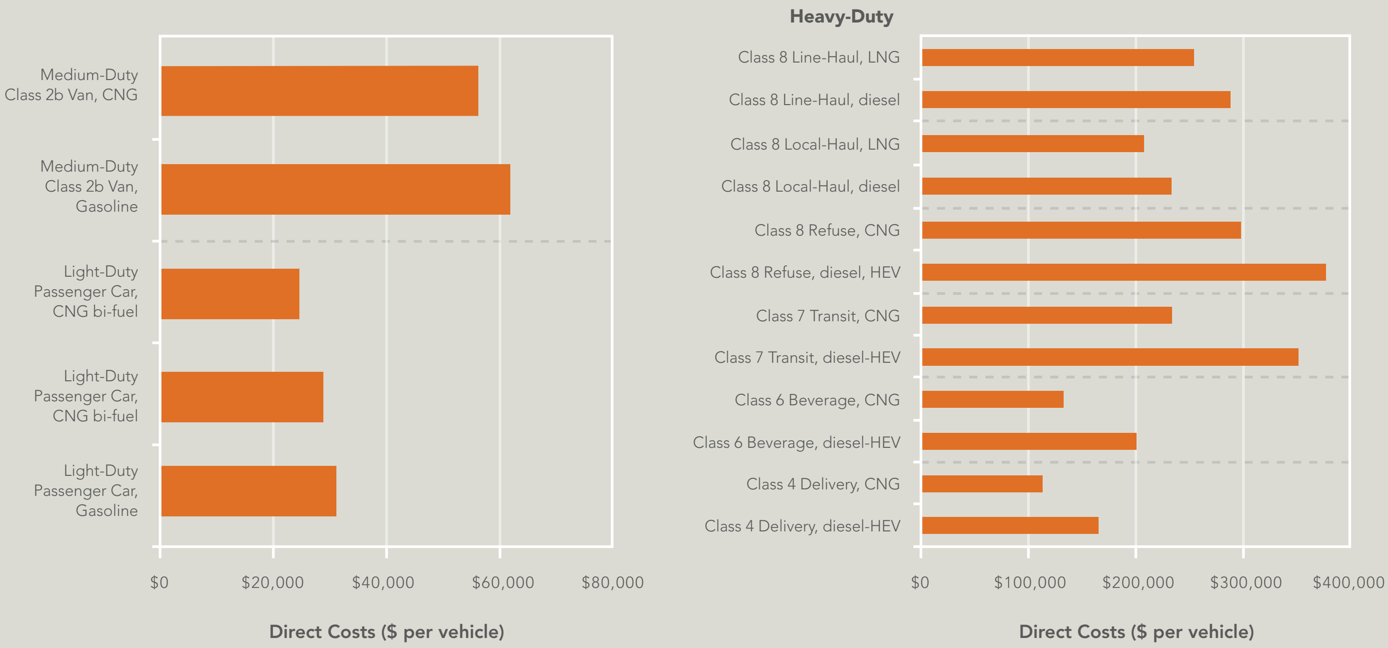



## Direct costs for natural gas vehicles compare favorably to conventional vehicles

Estimates of vehicle ownership costs include vehicle costs, fuel and other operating and maintenance costs, residual value, insurance, and financing costs. The illustration below shows estimated ownership costs for various vehicle applications. These costs include only vehicle and fuel costs; all other costs are assumed to be the same for NGVs and conventional vehicles. These lifetime costs are referred to as direct costs. For each vehicle application, NGVs are compared to conventional baselines. The baseline configurations project possible improvements with advanced engine and driveline technology, such as hybridization. Thus, the comparison uses the next generation advanced conventional technologies. Even with this assumption and a conservative pump price differential of $1.50 per equivalent gallon, direct costs for NGVs are lower in nearly every vehicle application. With higher differentials, NGVs offer even greater savings.

12 Energy Information Administration. "Annual Energy Outlook 2012." June 2012.

Direct vehicle costs, by vehicle and fuel type[13]




## Natural gas vehicles compare favorably to other alternative vehicles

Not all alternative vehicle ownership costs are equal. Ethanol and biodiesel blends can be used with existing technology without modification and do not require added vehicle costs. Natural gas and electric technologies have higher vehicle costs because they require more expensive storage systems—high-pressure or cryogenic tanks for natural gas and hydrogen and batteries for electric platforms. Fuel costs are lower for natural gas and electricity, projected to be the same for hydrogen, and the same or higher for biofuels. Infrastructure requirements also differ. Home refueling is primarily an option for electricity and natural gas, whereas blended fuels need few changes. Natural gas, hydrogen, electric, and E85 require the development of public fueling. Private fueling applies mostly to fleets using natural gas, biodiesel, or, in the future, hydrogen. Despite these differences, when contrasting NGV costs and fueling needs to those of other alternative vehicles, NGVs compare favorably.

13 See Comparative Analysis report of overall TIAX assessment for calculations of direct and societal costs of various vehicle technologies.

Comparison of alternative fuel vehicle and fuel costs to conventional

| Alternative Fuels | Vehicle Costs | Fuel Costs |
|---|---|---|
| Ethanol blend (E10) | Same | Same |
| Ethanol (E85) | Same | Same |
| Plug-in hybrid electric vehicle (PHEV) | More | Less |
| Battery electric vehicle (BEV) | More | Less |
| Hydrogen fuel cell vehicle (FCV) | More | Same |
| Light-duty NGV | More | Less |
| Heavy-duty NGV | More | Less |
| Biodiesel (B20) | Same | More |

## The line-up of NGVs is limited today but consumer demand could expand offerings

The options for NGVs in the light-, medium-, and heavy-duty vehicle segments are currently limited. However, recognizing the growing potential of NGVs, vehicle and engine manufacturers have shown interest in producing NGVs. Original equipment manufacturer (OEM) products are small in number, though recent announcements by major automakers demonstrate renewed interest in expanding NGV offerings. The Honda Civic Natural Gas is the only OEM passenger car available at present. GMC, Chevrolet, VPG, and Ford currently offer NGV products, either as turn-key NGVs or conversion-ready NGVs. For light- and medium-duty segments, conversion companies currently offer a variety of options for converting existing engines. These vehicles typically offer the same or similar warranties and features that end users expect from OEMs.

For heavy-duty segments, in which vehicles are built according to customer specifications, the availability of NGVs depends on the availability of natural gas engines that meet the power and torque requirements of specific vehicle applications. For example, a refuse truck that requires a 10-liter engine for its particular duty cycle may not have a natural gas option in the near term, unless the purchaser is willing to accept a vehicle with a 9- or 11-liter engine. In the near term, it appears that natural gas engines will not be available for heavy-duty vehicles that require engines in the 10- and 14-liter ranges. However, heavy-duty engine OEMs have expanded their offerings to a wider range of engine sizes in recent years and are continuing to do so.

For light- and medium-duty vehicles, up to seven OEM and OEM conversion-ready NGVs are currently available. For heavy-duty vehicles, up to six engines may be available, but natural gas choices for specific vehicle segments may be limited. The currently available vehicles are listed on the next page:

## Current NGV Lineup[14]

**Light- and Medium-Duty:**

### OEM Turn-Key NGVs


GMC Savana


Chevrolet Express


Honda Civic GX


VPG MV-1

### OEM Conversion-Ready NGVs


Ford Transit Connect


Ford E- Series


Ford F150- Series

**Heavy-Duty**

| | 7L Emission Solutions/ International Truck 7.6 L Phoenix | 8L Landi Renzo USA/ Baytech 8.1 L | 9L Cummins Westport 8.9 L ISL G | 10L | 11L Doosan Infracore America 11 L GK12 | 12L Cummins Westport 11.9 L ISX G | 13L Navistar 13 L Maxx-Force | 14L | 15L Westport Innovations 15 L GX |
|---|---|---|---|---|---|---|---|---|---|
| Heavy-duty truck | ● | | | | ● | | ● | | |
| Transit bus | | ● | ● | | ● | | | | |
| School bus | | ● | | | | | | | |
| Over-the-road coach | | | | | | | ● | | |
| Refuse / utility truck | | | | ● | ● | | | | |
| Drayage | | | | | | ● | | | ● |
| Vocational | | ● | | | | ● | | | |

HD NG Engine Currently Available

HD NG Engine Expected Near Term

● Indicates New or Additional Engine Needed

14 Illustrations courtesy of their respective manufacturers. See Light- and Medium-Duty Vehicle Ownership and Production and Heavy-Duty Vehicle Ownership and Production reports of overall TIAX assessment for details.

## Short range vehicles can benefit from natural gas immediately

Transit buses, refuse haulers, and package delivery vehicles have had the strongest market drivers for adopting natural gas. These applications are also well suited to the use of natural gas based on their market enabling features of short range and return-to-base duty cycles. Additionally, depending on the fuel capacity and typical range, fuel type is important. Vehicles that carry more than 80 DGE are more suited to liquid natural gas (LNG), whereas vehicles with less than 80 DGE often use compressed natural gas (CNG). Thus, vehicles with ranges greater than 300 miles (e.g., line- or regional-haul tractors) are primarily suited for LNG, while with less range than 300 miles use CNG.

## NGVs must keep pace with efficiency improvements in the conventional market

The current NGV market supports a limited number of vehicle offerings. Growth of the market could be influenced by lower vehicle ownership costs and by future regulations. Either of these factors would increase demand for natural gas engines and vehicles. Suppliers will need to be ready to provide products that include improvements to engine and vehicle efficiencies to this expanding market.

Natural gas is expected to compete well against diesel hybrid technologies in many sectors. Furthermore, with cost reductions, hybrid natural gas drivetrains could be competitive. With the focus on lower carbon dioxide emissions, diesel engine efficiency will also be improving. Similarly, gasoline technologies will be improving with technologies like direct injection, which may or may not be applicable to natural gas engines. Any increase in efficiency of conventionally fueled engines and vehicles without similar increases in natural gas technology will reduce the competitiveness of NGVs. This may result in lower fuel prices being required to compete. In addition to product improvements, engine and vehicle manufacturers should continue to educate dealers on the maintenance and servicing of NGVs as well as the benefits of NGVs.

One key question that remains for NGVs is whether they can keep pace with higher engine efficiency improvements for conventional fuel engines and therefore remain competitive as technologies evolve. Nevertheless, even with limited offerings of engines and vehicles, there are enough products available today to support expansion of the NGV market. As the market grows, more products will be demanded.

# Chapter 3

## Who will benefit from expansion of NGVs?

## Natural gas vehicles can create millions of jobs

Natural gas creates domestic jobs. Increasing the use of natural gas in transportation has significant potential to impact national employment by displacing foreign petroleum jobs, establishing new manufacturing and construction opportunities, and stimulating economy-wide spending through fuel savings to the consumer. Jobs may be permanent, such as those established to support increased economy-wide spending, or temporary, such as those established for the duration of a particular construction project.

Expanding North America's fueling infrastructure would create a cumulative total of over 3.7 million jobs by 2035. While some of these jobs would be temporary, they provide opportunities that Americans need today:

### Expanding the natural gas infrastructure is expected to create jobs[15]

| | Light-Duty CNG | Medium and Heavy-duty CNG | Heavy-Duty LNG |
|---|---|---|---|
| **Total number of new stations built by 2035[a]** | 12,800 | 12,100 | 700 |
| **Spending Changes and employment impacts in transportation fuel sectors** | | | |
| Job impacts (FTEs) per station: | 0.81 | 0.24 | 19.78 |
| Overall job impacts (FTEs):[b] | 10,400 | 2,900 | 13,800 |
| **Capital and infrastructure expansion** | | | |
| Job impacts (FTEs) per station built: | 112 | 179 | 166 |
| Overall job impacts (FTEs):[c] | 1,430,000 | 2,170,000 | 116,000 |

**a** - Based on potential market projections as detailed in the Scenario Analysis report of the overall TIAX assessment.
**b** - These jobs are permanent jobs across the economy.
**c** - These jobs are created for the duration of the manufacturing/construction project only; cumulative number in 2035 is presented.

15 Employment impacts based on IMPLAN Input-Output model and Jack Faucett Associates estimates; see Appendix

## The societal benefits of NGVs compensate for higher direct costs

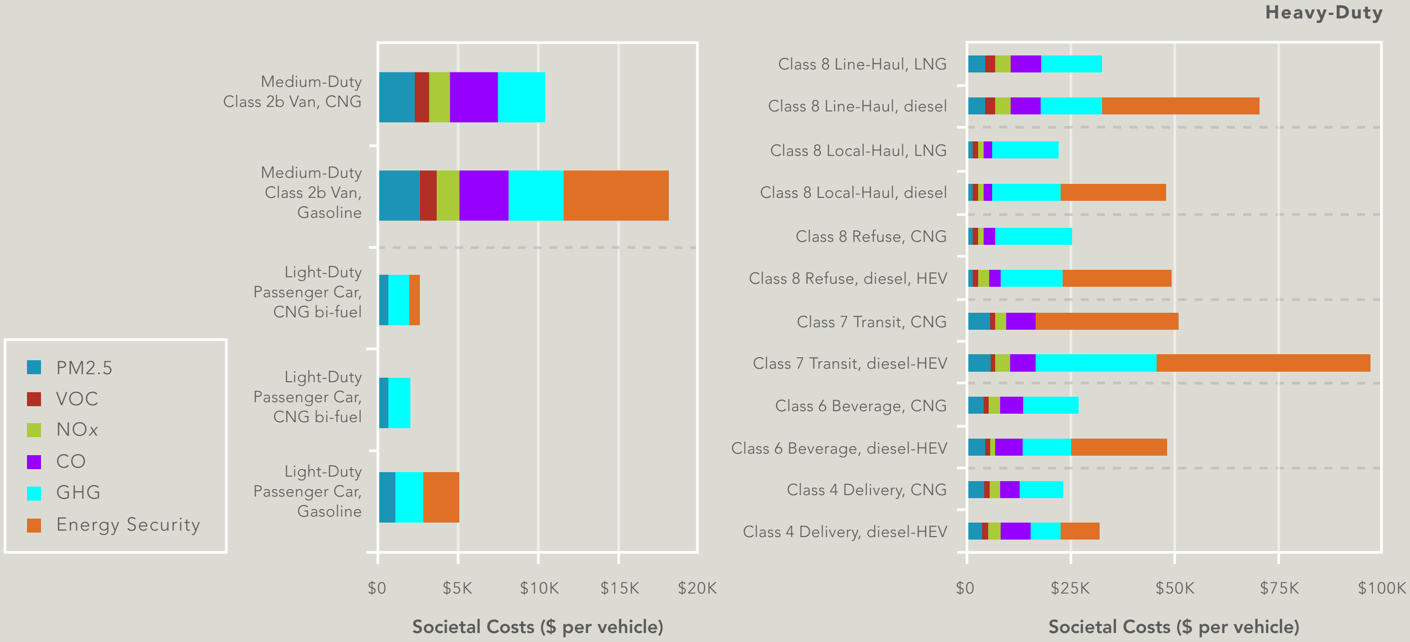
In addition to direct costs, the increased use of natural gas also results in fewer indirect costs to society as a whole. One of these reduced costs is the energy security premium, which has been estimated at approximately $0.462 per gallon.[16] Energy security can be defined as protecting the economy against significant increases and volatility in energy costs, which have contributed to U.S. recessions since the 1970s.

In addition, every transportation fuel carries a societal cost based on impacts to human health by criteria pollutant emissions. These costs are different for each fuel. The more use of natural gas as a transportation fuel, the more these societal costs can be reduced. The third societal cost of fuel use results from GHG emissions, which impact human health, property, agricultural productivity, and ecosystems.

Monetization of these societal costs provides a means to assess the societal benefits of the alternative fuels considered. The charts below demonstrate that, across multiple vehicle segments, the societal costs for NGVs are lower than those for conventional fuels. The net savings (of direct and societal costs) exceed $50,000 for some high fuel use applications and are comparable to saving 15 percent of lifetime costs. The savings for other applications may be less but are still significant. One way to capture these societal cost savings is by providing vehicle incentives to buy down the initial cost of the more expensive technology, noting that the total ownership costs of NGVs may be less than those of conventional vehicles due to lifetime fuel savings. This is currently done in several states and was recently part of federal programs as well.

16 See Comparative Analysis report of overall TIAX assessment for additional discussion of energy security and societal cost monetization.

Societal costs of various vehicles, by fuel type[17]




**Note:** Direct costs above include vehicle and lifetime fuel costs, assuming a $1.50 per equivalent gallon pump price differential. As indicated in Figure 2.3-1, the differential may be as high as $4.00 per equivalent gallon, which significantly lowers the relative direct costs of NGVs.

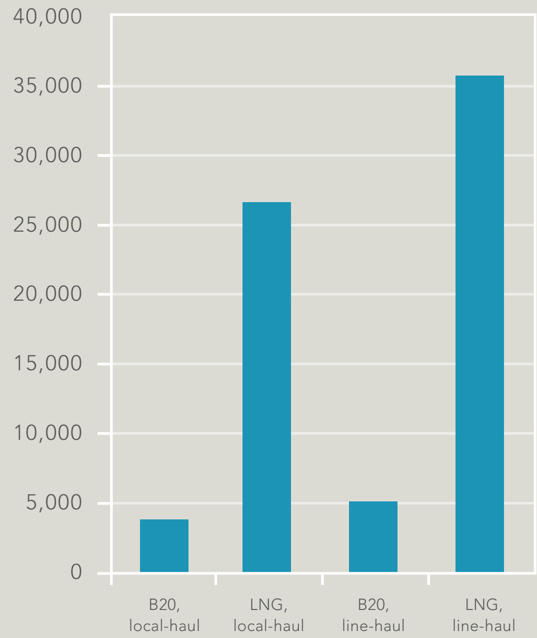
## Heavy-duty NGVs deliver the greatest societal benefits

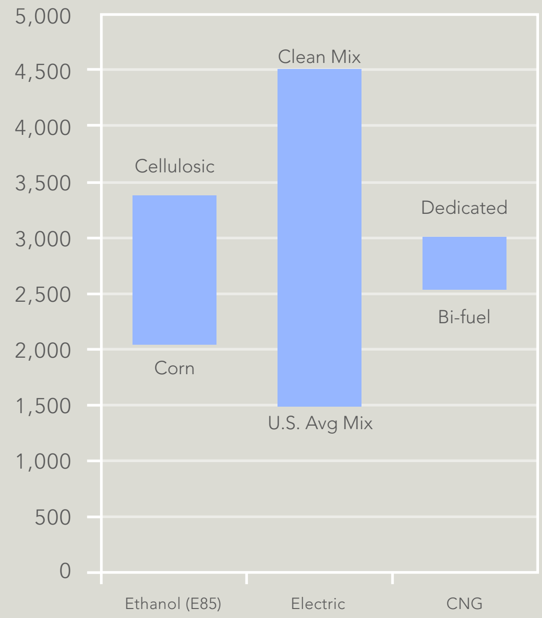
In understanding the societal costs of conventional and natural gas vehicles, this report monetizes the societal and indirect costs associated with various fuels and technologies. It focuses on those with the largest impact: local urban pollution, GHG emissions, and energy security. Emissions and energy use were determined using a full fuel cycle methodology, and the values of these externalities were calculated from accepted estimates used by federal agencies. The figure below shows two examples of the societal benefits of using alternative fuels compared with advanced gasoline and diesel technologies. For passenger cars, NGVs are essentially comparable to ethanol and electric options. In heavy-duty NGVs, high fuel use leads to greater societal benefits. The value of these benefits, applied as incentives, may help move the NGV market forward.

17 See Comparative Analysis report of overall TIAX assessment for calculations of direct and societal costs of various vehicle technologies.

## Societal costs of various transportation fuels[18]

**Societal Cost Savings Compared to Conventional Vehicle** ($)




## Energy policy to date has not decreased transportation fuel consumption

Americans experienced the first petroleum price shock in 1974 when the Organization of Petroleum Exporting Countries (OPEC) embargoed petroleum to the U.S. Its price more than doubled, and Americans experienced shortages at local fueling stations. The second "petroquake" occurred in 1979 with the Iranian War and petroleum again being embargoed. These two events resulted in the first of a series of Energy Policy Acts (EPActs) (Figure 6.1-1). The Corporate Average Fuel Economy (CAFE) standards of the first act approximately doubled fuel economy of new vehicles and were one of the reasons fuel prices fell in the early 1980s.

Although a number of other global events affected the price of petroleum over the next several decades, as world demand slowly increased, the price of petroleum reached a new high in 2008. Increasing petroleum prices have been associated with U.S. recessions; although each U.S. President responded to the energy crisis, there were no standards or regulations implemented to reduce fuel consumption in the transportation sector (other than CAFE and the more recent fuel economy and GHG standards).

The policy approach of the time was to let market forces regulate energy prices. This was a reasonably successful policy for providing consumers with relatively low and stable fuel prices from 1985 to the early 2000s. This policy also resulted in the U.S. importing more and more petroleum to meet the growing demand associated with population and economic expansion. The chart below details significant energy milestones and government energy policy introductions:

18 See Comparative Analysis report of overall TIAX assessment for societal cost calculation details and assumptions.

| Date | Energy Milestones |
|---|---|
| 1973 | Yom Kippur War, OPEC petroleum embargo, Project Independence (self sufficient by 1980) |
| 1975 | Energy Policy and Conservation Act |
| 1977 | Carter signs DOE Organization Act |
| 1978 | National Energy Act-Energy Tax Act |
| 1979 | Iran War, 2nd oil crisis, decontrol of oil prices |
| 1980 | Energy Security Act |
| 1981 | Decontrol of crude and refined product prices |
| 1988 | Alternative Motor Fuel Act |
| 1990 | Gulf War |
| 1992 | EP Act 1992 |
| 2001 | "9-11" Terrorist Attack |
| 2003 | Iraq War |
| 2005 | Gulf hurricanes—Katrina, Rita |
| 2005 | EP Act |
| 2007 | EISA |
| 2008 | Great Recession |

## Environmental standards are decreasing emissions and need to keep pace with fuel consumption

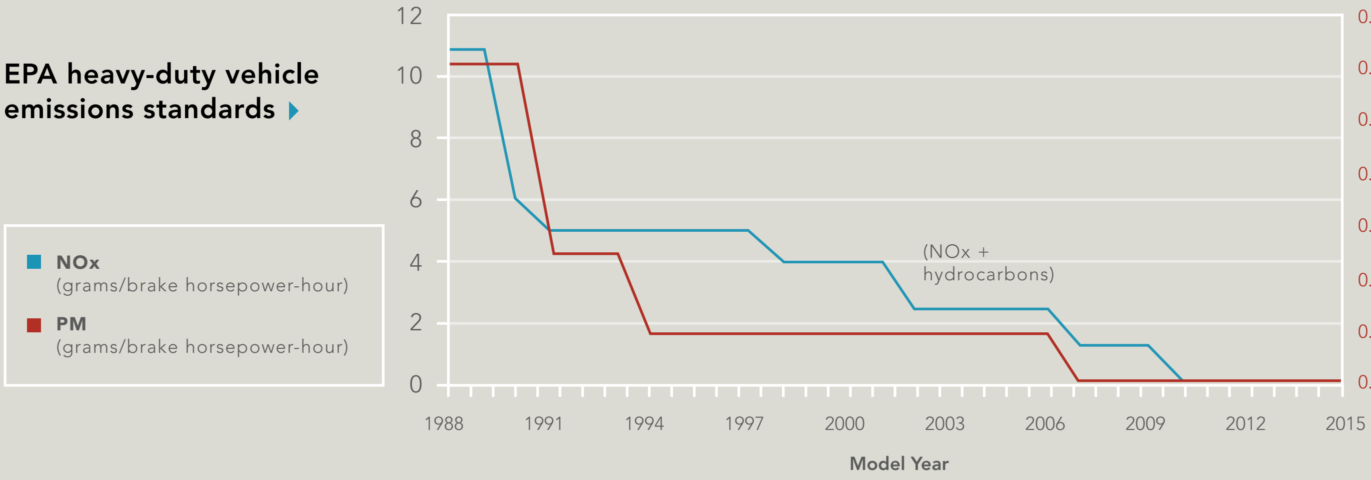
In response to health effects of local pollution (ozone, carbon monoxide, oxides of nitrogen (NOx), particulate matter (PM), and lead)[19], the U.S. federal government established the EPA and empowered it through the Clean Air Act (CAA) and its Amendments (CAAA) to set ever tighter fuel and vehicle standards to help regions comply with health-based ambient air quality standards. A number of programs that resulted from this overall policy are also shown in the table.

19 Health effects of these pollutants include respiratory and cardiovascular diseases.

| Date | Environmental Milestones |
|---|---|
| 1970 | EPA opens, Clean Air Act passes |
| 1971 | EPA sets National Ambient Air Quality Standards |
| 1973 | EPA starts lead phase-out |
| 1975 | EPA requires catalysts on vehicles |
| 1977 | CAAA passed |
| 1985 | EPA sets new limit on lead in gasoline; expands air toxins program |
| 1988 | EPA sets standards for underground tanks |
| 1989 | Exxon Valdez oil spill |
| 1990 | CAAA of 1990 |
| 1993 | Wintertime Oxygenated Fuel Program |
| 1994 | Phase in cleaner car standards |
| 1995 | Reformulated Gasoline Standard |
| 2002 | Diesel $NO_x$ and PM standards |
| 2005 | RFS |
| 2006 | Ultra low sulfur diesel fuel |
| 2007 | Tighter diesel $NO_x$ and 90% PM standards |
| 2007 | RFS II |
| 2010 | 90% control of $NO_x$ PM diesel |

The environmental policy of the 1970s (the Clean Air Act) was much different than the energy policy in that affected industries were mandated to reduce emissions. In general, the philosophy was to set performance standards and let industry determine the most cost-effective ways to comply. The result has been a dramatic decrease in fuel and vehicle emissions and substantial improvement in air quality, as evidenced in the graphic below. However, economic expansion continues to put pressure on achieving and maintaining air quality in many regions of the U.S. In addition, the finding that climate change is a serious threat to human health requires additional reductions in GHG emissions—promoting improved fuel economy and lower carbon fuels.

**EPA heavy-duty vehicle emissions standards**




Economists agree that policy intervention is needed when market forces do not account for the full costs of using a technology, such as the societal damages caused by vehicle emissions. In the past, this has justified the use of incentives to correct for this market imperfection. However, except for incentives in the various EPA acts and the mandates in the Renewable Fuel Standard (RFS), there has not been a clear objective to reduce the U.S. dependence on foreign sources of energy from geopolitically unstable regions of the world, despite growing evidence that the costs of this dependence are not fully accounted for in the fuel price.

## Where energy and environmental policies have been unsuccessful, NGVs can succeed in increasing our energy security

Despite the volatility of our energy prices and warnings about the dangers of climate change, energy and environmental policy has not significantly affected transportation fuel consumption. As global demand for petroleum grows, North American dependence on foreign petroleum from geopolitically unstable regions of the world becomes an increasing vulnerability. Recent discoveries of abundant and domestic natural gas supplies coupled with the maturity of NGV technologies makes natural gas a viable and sustainable option for widespread use in transportation. NGVs can provide lower overall operating costs, reduced air pollutant and GHG emissions, and reduced petroleum consumption, as well as offer significant job creation opportunities. Given these factors, North America is currently in a position to make radical changes in its approach to fuel sources for transportation.

NGVs offer proven benefits and are the new frontier of North American prosperity

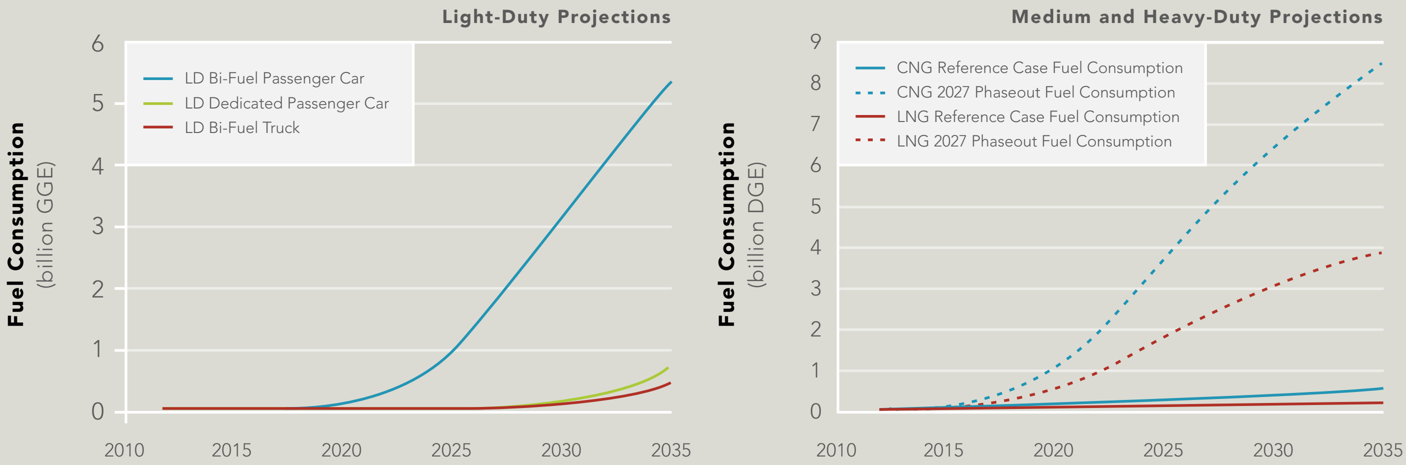
## Proliferation of NGVs establishes a new market for natural gas

The NGV market can be considered to have three main components: the light-duty CNG market, the medium- and heavy-duty CNG market, and the heavy-duty LNG market. Medium- and heavy-duty vehicles are grouped in the same market because they are employed in commercial applications, whereas the light-duty vehicles are also employed for personal use.

Under an aggressive expansion scenario, by 2035, the NGV market may potentially enable the consumption of 5.5 billion GGE of CNG in the light-duty market and 8.5 billion DGE of CNG and 3.9 billion DGE of LNG in the medium- and heavy-duty markets. Together, this consumption equals 2.2 TCF of natural gas annually and is approximately 30 percent of the current natural gas consumption in the power generation sector. This level of use in the transportation sector represents a significant new market for natural gas.  The increase in fuel required to power a growing NGV market is shown below:

20 Data from DieselNet, "Emission Standards: USA: Heavy-Duty Truck and Bus Engines," http://www.dieselnet.com/standards/us/hd.php, accessed October 2010;

### Prospective fuel consumption in light, medium, and heavy duty vehicles[21]




## Natural gas also offers profitable opportunities for players in the natural gas supply chain

The transportation sector offers significant market potential for natural gas supply chain companies. The business case for gas producers, pipeline companies, gas utility companies, and fueling station operators depends on reliable natural gas throughput and reasonable profit margins over costs. Because all of these individual companies are part of the same supply chain, they must work together to provide compelling natural gas prices at the pump. As such, it is critical to the long-term sustainability of the natural gas transportation market that these entities cooperate with one another to efficiently deliver natural gas to transportation customers. In order for each of these entities to remain in the NGV market, each must see a reasonable business case.

## Making vehicles ready for natural gas creates new business opportunities for manufacturers and suppliers

End user vehicle requirements vary widely depending on the application in which vehicles are used. Different end use applications need different vehicle attributes and place varying levels of importance on these attributes. Aligning NGV characteristics with required attributes determines whether NGVs are a viable option for end users. Some characteristics of various vehicle segments are conducive to the use of natural gas while others require tradeoffs in order to gain the benefits of natural gas. Transit, refuse, school buses, and heavy-duty package delivery vehicles have the most favorable characteristics, and not surprisingly, these applications currently dominate NGV use, along with light-duty fleet applications. Other applications are considering or currently trying NGVs, including local- and regional-haul tractors.

The table below summarizes current suitability of different vehicles for natural gas. It also provides insight into the work that will be required to bring products to market.[22]

21 See Scenario Analysis report of overall TIAX assessment for details and assumptions.
22 See Market Segmentation report of overall TIAX assessment for additional discussion of vehicle segment characteristics.

| Vehicle Segment | Range | Base | Fueling Infrastructure | Vehicle Availability | Fuel Cost Sensitivity | Environmental Policies |
|---|---|---|---|---|---|---|
| Passenger Car/Light Truck (Retail) | Good | Good | Fair | Fair | Weak | Fair |
| Passenger Car/Light Truck (Commercial) | Fair | Good | Good | Fair | Weak | Fair |
| Medium-Duty Private and Commercial Van/Truck | Good | Good | Good | Fair | Fair | Fair |
| Heavy-Duty: Package Delivery | Good | Good | Good | Weak | Good | Good |
| Heavy-Duty: Utility Trucks | Good | Good | Good | Fair | Fair | Fair |
| Heavy-Duty: Beverage Truck | Good | Good | Fair | Fair | Fair | Fair |
| Heavy-Duty: School Bus | Good | Good | Good | Fair | Weak | Good |
| Heavy-Duty: Transit Bus | Good | Good | Good | Good | Good | Good |
| Heavy-Duty: Refuse Trucks | Good | Good | Good | Good | Good | Good |
| Heavy-Duty: Local-Haul Tractor | Good | Fair | Fair | Fair | Good | Fair |
| Heavy-Duty: Line Haul-Truck Tractor | Weak | Weak | Weak | Weak | Good | Fair |
| Off-road Service/Utility Vehicles | Fair | Good | Good | Fair | Fair | Fair |
| Construction Equiptment | Weak | Weak | Weak | Weak | Weak | Weak |
| Mining Equiptment | Weak | Good | Good | Weak | Good | Weak |

● Good ○ Fair ○ Weak

# Definitions*

**Good:**
1- Strongly enables the use of NGVs with the current state of the NGV market, or
2- Provides significant benefits from the use of NGVs

**Fair:**
1- Provides limited options to enable the use of NGVs or needs additional development, or (2) Provides modest benefits from the use of NGVs

**Weak:**
1-Requires significant additional development to enable the use of NGVs, or
2-Provides no benefits from the use of NGVs or increases overall costs

*Note that the assessment of any criterion for any application as good, fair, or weak is subject to change as the markets and various external pressures change

**Legend:**
For each vehicle segment, six criteria are identified that align with characteristics that are suitable for natural gas. These are described below. Ratings of good, fair and weak are assigned to identify the best markets for NGVs.

**"Range"** describes the typical daily operating range of vehicles in a particular application. In most applications, whether on-road or off-road, it is preferred by vehicle users that the vehicle carry enough fuel to operate for several days or be able to miss a typical refueling event without running out of fuel. This provides the user with some margin of safety if daily operations deviate from the norm. At a minimum, it is assumed that a vehicle must carry enough fuel to work through an entire shift or typical day of operation.

**"Base"** refers to the location where the vehicle is parked or stored when not in operation. Return-to-base applications, where the vehicle is returned to the same location each day, are the most conducive to NGV use because they allow for daily refueling, thereby minimizing onboard fuel storage requirements. These return-to-base applications often include centralized maintenance facilities and staff, allowing a few trained technicians to support numerous NGVs.

**"Fueling Infrastructure"** describes the typical method of refueling employed for a particular vehicle application as well as the potential for adding natural gas capability. Fleets that fuel their vehicles at fleet yards or operations centers (e.g., warehouses and ports) are best positioned to use nearby public fueling stations or install fleet-controlled natural gas fueling equipment.

**"Vehicle Availability"** describes the number and types of vehicles currently available for a particular application. In general, more vehicle and engine options ensure that NGVs will be suitable for users within an application. Original equipment manufacturer (OEM) options provide a single responsible party for warranty and service, making these offerings more appealing.

**"Fuel Cost Sensitivity"** considers the relative importance of fuel costs to vehicle purchase and operating costs. In general, high fuel consumption applications are highly sensitive to fuel costs. Low fuel consumption applications tend to be more sensitive to purchase and maintenance costs.

**"Environmental Policies"** as a criterion attempts to describe whether vehicle users within a particular application are sufficiently motivated by internal policies or external regulations to make vehicle purchase decisions based on the relative environmental impacts of the vehicles.

## How can we make NGVs more available and affordable?

Making NGVs more available and affordable will involve all of the four major stakeholders in the NGV industry—end users, natural gas supply chain companies, vehicle and engine manufacturers and government—working together. Each has a specific role, as well as significant opportunities for gain, in the NGV market:

| Major NGV Stakeholder | Role in NGV Market |
|---|---|
| End users | Provide demand for NGVs and natural gas fuel |
| Natural gas supply companies | Supply natural gas to transportation market; establish and operate fueling infrastructure; help in the education and training of and outreach to the other industry stakeholders to dispute market risk |
| Vehicle & engine manufacturers | Provide NGV offerings meeting the requirements of end users |
| Government | Level the playing field relative to other alternative fuels and vehicles and avoid picking alternative fuel winners and losers |

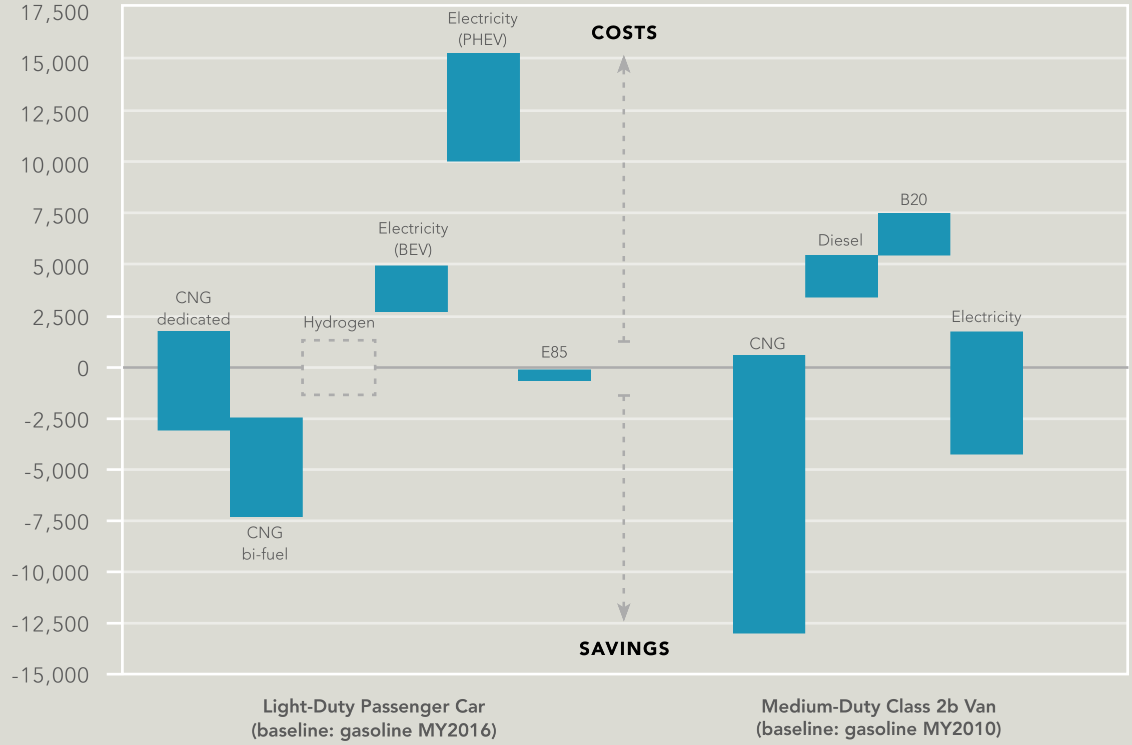
## Building a foundation for NGVs: End users need affordable options

End-user vehicle purchase decisions focus primarily on three criteria: potential savings, fueling infrastructure availability, and vehicle choices. Whether end users rely on public fueling infrastructure or are capable of accessing a home fueling appliance[23], the availability of infrastructure drives the vehicle purchase decision. End users' purchase decisions will be influenced by the relative lifetime costs or savings offered by various technology options compared to gasoline and diesel vehicles. The table below presents information on the existing fueling infrastructure by fuel type. Adoption of NGVs is also highly dependent on engine and vehicle availability.

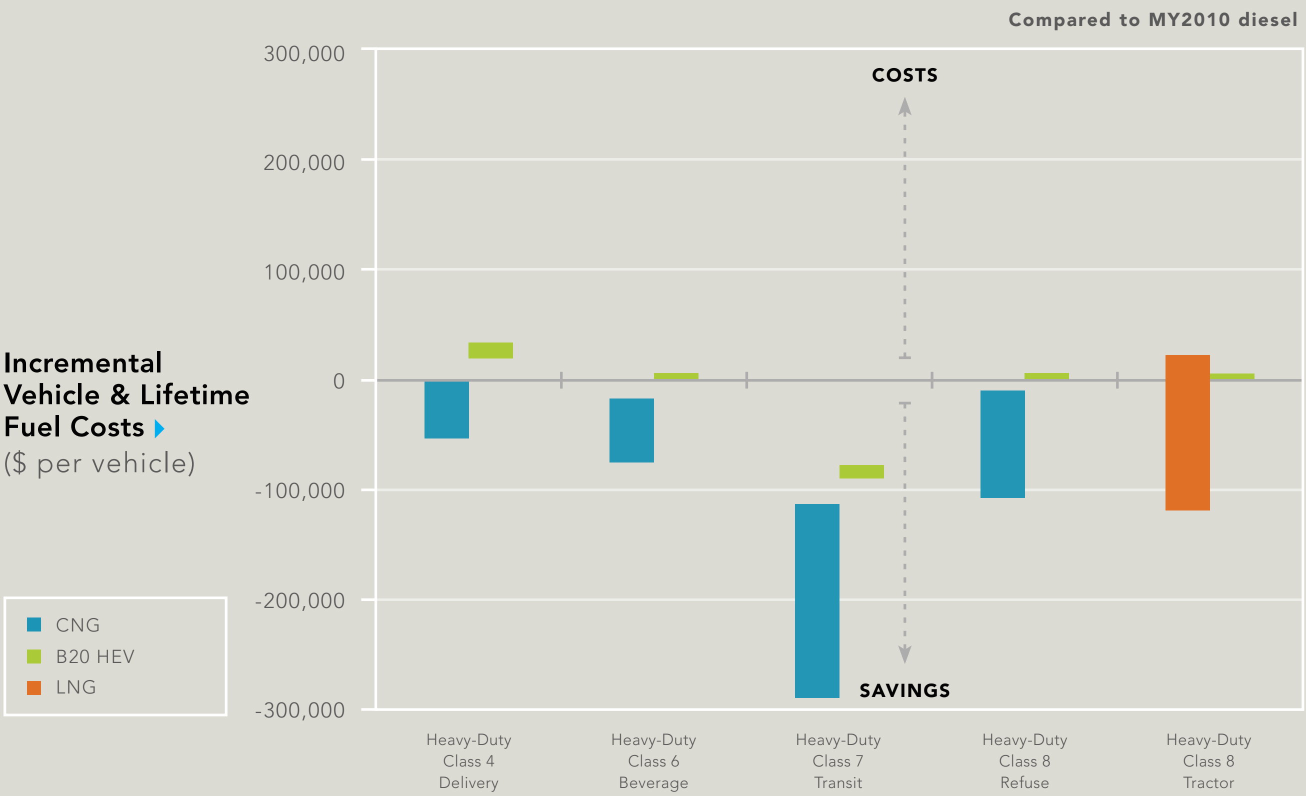
23 An in-home fueling device is a home-based gas utility or personal fueling device. It would be approximately the size of a small chair and could sit outdoors or indoors.

## Lifetime fuel costs by vehicle and fuel type[24]

**Incremental Vehicle & Lifetime Fuel Costs**
($ per vehicle)




**Incremental Vehicle & Lifetime Fuel Costs**
($ per vehicle)




24 Lifetime costs include the cost of fuel over the vehicle's first-owner operating lifetime and reflect the vehicle application's operating characteristics. See Comparative Analysis report of overall TIAX assessment for calculation details and assumptions.

## Rising fuel costs and environmental concerns attract consumers to NGVs

There are six criteria that drive end-user purchase decisions: range, base, refueling infrastructure, vehicular availability, fuel cost sensitivity, and environmental policies. In general, economic, environmental, and social pressures influence vehicle purchase decisions. These pressures will ultimately dictate which market segments seek alternatives to traditional petroleum fuels and what alternative fuels they select. Of the six criteria used to evaluate the various market segments as previously discussed, two of these criteria represent market drivers that incentivize or discourage the acceptance of alternative fuels. These criteria are sensitivity to fuel cost and environmental policies and represent economic and environmental/social pressures respectively. While not complete or exhaustive, these two criteria are important and reflect those markets that have seen the greatest penetration of NGVs.

Consumer demand for NGVs depends on their value proposition, which depends on initial vehicle costs, expected fuel savings, vehicle incentives, vehicle and fueling infrastructure availability, and other non-financial motivators, such as carpool lane access or a "green" image. They want sufficiently large and constant fuel cost differentials and reasonable initial vehicle costs relative to their discounting of future fuel savings.

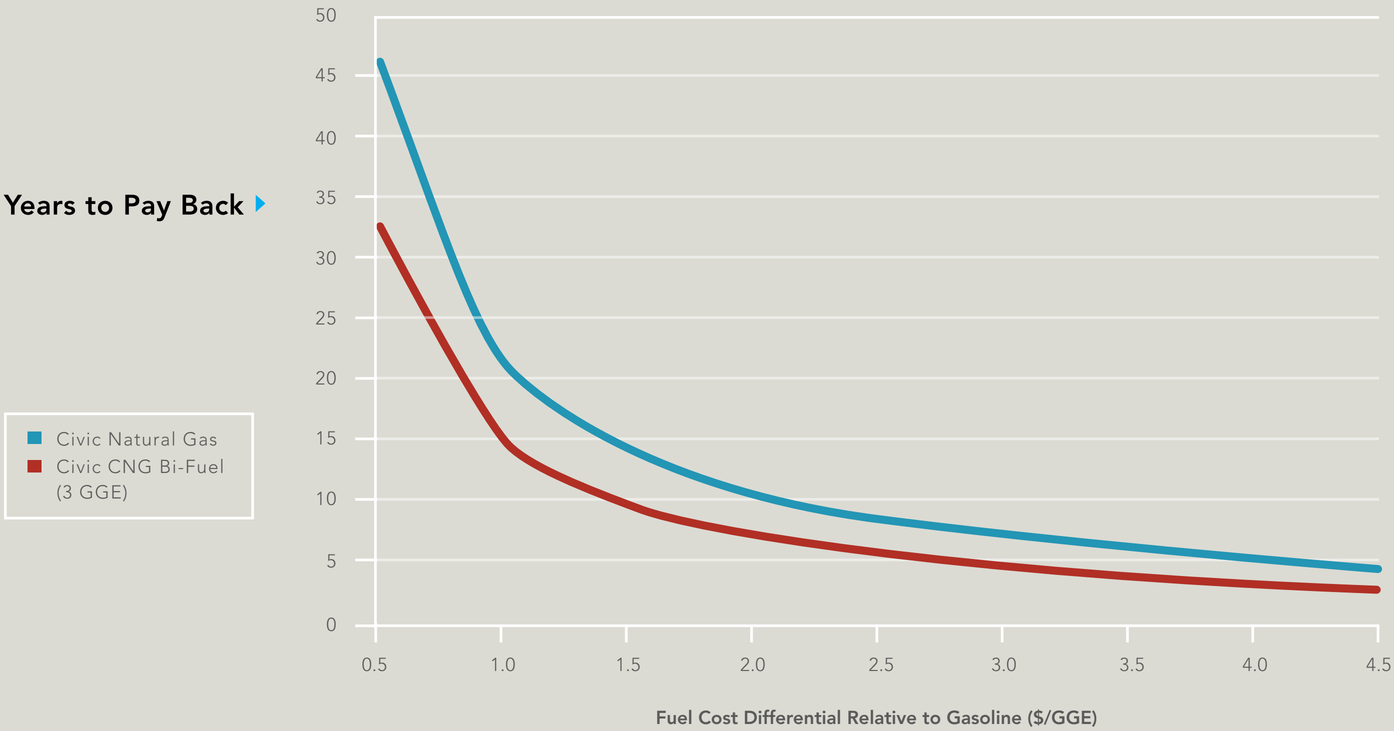
## Consumers consider payback timeframe when making a purchase decision

Years-to-payback is the main economic indicator end-users focus on when determining the attractiveness of an NGV. This is defined as the number of years required to achieve payback on higher initial vehicle costs through fuel savings. It is a function of the pump price differential between natural gas and petroleum fuels, as well as incentives for vehicle purchase, including tax credits and rebates. Because there are several competing vehicle technology options to choose from, end users should weigh the relative merits of conventional and other alternative fuel vehicles against those of NGVs in their purchase decisions.

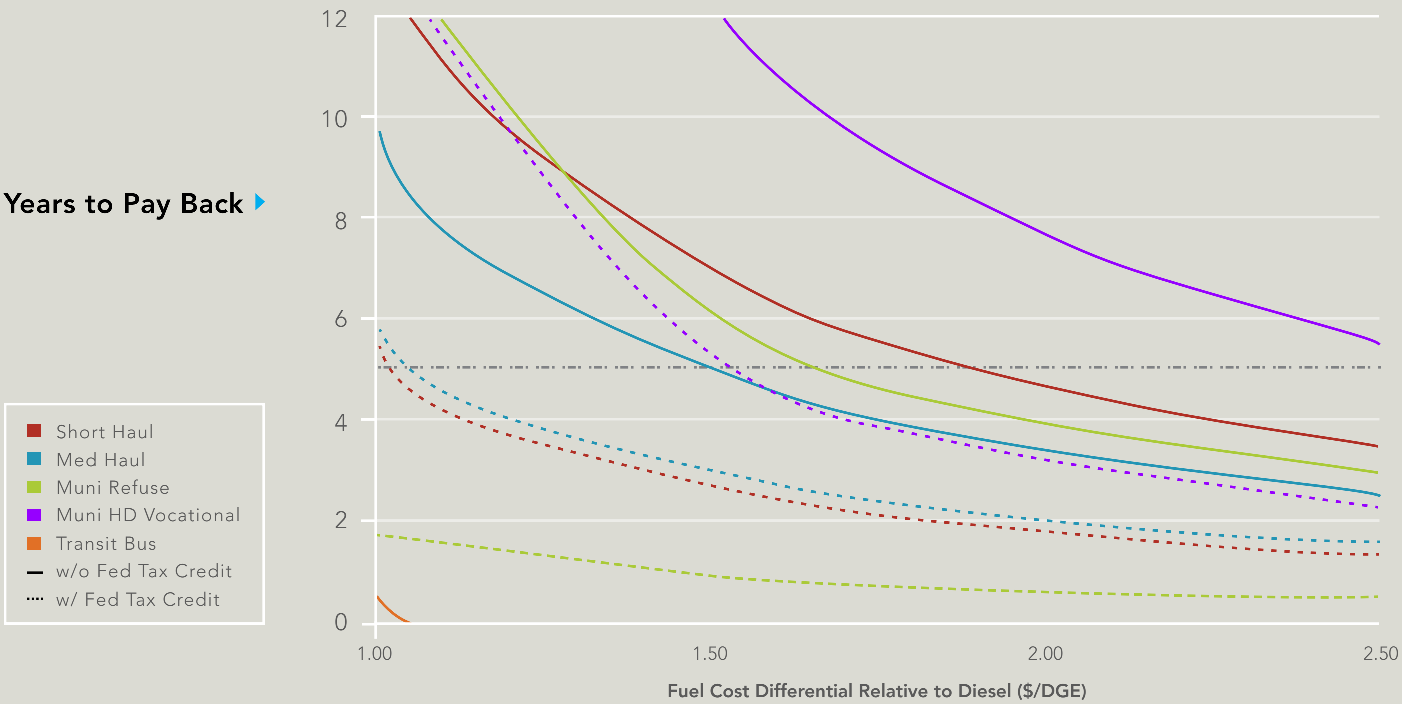
Though the duration of vehicle ownership may be much longer, the payback period required by consumers may be three to five years, so the value proposition hinges on whether the combination of fuel price differentials and incentives allows such a payback period, if any. In the light-duty personal use vehicle market, typical driving cycles may allow the option of using small natural gas capacity bi-fuel NGVs[25] (operating on both natural gas and gasoline), which attains payback more quickly than dedicated NGVs. If consumers see a value proposition for NGVs, whether in the personal use market or the commercial fleet market, manufacturers have indicated that they will be "fast followers" into this market.

25 On the order of 3 GGE of natural gas capacity; see Light- and Medium-Duty Vehicle Ownership and Production report of overall TIAX assessment for details.

## Years-to-payback for a Honda Civic Natural Gas and a bi-fuel model[26]




## Years-to-payback for heavy-duty NGVs[27]




26 See Light- and Medium-Duty Vehicle Ownership and Production report of overall TIAX assessment for details and assumptions of payback analyses.
27 See Heavy-Duty Vehicle Ownership and Production report of overall TIAX assessment for details and assumptions of payback analyses.

## Building a foundation for NGVs: Manufacturers need a viable marketplace

### Consumer demand, profitability and supporting regulations will drive vehicle and engine manufacturers' activity

Vehicle and engine manufacturers across the light, medium, and heavy-duty segments are driven by three key factors: consumer demand, profitability, and regulations. As detailed above, to capture consumer demand, manufacturers must play a role in garnering rebates. The attractiveness of natural gas to vehicle and engine manufacturers will depend on how well it can meet the standards and the cost of producing natural gas vehicles and engines compared to other options that meet the same standards.

Manufacturers' profitability depends on the costs of developing a natural gas version of their products and the volume of vehicles or engines over which these development costs can be amortized. Light-duty vehicle OEMs are estimated to require volumes of 50,000 to 60,000 units for NGVs to be considered "at scale,". For OEMs with existing CNG experience, the cost of developing a new, ground up natural gas powertrain is estimated to require $50 million in incremental costs. Heavy-duty vehicle OEMs reported the need for annual sales of approximately 1,000 to 10,000 units to justify expanded investments in the North American NGV market, estimating costs to develop and commercialize natural gas versions of their vehicles at $100,000 to $3.5 million, depending on the vehicle type and previous natural gas vehicle design. Heavy-duty engine OEMs reported the need for annual sales of approximately 10,000 units worldwide and estimated costs to develop and commercialize natural gas versions of their engines at $2 to $10 million also depending on the extent of base engine modifications.

Finally, regulations influence manufacturers to produce certain vehicles and engines. As air pollutant and GHG emissions standards are expected to grow more stringent, vehicle offerings will need to meet these standards. In the near term, air pollutant emissions standards and fuel economy standards will drive light-, medium-, and heavy-duty vehicle production.

## Natural gas requires an efficient fueling infrastructure

### Consumers see natural gas as a viable transportation option but fueling infrastructure is lacking

Natural gas is a mature and proven technology that can hold its own with other fuels across a range of vehicle segments but will require significant expansion of infrastructure to be widely accepted. The figure below presents a comparison of vehicle ownership costs in seven market segments for both baseline and alternative fuel types.

## Comparison of consumer considerations for alternative fuel vehicles[28]

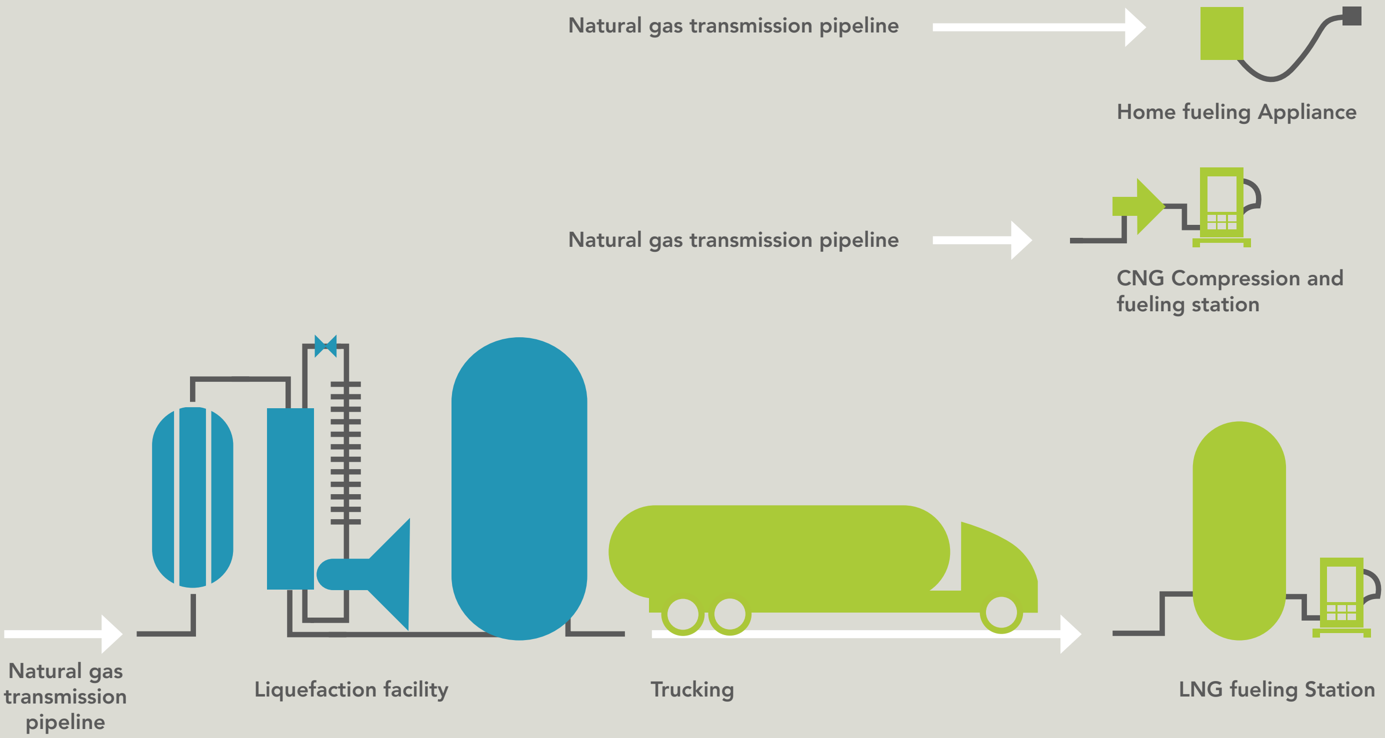
| Vehicle Technology | Number of U.S. Stations | Primarily Used In: Light-Duty | Primarily Used In: Med-Duty | Primarily Used In: Heavy-Duty | Consumer Perception |
|---|---|---|---|---|---|
| Gasoline | 118,756 | O | O | | Familiar technology; for medium-duty vehicles, may be more economically attractive than the 2010 compliant diesel technologies emissions |
| Diesel | 32,000 | | O | O | Familiar and efficient; new diesel technology may be costly |
| E85 | 2,544 | O | | | Generally, unaware that vehicles may already be an FFV; E85 price may not be enough to motivate acceptance of lower energy content and station availability |
| CNG | 1,091 | O | O | O | Mature and proven technology that may be more economically attractive than advanced gasoline or diesel technologies |
| Biodiesel | 679 | | O | O | Quality-controlled B20 accepted by many manufacturers; potential issues at cold temperatures and fuel price |
| Electricity | 12,542 | O | O | O | Can help enhance green image; economics may be favorable if battery costs meet expectations |
| Hydrogen | 54 | O | | | Significant interest, but not yet commercially available |
| LNG | 58 | | | O | Can help enhance green image; economics may be favorable for high fuel use applications |

The discoveries of significant natural gas resources expand natural gas use from heating and power generation to include transportation. However, significant investments aimed at establishing a cohesive network of fueling stations are required. In order for the transportation market to access this supply of natural gas, the appropriate infrastructure must be in place to fuel vehicles.

The required infrastructure for CNG and LNG differs from that of gasoline and diesel. For CNG, natural gas is supplied to the fueling station or home garage via pipeline and compressed before it is dispensed as vehicle fuel. For LNG, natural gas is supplied to a liquefaction facility via pipeline, where it is cooled and liquefied into LNG and transported by truck to fueling stations, as the following diagram shows:

28 U.S. Census Bureau, "Economic Census," 2007; Alternative Fuels and Advanced Vehicles Data Center, "Alternative Fueling Station Counts by State," http://www.afdc.energy.gov/fuels/stations_counts.html, July 31, 2012; TIAX LLC, "SCR-Urea Implementation Strategies Update," prepared for Engine Manufacturers Association, 2006

Natural gas fueling options[29]



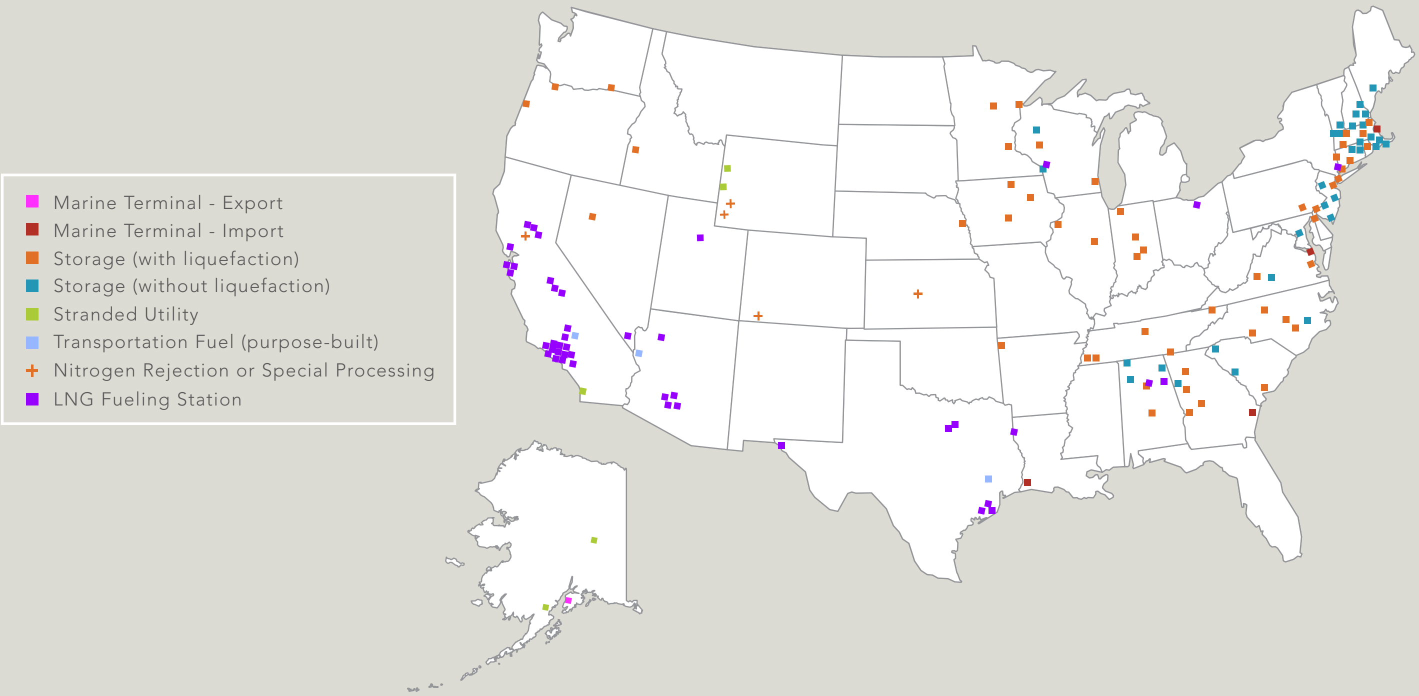

## Initially, the current infrastructure can be leveraged in the natural gas supply chain

Several approaches have been used to establish natural gas fueling infrastructure. For example, a gas utility company may decide to build a station to serve its own NGV fleet as well as provide natural gas for public access. A transit agency or large commercial fleet may decide to build a station to fuel its NGV fleet and may or may not offer natural gas for public access. Alternatively, an independent fuel retailer may decide to build a station to serve the public at large. Combined, the various approaches to building infrastructure have resulted in 1,091 CNG and 58 LNG stations to date in the U.S.[30] It is important to note that a regional hub-and-spoke approach to building up natural gas infrastructure can be effective in establishing a fueling network, but purely private fleet stations may not help in this regard.

To achieve the reliable throughput needed by natural gas supply chain companies, the expansion strategy for natural gas infrastructure should be focused and incorporate growth potential. The transition between low demand in the near term and higher demand in the long term may be bridged by leveraging current stations and liquefaction facilities. Most, if not all, stations at present are operating below maximum capacity and thus are able to support significant growth of the NGV market in the near term. (Location, however, may be limiting.) As shown in the map below, liquefaction facilities exist across the U.S., even in areas where LNG stations do not yet exist

29 See Compressed Natural Gas Infrastructure and Liquefied Natural Gas Infrastructure reports of overall TIAX assessment for additional discussion of natural gas supply chains for transportation.
30 Alternative Fuels and Advanced Vehicles Data Center. "Alternative Fueling Station Counts by State." http://www.afdc.energy.gov/fuels/stations_counts.html. July 31, 2012.

Current U.S. LNG fueling infrastructure[31]




Only three liquefaction facilities currently serve the transportation market, though LNG is produced for other purposes in various areas. Leveraging this remaining liquefaction capacity can support a regional expansion model of natural gas infrastructure development. Though these facilities do not specifically serve the transportation market, they can help meet demand for LNG as new LNG infrastructure is being developed. Furthermore, building stations with modularized natural gas capacity, such that additional compressors, tanks, and/or dispensers can be easily added as needed at a later date, can help match capacity to throughput and offer more favorable return on investment.

## Future fueling infrastructure requirements differ depending on NGVs types

At the systems level, the expansion strategy for CNG and LNG may differ slightly, depending on the vehicle segments being targeted. Growth of the fueling infrastructure network for both CNG and LNG may be based on first establishing regional centers then connecting regional centers to allow expansion. For LNG, regional/line-haul tractors will require a complete corridor before they can be placed into long-distance service, and thus pre-planning of the location of these corridors will be important to infrastructure development. Finally, because the pipeline infrastructure is currently designed to serve heating and power generation needs, pipeline companies must ensure that the distribution infrastructure will be capable of handling increased volumes for transportation.

31 See Liquefied Natural Gas Infrastructure report of overall TIAX assessment for additional discussion of the various types of LNG facilities.

## A North American natural gas fueling infrastructure requires significant investments

While some of the existing fueling infrastructure can be used for an expanding NGV market, large investments are needed to expand the fueling infrastructure to support its growth. The cost of establishing a CNG station may range from $675,000 for a time-fill station dispensing 1,320 DGE in a ten-hour period to $1,000,000 for a fast-fill station dispensing 200 DGE in a one-hour period. The cost of establishing an LNG station may range from $2.25 to $7.5 million for dispensing capacities of 4 to 20 million DGE per year. The LNG pathway also requires constructing liquefaction facilities, which may cost on the order of $30 million per facility with capacity of approximately 100,000 LNG gallons per day[32]. In order for these investments to be reasonable, the throughput of natural gas must grow quickly enough to offer favorable return on investment and justify costs.

### Vehicle suppliers and natural gas supply chain companies must collaborate

The natural gas supply chain includes production companies, pipeline companies, LDCs, and private companies. To grow the NGV market, these companies will have to provide a cost-effective fuel that meets fuel quality and supply expectations similar to those provided by the petroleum supply chain. By 2035, aggressive expansion of the NGV market may potentially enable the equivalent of 2.2 TCF of natural gas to be consumed annually in transportation. Work has started on building an infrastructure to compete with petroleum, but much more work will be required to scale up this initial effort to effectively cover a much broader range of vehicle applications—from light-duty passenger cars to over-the-road trucks. This much broader adoption of NGVs can be a major growth market for the industry.

To support this emerging market, the supply chain companies will have to work closely with other stakeholders to develop the business cases for using natural gas. This will include working with government and other stakeholders to develop a comprehensive energy and environmental policy, working with engine and vehicle manufactures to improve their NGV offerings, and working with users to make sure their fueling requirements are met. A major focus of the supply chain companies should be on developing a robust, cost-competitive fueling infrastructure throughout the U.S. and Canada. This will require private firms working with regulated entities and equipment and construction companies to execute a plan to bring natural gas to the transportation market. The table below spells out the specific actions that vehicle suppliers and natural gas supply chain companies must take in order to grow the NGV market:

32 See Compressed Natural Gas Infrastructure and Liquefied Natural Gas Infrastructures reports of overall TIAX assessment for additional details of vehicle throughput and fuel volume.

## Vehicle suppliers' steps going forward to provide NGVs to the commercial and retail vehicle markets:

**Engine Manufacturers:**

Provide most efficient technology for natural gas

**2.** Continue to evaluate cost-effective applications of advanced diesel engine technologies to natural gas engines

**3.** Develop and commercialize wider selection of natural gas engines and ratings to meet the increasing demand

**Vehicle Manufacturers:**

**1.** Continue to provide a quality natural gas vehicle to customers meeting the same reliability, durability as gasoline and diesel products

**2.** Continue to train and educate dealers on the service and maintenance of natural gas vehicles as well as the benefits of NGVs

**3.** Work with equipment suppliers to drive down the costs of natural gas vehicle components

## Natural gas supply chain companies' steps going forward to provide natural gas to commercial and retail customers:

**Fuel Supply Chain:**

**1.** Work to match fueling station throughput to vehicle demand

a. Pipeline infrastructure
b. Liquefaction facilities
c. Local fueling stations

**2.** Develop successful business cases for infrastructure development

**3.** Use government fuel infrastructure incentives to connect regions

**4.** Promote competition to reduce costs of CNG and LNG supply to end-users

**5.** Work with equipment suppliers to develop cost effective, modular station designs to drive down cost of designing, building, and operating natural gas fueling stations

## Government can level the playing field to make NGVs more affordable

For the NGV market to grow, each major market player will need to take steps to promote the use of natural gas. The higher incremental cost of NGVs is one reason that natural gas tends to rely on regulations and incentives rather than fuel cost differential. In particular, the infrastructure costs associated with installing private natural gas fueling stations can be prohibitive for many small fleets without funding assistance to offset costs. In addition, the incremental cost of NGVs can prevent adoption in low fuel consumption applications where the return on investment is low.

## A level playing field among alternatives can make NGVs more affordable.

Government intervention is critical to support new fuel alternatives that are more expensive for consumers. For example, no vehicle incentives are needed for fuels that do not have increased costs, whereas vehicle incentives may be recommended for those that do. Similarly, no incentives are needed for fuels that are less expensive on an energy basis or that are currently mandated through existing standards. The table below shows how policy might be structured to reflect the differences between alternative fuels:

| Alternative Fuel | Vehicle Costs | Fuel Costs | infrastructure Needs | | | Incentive Needs | | |
|---|---|---|---|---|---|---|---|---|
| | | | Home | Public | Private | Vehicle | Fuel | Infra-structure |
| Ethanol blend (E10) | Same | Same | No | No | No | No | No | No |
| Ethanol (E85) | Same | Same | No | Yes | No | No | Yes | Yes |
| Plug-in hybrid electric vehicle (PHEV) | More | Less | Yes | Some | No | Yes | No | Yes |
| Battery electric vehicle (BEV) | More | Less | Yes | Some | No | Yes | No | Yes |
| Hydrogen fuel cell vehicle (FCV) | More | Same | No | Yes | Yes | Yes | Yes | Yes |
| Light-duty NGV | More | Less | Yes | Yes | No | Yes | No | Yes |
| Heavy-duty NGV | More | Less | No | Yes | Yes | Yes | No | Yes |
| Biodiesel (B20) | Same | More | No | Yes | Yes | No | No? | No |

The growth of NGVs over the past twenty years has been driven by environmental objectives of lowering fuel and vehicle emissions—particularly those produced by heavy-duty diesel vehicles.

EPAct helped drive the purchase of NGVs and the establishment of natural gas fueling stations. Regions having the most success at increasing the use of NGVs were those that required alternative fuels but at the same time provided incentives for users to purchase the higher cost technologies. The South Coast Air Quality Management District (SCAQMD) "1190" fleet rules are a good example of requiring the use of alternative fuels in fleets such as transit and refuse as a way to reduce NOx and PM emissions from diesel engines. Using local and state funding, SCAQMD was able to provide incentives to those complying with the regulations.

Federal and state agencies are developing regulations to control GHG emissions. At the federal level, EPA is working with the U.S. Department of Transportation to regulate GHG emissions for light- and heavy-duty vehicles. To date, these regulations have primarily focused on increasing fuel economy and not on the use of low carbon fuels. An exception to this is California and other states that are developing a low carbon fuel standard to encourage the use of alternative fuels that will decrease carbon emissions and increase energy security. Increased CAFE standards will also help to increase the use of alternatives. Going forward, there needs to be a consensus on reducing transportation energy consumption above and beyond that is achievable through increased efficiency alone. Furthermore, government policy, supported by stakeholders, should reflect parity for the various alternative fuels, each of which has different requirements as indicated earlier in this report. The current renewable fuels standard is a step in the right direction but is specific to biofuels. A broader stakeholder-supported regulation is needed to include not only efficiency and biofuels but also other low carbon fuel sources like natural gas. The specific actions that the government and end users must take in order to grow the NGV market are outlined below:

## Government steps going forward to encourage the use of natural gas in the transportation sector:

**1.** Develop consensus on objectives and policies to increase energy security

**2.** Integrate energy objectives and policies with environmental objectives and polices

**3.** Evaluate and select policy instruments to achieve environmental and energy objectives

**4.** Do not wait for "silver bullet" technologies.

**5.** Level the playing field by evaluating alternative fuels based on needs and benefits

**6.** Set performance standards for increasing use of alternative, domestic fuels in government fleets to avoid "picking winners" and to allow for industry to comply cost-effectively

**7.** Continue to educate consumers through Clean Cities program

## Commercial and retail car, truck, and bus purchasers' steps going forward on the use of natural gas as a transportation fuel:

**1.** Make use of information, funding, and incentives available from natural gas suppliers, vehicle suppliers, and government to evaluate the benefit of NGVs to company's operation.

**2.** Work with similar industries in region to evaluate and aggregate demand to justify public natural gas stations.

**3.** Work with vehicle suppliers to expand availability of NGV products—vehicle and performance characteristics

Any regulation developed should be structured to allow the affected industries the flexibility to meet the regulations as cost-effectively as possible. Lastly, government organizations are very effective at disseminating unbiased information on alternatives. The U.S. Clean Cities program has been particularly effective in this regard and should be leveraged to continue providing information on NGVs as well as other alternatives.

End users should make use of the information provided by the government and vendors to make business decisions on the savings possible with NGVs. Users should also work with similar industries to help natural gas fuel providers to aggregate demand in various locations and regions. Finally, users should provide feedback to engine and vehicle manufacturers as well as suppliers regarding needed product improvements and expansion of product offerings

This page intentionally left blank

This analysis covers three scenarios (light-duty CNG, medium- and heavy-duty CNG, and heavy-duty LNG) involving expansion of the supply of natural gas as a transportation fuel, as well as the construction of the necessary infrastructure (including stations, processing plants and heavy-duty trucks) to support that expansion. Employment impacts vary with the scale of additional spending that occurs within sectors. For this analysis, the results are reported as the impact associated with each additional station. These numbers should be understood as averages, however, and they take into account the assumption that a significant expansion is modeled. These numbers would be less reliable in the case of an expansion on a very small scale (involving only a few new stations and a few thousand new vehicles).

Employment impacts are expressed in full-time equivalent units (FTEs) of employment. An FTE represents the level of employment equal to a single full-time employee working forty hours per week. The use of FTEs as a measure does not imply that the employees under consideration are full-time employees, however. Two or more employees may be employed on a part-time basis, and their total employment may comprise a single FTE.

## Employment impacts from infrastructure expansion

Infrastructure expansion for the provision of expanded supplies of natural gas requires significant spending on fueling stations, processing facilities and additional heavy-duty tanker vehicles to carry supply not deliverable through the existing natural gas pipeline network. In addition, incremental capital costs are anticipated for the construction of vehicles capable of using natural gas as a transportation fuel.

In the three scenarios under consideration, the assumptions regarding the capital costs of infrastructure and vehicles are expressed as the costs associated with each additional natural gas fueling station. As such, the vehicle costs represent the additional fleet that can be supported by a single additional fueling station. The processing plant costs represent that share of a single plant's output sold by a single additional fueling station. The truck and pipeline costs are the cost to supply a single station.

The full infrastructure expansion costs are shown in Table A-1.

**Table A-1.** Assumptions and Costs of Capital and Infrastructure

| | Light-Duty CNG | Medium and Heavy-duty CNG | Heavy-Duty LNG |
|---|---|---|---|
| **Fueling Station Construction** | | | |
| Units | 1 | 1 | 1 |
| Cost/unit ($millions) | $1.00 | $1.00 | $0.77 |
| Total Cost ($millions) | $1.00 | $1.00 | $0.77 |
| **Processing / Liquefaction Facility Construction** | | | |
| Units | 0 | 0 | 0.1 |
| Cost/unit ($millions) | $31.8 | $31.8 | $31.8 |
| Total Cost ($millions) | $0 | $0 | $3.18 |
| **LNG Distribution Trucks** | | | |
| Units | 0 | 0 | 1 |
| Cost/unit ($millions) | $0.345 | $0.345 | $0.345 |
| Total Cost ($millions) | $0 | $0 | $0.345 |
| **Supported Vehicle Fleet** | | | |
| Units | 2,300 (LDVs) | 34 (Class 3)<br>200 (Class 4-6)<br>47 (Class 7-8) | 114 (Class 7-8) |
| Incremental Vehicle Cost/unit ($millions) | $0.002916 | $0.017 (Class 3)<br>$0.040 (Class 4-6)<br>$0.060 (Class 7-8) | $0.060 (class 7-8) |
| **Total Cost ($millions)** | **$6.71** | **$11.40** | **$6.84** |

To produce employment impacts, these final demand values were converted to associated employment levels per station through the use of input-output multipliers. These employment multipliers are developed as part of macroeconomic modeling tools and utilized to determine the specific employment impacts of changes in spending in particular sectors.

Employment multipliers for the construction and heavy manufacturing sectors were taken from the IMPLAN Input-Output Model, a macroeconomic modeling tool. Employment multipliers are expressed as the number of FTEs created for each $1 million in final demand directed to a given sector. The IMPLAN employment multiplier for the construction sector is 15.95, indicating that the model assumes that 15.95 FTEs are created for every $1 million of spending in the construction sector. The employment multiplier for manufacturing is 14.28. This slightly lower number indicates that manufacturing is slightly less labor-intensive per dollar of spending in the sector than construction.

Employment impacts in specific sectors are derived from the product of the spending in a given sector and its corresponding employment multiplier. Table A-2 shows the estimates of employment impacts from natural-gas infrastructure expansion (again, measured per fueling station).

**Table A-2.** Employment Impacts from Capital and Infrastructure

| | Light-Duty CNG | Medium and Heavy-duty CNG | Heavy-Duty LNG |
|---|---|---|---|
| **Fueling Station Construction** | | | |
| Employment Impacts | 15.95 | 15.95 | 12.28 |
| **Processing/Liquefaction Facility Construction** | | | |
| Employment Impacts | 0 | 0 | 50.72 |
| **LNG Distribution Trucks** | | | |
| Employment Impacts | 0 | 0 | 4.93 |
| **Supported Vehicle Fleet** | | | |
| Employment Impacts | 95.77 | 162.76 | 97.68 |
| **Overall Job Impacts (FTEs) per Station:** | **111.72** | **178.71** | **165.60** |

These numbers refer to the years in which the spending occurs. The additional employment created by this expenditure would disappear when the construction and manufacturing was completed.

## Employment impacts from transportation fuel sales

Employment impacts from the increased use of natural gas fuels are affected by both the growth in employment created from expanded spending on natural gas as well as losses in employment caused by spending shifting away from the petroleum sector. Importantly, because the scope of the job impacts is domestic, petroleum jobs lost outside of the country are not counted as losses to the domestic economy; in essence, the effect is a shift of foreign petroleum jobs to domestic natural gas jobs. The overall net impact is positive – the increased use of natural gas under these scenarios creates more employment than it displaces.

An important component of these job impacts is driven by the fact that natural gas has historically been, and is projected to be, approximately 45 percent cheaper than gasoline or diesel when measured per unit of energy. For this analysis, which is prospective, price projections for the near future were selected. The averages of the projected prices for all three fuels for the next five years were taken from the Department of Energy's "Annual Energy Outlook," published in March 2010. The prices assumed are in the table below, and are expressed in both GGE and DGE (Table A-3).

**Table A-3.** Fuel Prices[33]

| | CNG/LNG | Gasoline | Diesel |
|---|---|---|---|
| GGE | $1.37 | $2.81 | $2.34 |
| DGE | $1.56 | $2.91 | $2.86 |

Because the additional energy used from natural gas was similar in quantity to the energy left unused from petroleum fuels, the shift from consumption of gasoline and diesel to the consumption of natural gas presents a net savings to the consumer. This has two conflicting impacts on employment. First, employment from the direct provision of fuel goes down, because natural gas is less labor-intensive to provide and because less money enters that sector than leaves the petroleum sector. Second, economy-wide employment rises as a result of increased spending triggered by the additional money available as a result of fuel savings.

## Employment Multipliers

Accurate assessment of the impacts of spending on CNG and LNG as transportation fuels required the development of customized employment multipliers. The IMPLAN and REMI macroeconomic models use historical data, and have not developed sector-specific multipliers for the large-scale provision of natural gas as a transportation fuel. Multipliers exist for provision of natural gas for heat and power generation, but these multipliers do not take into account the additional labor involved in distributing transportation fuels (especially liquid fuels) to fueling stations, or the additional labor involved in maintaining and operating retail fueling facilities.

For CNG, analysts began with the employment multiplier established in IMPLAN for the natural gas utility sector, which is 5.57 jobs/$million in final demand. Analysts treated this level as a lower bound, and then made assumptions regarding additional labor requirements regarding the distribution and retail components of CNG as a transportation fuel. This produced a custom employment multiplier of 9.18 jobs/$million in final demand.

For LNG, which must be distributed in the same manner as conventional gasoline and diesel fuel, analysts used the employment multiplier of petroleum fuels (12.8 FTE/$million in final demand) as a benchmark from which to start. Analysts then adjusted the distribution to take into account that LNG contains only 58 percent of the energy per unit volume that diesel fuel contains. This lower energy content requires significant additional transportation resources to transport the same amount of energy to the fueling station. Analysts developed an estimate of the share of the employment multipliers dedicated to distribution, and adjusted for the scenario stipulations regarding total amounts of energy produced and displaced, to arrive at a custom employment multiplier for LNG of 15.6 FTE/$million in final demand.

Table A-4 displays the scenario assumptions, corresponding spending changes, and employment multipliers for transportation fuel sales.

33 Source: U.S. Energy Information Administration “Annual Energy Outlook,” 2010, averages of projected prices for 2011 to 2015

**Table A-4.** Spending Changes and Employment Impacts, Transportation Fuel Sectors

| | Light-Duty CNG | Medium and Heavy-duty CNG | Heavy-Duty LNG |
|---|---|---|---|
| **Natural Gas Fuel Sales Growth** | | | |
| Final Demand Change | $0.88 | $1.59 | $2.99 |
| Employment Multiplier | 9.185 | 9.185 | 15.60 |
| FTEs Created | 8.12 | 14.61 | 46.70 |
| **Petroleum Fuel Sales Displacement** | | | |
| Final Demand Change | -$1.77 | -$2.92 | -$5.53 |
| Employment Multiplier | 12.8 | 12.8 | 12.8 |
| FTEs created | -22.70 | -37.40 | -70.76 |
| **Increased Non-Fuel Spending** | | | |
| Final Demand Change | $0.89 | $1.33 | $2.53 |
| Employment Multiplier | 17.3 | 17.3 | 17.3 |
| FTEs created | 15.39 | 23.03 | 43.85 |
| **Overall Job impacts (FTEs) Per Station per Year:** | **0.81** | **0.24** | **19.78** |

These results indicate that the scenario seeking to expand the use of LNG in the heavy-duty sector produces the largest ongoing positive job impact. Because LNG provision is more labor-intensive, expansion of LNG has a larger positive impact on employment. All three scenarios demonstrate the benefits to the overall economy of savings from using natural gas in place of petroleum. In all three cases, the scenario produces greater positive employment impacts outside the natural gas sector than within it – entirely through creating significant energy savings to the transportation sector.

# This assessment was sponsored by America's Natural Gas Alliance with the support of participating American Gas Association companies.

For questions, please contact:

TIAX LLC
20813 Stevens Creek Blvd, Suite 250
Cupertino, CA 95014

http://www.tiaxllc.com/services/

The opinions expressed within the Executive Summaries of Modules 1 and 2 of this market assessment are the work product of America's Natural Gas Alliance (ANGA) and participating American Gas Association (AGA) companies based upon data provided by TIAX LLC.

The Final Reports of Modules 1 through 5 are the work of TIAX LLC as a market assessment sponsored by ANGA with the support of participating AGA companies.

Date of Request: April 15, 2016 DPS Request No. DPS-443 JS-7
Due Date: April 25, 2016 KEDNY/ KEDLI Req. No. BULI-478

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, John Sano

TO: National Grid, Revenue Requirements Panel

SUBJECT: Geothermal/Solar Technologies

Request:

1) Do the Companies currently have any programs to assist customers in pursuing geothermal or solar thermal technologies?

2) Do the Companies have any information on the potential for those two technologies in their service territories, specifically information that describes the potential in terms of numbers of customers and potential thermal load displaced expressed in dekatherm equivalents?

3) Do any of the Companies' affiliates have any incentive programs aimed at these technologies?

Response:

1)

The Companies do not currently have any programs to specifically assist customers in pursing geothermal or solar thermal technologies. However, an unregulated National Grid affiliate, National Grid Energy Management, offers installation services for solar thermal systems.

2)

The Companies do not have a resource assessment on the potential for those two technologies in their service territories.

3)

At present, no National Grid affiliate has any incentive program specifically aimed at these technologies.

Name of Respondent:
Chris Cavanagh/Keith Sperling

Date of Reply:
April 25, 2016

Date of Request: April 22, 2016
Due Date: May 2, 2016

DPS Request No. DPS-460 CS-1
KEDNY/ KEDLI Req. No. BULI-568

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, Claude Semexant

TO: National Grid, GIOP

SUBJECT: Chromatographs – KEDNY & KEDLI

Request:

The Following questions refer to the forecasts of Gas System Reinforcement Program for KEDNY, as listed in Exhibit__ (GIOP-4):

1) Provide the total number and the location(s) of the existing Chromatographs for both Companies (KEDNY and KEDLI).

2) Provide the total number and location(s) of Chromatographs installed in the last five years for both Companies KEDNY and KEDLI.

3) Provide the justification for the three additional chromatographs in the Company (KEDNY) gas system reinforcement program.

4) Describe the methodology used to calculate the billing zone determinant(s) for both Companies KEDNY and KEDLI. Provide all supporting documentation for the underlying calculation.

    a. Describe and explain how this information has been communicated to customers.

5) Provide the locations of the billing zones for both Companies KEDNY and KEDLI, on a system map.

Response:

1) and 2)

Please refer to the table below:

| ***Company*** | ***Location*** | ***Purpose*** | ***Installed in the Last 5 Years*** |
|---|---|---|---|
| KEDNY | Cambria Heights | Therm Billing Zone # 9 | No |
| KEDNY | Transco Linden Mix | Supply | No |
| KEDNY | Maspeth Station | Therm Billing Zone # 1 | Yes - Replacement |
| KEDNY | Newtown Transfer | Supply | No |
| KEDNY | LaGuardia | Therm Billing Zone # 1 | No |
| KEDNY | Fresh Kills | Supply | No |
| KEDNY | Tetco Goethals | Supply | Planned |
| KEDNY | Transco | Supply | No |
| KEDNY | Cubit Power | Therm Billing | Planned |
| KEDNY | North Queens | Therm Billing | Planned |
| KEDNY | Chelsea Gate | Therm Billing | Planned |
| KEDNY | Brooklyn Navy Yard | Therm Billing | Yes |
| KEDNY | KIAC JFK CoGen | Therm Billing Zone # 2 | Yes |
| KEDNY | Newtown Creek Biogas | Supply | Planned |
| KEDNY | Brooklyn Narrows | Supply | Yes |
| KEDNY | NYPA Kent | Therm Billing | No |
| KEDNY | NYPA 23 Street | Therm Billing | No |
| KEDNY | NYPA Pouch | Therm Billing | No |
| KEDNY | Gowanus Power | Therm Billing | No |
| KEDNY | Narrows Power | Therm Billing | No |
| KEDNY | Arthur Kill Power Plant | Therm Billing | No |
| KEDNY | South Gate | Therm Billing Zone # 8 | No |
| KEDNY | Pratt (Visy Paper) | Therm Billing | No |
| KEDNY | Canarsie | Therm Billing Zone # 2 | No |
| KEDNY | Citizens | Therm Billing Zone # 2 | No |
| KEDNY | Floyd Bennett Field | Supply | Yes |
| KEDNY | Kew Gardens | Therm Billing | Planned |
| KEDNY | Downtown Brooklyn | Therm Billing | Planned |
| KEDLI | Long Beach M&R Station | Therm Billing Zone # 1 | No |
| KEDLI | South Commack M&R Station | Therm Billing Zone # 3 | No |
| KEDLI | Lake Success Meter Station | Supply | No |
| KEDLI | NYPA Holtsville | Therm Billing | No |
| KEDLI | EF Barrett Power Station | Therm Billing | No |
| KEDLI | Glenwood | Therm Billing | No |
| KEDLI | Port Jefferson | Therm Billing | No |
| KEDLI | Northport | Therm Billing | No |
| KEDLI | NYPA Pilgrim | Therm Billing | No |
| KEDLI | Freeport | Therm Billing | No |
| KEDLI | NDEC | Therm Billing | No |
| KEDLI | Caithness | Therm Billing | No |
| KEDLI | Far Rockaway | Therm Billing | No |
| KEDLI | Calpine | Therm Billing | No |

"Therm billing" listed without a zone refers to billing to a single customer such as a power plant. To calculate the BTU values for KEDLI zone 2 and KEDNY zones 3, 4, 5, 6, 7, and 10, see the Companies' response to Question 4 below. "Planned" refers to chromatographs that are going to be installed in the near future. “Supply” refers to the chromatograph sites that are for gas quality purposes where there is no direct customer but the site supplies gas to areas leading into direct customer feeds.

3. The additional chromatographs in KEDNY’s gas system reinforcement program are for three new regulator stations. The Company installs standard gas monitoring/regulating equipment at these stations, such as telemetering, heaters, regulators, filters and chromatographs. The chromatographs will monitor gas heating value and quality at these new sources of gas into the distribution system.

4. For KEDNY, the heating value of gas the Company receives at its city gates is measured by gas chromatographs located at:

- Transcontinental Gas Pipe Line (“Transco”) stations in Linden, NJ, and Floyd Bennett Field

- Texas Eastern Transmission Pipeline (“Tetco”) station in Goethals, Staten Island

In addition, KEDNY has installed gas chromatographs on its distribution system at the following large metering stations: LaGuardia, Maspeth, Citizens, Canarsie, the Staten Island Landfill Plant, and South Staten Island gate station.

There are also gas chromatographs at transfer metering stations at the following locations:

- Cambria Heights – the point of transfer between KeySpan Gas East Corporation d/b/a National Grid (“KEDLI”) and KEDNY
- Newtown – the point of transfer between Con Ed and KEDNY.

Lastly, large customers (*i.e.,* power plants) either have a BTU measuring device located at their site or use the readings from a specific BTU measuring device on the system. These customers are billed in accordance with the heating value measured by these devices.

KEDNY performed an engineering study using the GL Noble Denton SynerGEE (Stoner) Model that established ten therm billing zones within the Company’s service territory.

Four therm billing zones within the boroughs of Brooklyn and Queens together constitute the vast majority of the Company’s service territory. These include:

- Zone 1, the Northern zone
- Zone 2, the Central zone
- Zone 3, the Southern zone
- Zone 9, the Eastern zone.

Southern Zone 3 extends from Brooklyn into Staten Island where it represents the majority of the Staten Island. At the extreme southern end of Staten Island, Zone 8 is influenced by the gas received from the Staten Island Landfill Plant and is measured by a gas chromatograph at South Staten Island gate station. When there is no flow into Zone 8 through South Staten Island gate station (typically above 40°F average temperatures), all of Staten Island is treated as Zone 3.

To determine the thermal conversion factor for each zone, KEDNY first computes each day the overall heating value of gas received into its service territory. To do this, the Company takes the measured heating value of the gas supplies received at each city gate and transfer metering station, and multiplies those heating values by the associated metered volumes to compute the total dekatherm quantity received. The average system heating value is next computed by dividing the total quantity received in dekatherms by the total volume received in Mcf.

Second, KEDNY computes the thermal conversion factors for Zones 1, 2, 8, and 9 using the same approach described above. The measured heating value of the gas chromatograph(s) located within each zone is multiplied by the associated metered volumes to compute total dekatherms received into each zone. The Company then divides the computed dekatherm quantity received by the metered Mcf volume received to arrive at the thermal conversion factor for each zone.

Zone 3 is determined as the difference between the overall KEDNY distribution system heating value and that of Zones 1, 2, 8 and 9.

The thermal conversion factors for Zones 4 to 10, which are transitional zones that account for variances in transmission system flows, are then established as follows:

- Zone 4 receives the lower of Zone 1 or 2
- Zone 5 receives the lower of Zone 1 or 9
- Zone 6 receives the lower of Zone 2 or 3
- Zone 7 receives the lower of Zone 3 or 8
- Zone 10 receives the lower of Zone 2 or 9

With the exception of large customers that are assigned to a specific BTU measuring device, the calculated thermal content of the gas is then applied uniformly to all customers within a particular zone.

For KEDLI, a similar engineering study was performed using the GL Noble Denton SynerGEE (Stoner) Model that established three therm billing zones within the Company's service territory. These zones account for the difference in heating value between supplies received at the Long Beach, NY city gate on the Transcontinental Gas Pipe Line ("Transco") and the South Commack, NY city gate on the Iroquois Gas Transmission System ("Iroquois").

The zone boundaries are such that Zone 1 comprises the western end of the Company's service territory, Zone 3 comprises the eastern end of the service territory, and Zone 2 is a transitional zone located between Zones 1 and 3. The engineering study determined that Zone 2 receives Transco supply in the winter (November 1st through March 31st) and Iroquois supply in the summer (April 1st through October 31st).

The Zone 1 conversion factor is set each day based on the gas chromatograph measured heating value of gas received at the Transco Long Beach city gate. Similarly, the Zone 3 conversion factor is based on the gas chromatograph measured heating value of gas received at the Iroquois South Commack city gate. The Zone 2 conversion factor is equal to Zone 1 during the winter and Zone 3 during the summer.

The calculated thermal content of the gas is applied uniformly to all customers within a particular zone with the exception of large customers (*i.e.*, power plants) that have a BTU measuring device located at their site. These customers are billed in accordance with the heating value measured by the local devices.

a. On the front of the customer bill, the therm factor used to covert usage from CCF to therms is specified. The back of the bill in a section titled "Understanding Terms On Your Bill" defines CCF, thermal factor and therms. A representative copy of a KEDNY bill is provided as Attachment 1. The language on the KEDLI bill is the same.

5. Attachment 2 is the currently available map for the Brooklyn Queens Area of KEDNY. This map does not reflect the latest addition of zones 9 and 10 to Queens and the associated revision of the other zones in the Brooklyn Queens area. Attachment 3 is the currently available map for the Staten Island area of KEDNY. Attachment 4 is the currently available map for KEDLI.

| Name of Respondent: | Date of Reply: |
|---|---|
| Peter Metzdorff | May 2, 2016 |
| Stephen Greco | |
| Eric Aprigliano | |

nationalgrid

2014143

0200007000000

**C 078 053945

Please Pay
Upon Receipt
86.05 H

Account Number

Tear here

Please mail this part of bill with your payment.

Make checks payable to National Grid.
Write your account number on check.

| Service To | Account Number | Next Meter Reading | Bill Date |
|---|---|---|---|
| | | Jun 20 '14 | May 22 '14 |
| | Rate 1B Res. Heating | For Customer Assistance Please call (718) 643-4050 | |

## CURRENT BILL ITEMIZED

**In 30 days you used 47 therms:**

| | |
|---|---|
| May 22 2014 reading ACTUAL | 5633 |
| Apr 22 2014 reading ACTUAL | 5588 |
| CCF Used for METER# | 45 |
| Thermal Factor | x1.0363 |
| Total therms used | 47 |

**Your Cost is determined as follows:**

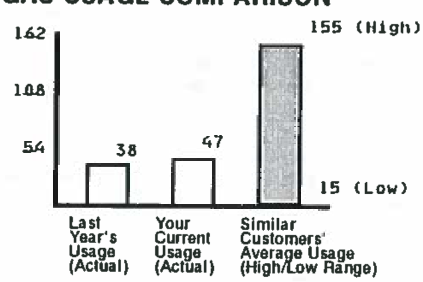
| | |
|---|---|
| Minimum Charge (First 3.0 therms or less) | $20.77 |
| Next 44.0 @ $.5901 | 25.96 |
| Delivery Rate Adjustment: @ $.08021 /therm | 3.77 |
| System Benefits Charge: @ $.02370 /therm | 1.11 |
| MTA Surcharge | .10 |
| GAS DELIVERY CHARGE | $51.71 |
| GAS SUPPLY CHARGE @ $.63360 /therm | 29.78 |
| MTA Surcharge | .06 |
| 4.5000 % Sales Tax | 1.34 |
| Supply Subtotal | $31.18 |
| 4.5000 % Sales Tax on Gas Delivery | 2.33 |
| Bill. Charge (incl. tax & surchg) | .83 |
| **TOTAL CURRENT CHARGES** | $86.05 |

## SUMMARY OF CHARGES

| | |
|---|---|
| Total Current Charges | $86.05 |
| Amount Due Last Bill | 138.08 |
| Your Total Payments Since Last Bill. Thank You! | -138.08 |
| **Please Pay Upon Receipt** | $86.05 |

If payment received after 06/14/2014
a late payment charge of $1.29
(1.5% of outstanding charges) may be added.

## YOUR GAS USAGE COMPARISON




During this period the average temperature

## IMPORTANT MESSAGES

The Billing Charge, now shown separately, is not charged when you buy gas supply from an ESCO that includes its charges on our bills; one of several savings opportunities. It has been separated from the Minimum Charge, which has been reduced, so there is no effect on your overall cost.

**Your unique online Access Code is:**
We're online, anytime! View and pay your bill, check your balance, submit meter readings. The code above provides free, instant access with "My Account" - visit www.nationalgridus.com. Many automated services are also available at the telephone number above.



nationalgrid www.nationalgridus.com

See back for definitions of terms used in this bill and more information.

**Bill Payment**
Bills may be paid at any National Grid Customer Service Center on weekdays from 8:30 a.m. to 5:00 p.m. or at Authorized Payment Locations in Brooklyn, Queens, and Staten Island. A list of locations is available online and upon request.

**DirectPay Service**
Have your bill payments transferred automatically from your checking or savings account. Enroll online or call.

National Grid
P.O. Box 11741
Newark, NJ 07101-9839

**Moving?**
Please give 10 days' notice when moving.
Make your move easier - open or close an account at **www.nationalgridus.com.**

Tear here

Please be sure the address above appears in the return envelope window.
For greater convenience, pay your bill online, anytime, at : **www.nationalgridus.com**

Tear here

### Billing or Service Questions
***Call (718) 643-4050** or visit a National Grid Customer Service Center. Call us first! Most questions can be answered by telephone. Please speak to a Supervisor if you need additional help. If you prefer to write include a note with your payment and mail to: National Grid, Attn: Customer Correspondence, One MetroTech Center,16th Floor, Brooklyn, NY 11201.

### Billing Rate Schedule:
Your billing rate is shown on the front. A complete rate schedule is available upon request.

### Customer Service Centers:
Open weekdays from 8:30 a.m. to 5:00 p.m.

**Brooklyn**
-One MetroTech Center (Jay St. near Willoughby St.)
-1535 Pitkin Avenue

**Queens**
-89-67 162nd Street

**Staten Island**
- 2031 Forest Avenue (Corner of Maple Pkwy)

### Special Customer Services:
**Hearing or Speech-Impaired Customers**
Call TTY Line (718) 237-2857
**Services for Sight Impaired Customers**
Braille and large print bills are available.
**Senior Citizen/Disabled Customer Programs**
**Financial Assistance Programs**
Call (718) 403-2171

### Visit National Grid Online:
Check your latest account status, view and pay your bill, or provide a meter reading, 24 hours a day, 7 days a week at **www.nationalgrid.us.com.**

### Payment Address:
Our payment address is: National Grid, P.O. Box 11741, Newark, NJ 07101-9839

### Statement of Account:
A comprehensive statement of your account showing your past use and bills is available online or upon request.

### Notice About Electronic Check Conversion:
When you mail a check as payment, you authorize us to use information from your check to withdraw funds from your account either as a one-time electronic fund transfer (EFT) or as a check transaction. When we process an EFT, funds may be withdrawn from your account as soon as the same day we receive your payment and your financial institution will not return the check to you.

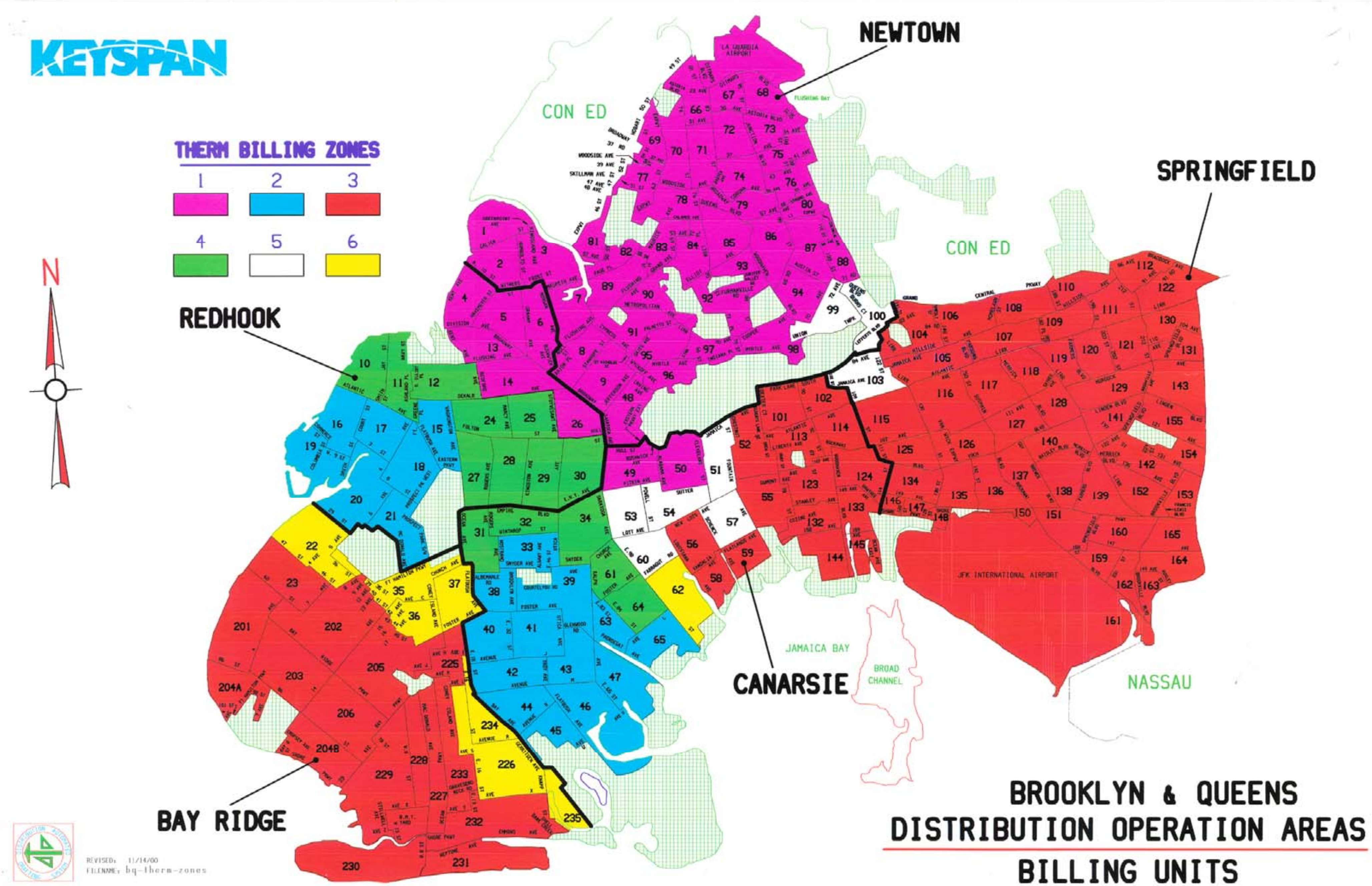
### Understanding Terms On Your Bill:
**CCF:** The unit of gas volume (100 cubic feet) as measured by your meter.
**Thermal Factor:** The factor that converts the quantity of gas used (CCF) to a quality measurement (Therms).
**Therm:** A unit of heat content equal to 100,000 British Thermal Units (BTU). A BTU represents the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit. The number of CCFs is multiplied by a conversion factor to determine the therms used. The number of therms is used to determine the gas charges on your bill.
**Fixed Factor Multiplier:** Due to their design, some meters record a fraction of the total usage. The multiplier is used to convert the recorded meter reading on these types of meters to total actual consumption.

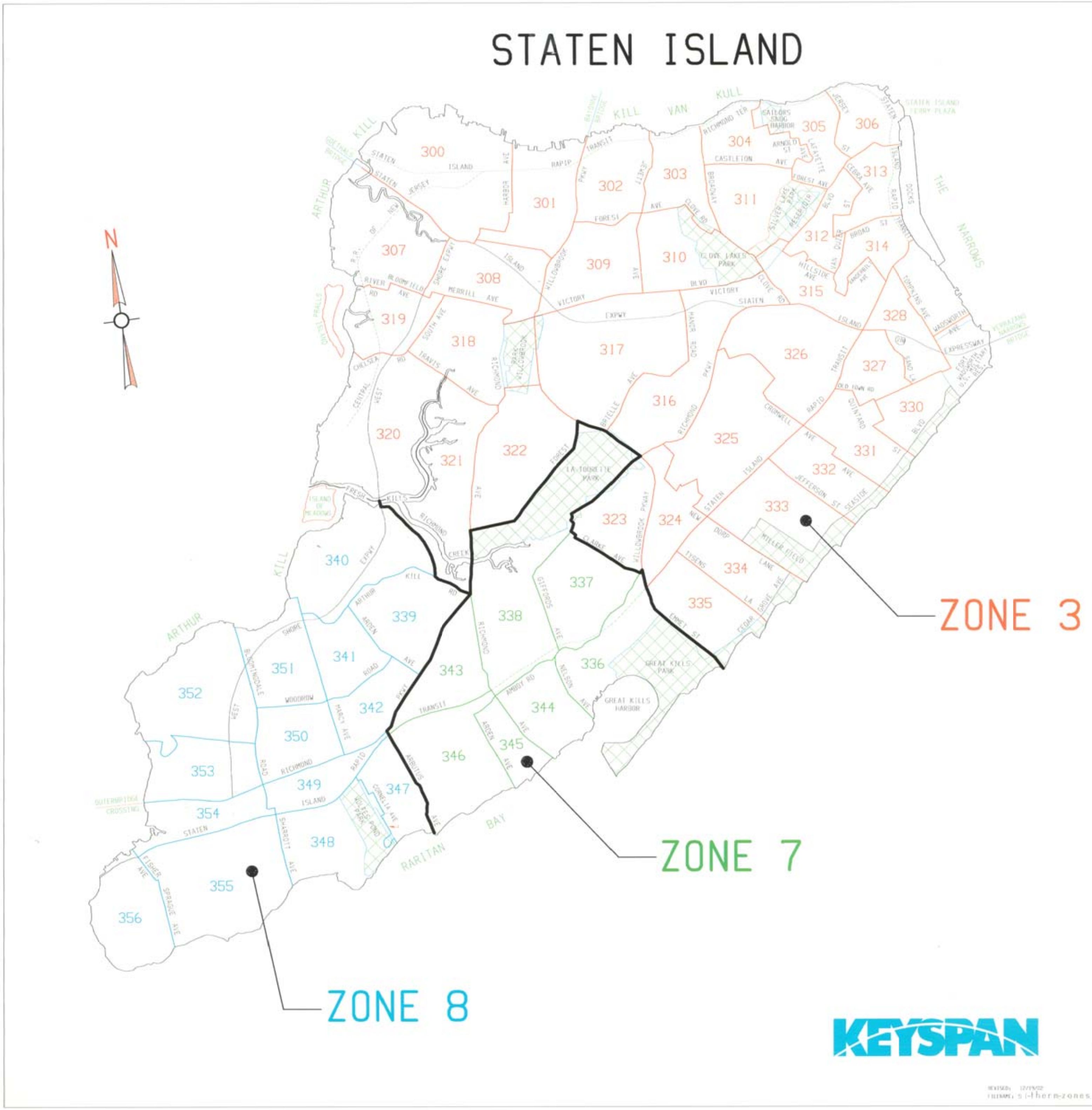
**Gas Delivery Charge:** The **Minimum Charge** is a fixed charge prorated for the number of days of service. The **Billing Charge** reflects costs associated with issuing bills and processing payments. If you buy gas supply from an ESCO who does not bill its charges separately, you avoid the Billing Charge. The **Delivery Rate Adjustment** includes the Incremental State Assessment Surcharge (in accordance with NYS Public Service Law Section 18-a), the Site Investigation and Remediation Surcharge (recovers deferred site remediation costs) and weather-related debits and/or credits (heating customers only). The **System Benefits Charge** recovers the cost of energy efficiency programs. It also includes State and City Gross Receipts Tax (4.548% Residential; 2.407% Commercial).

**Gas Delivery Adjustment:** The cost of storing and transporting natural gas. It also includes Gross Receipts Tax (2.407%).

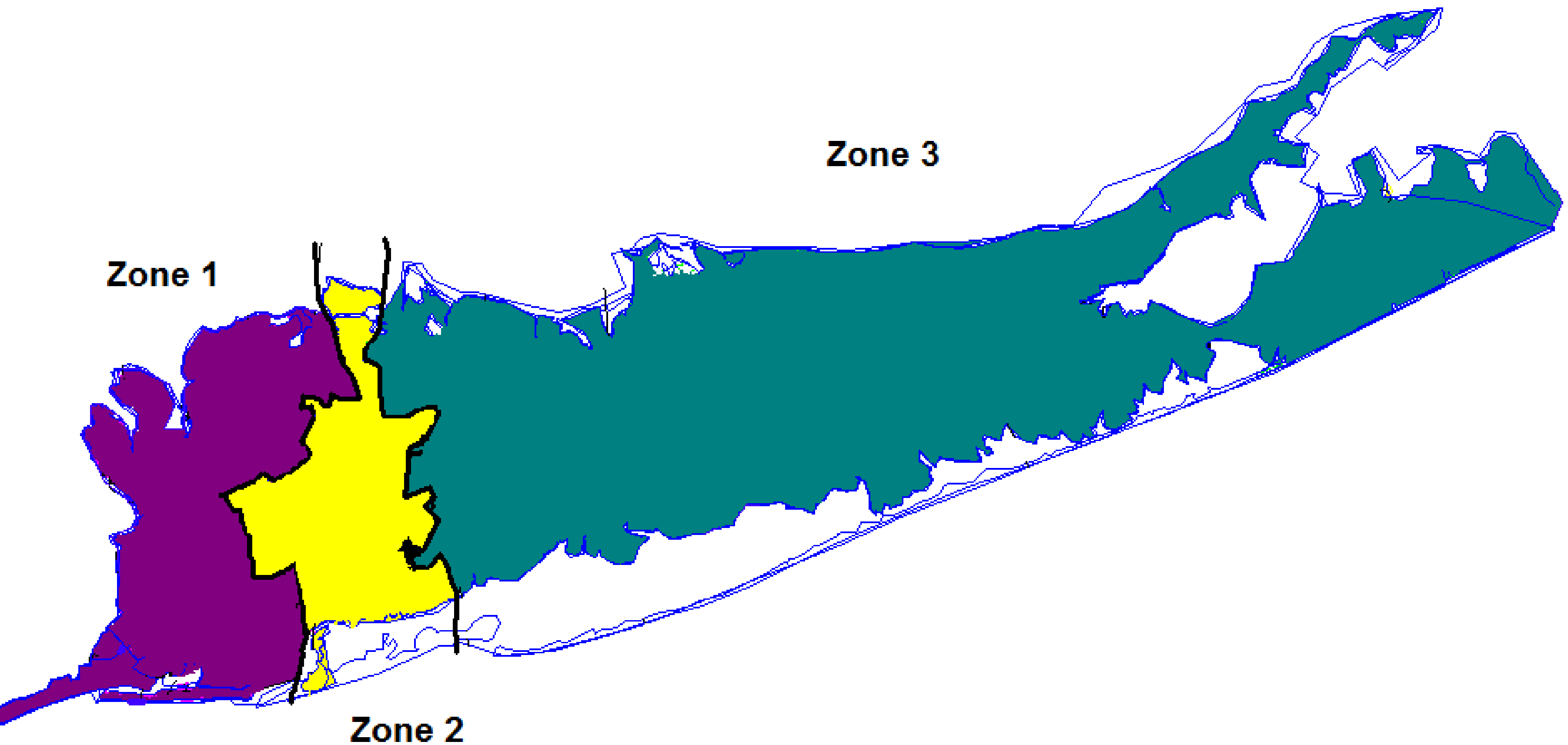
**Gas Supply Charge:** A charge to reflect the Company's cost of gas purchased from suppliers and transporting the gas to the Company's distribution system. If you choose an alternate supplier, the price will be what you agree upon with that supplier. It also includes Gross Receipts Tax (2.407%).

**MTA Surcharge:** State imposed taxes on utilities to maintain mass transit fares.
**Sales Tax:** The Company is required to collect state and local sales tax in all NY State counties. Some school districts also impose sales tax.


KEYSPAN
THERM BILLING ZONES
1
2
3
4
5
6
N
NEWTOWN
REDHOOK
SPRINGFIELD
CANARSIE
BAY RIDGE
CON ED
CON ED
LA GUARDIA AIRPORT
JFK INTERNATIONAL AIRPORT
JAMAICA BAY
BROAD CHANNEL
NASSAU
REVISED: 11/14/00
FILENAME: bq-therm-zones
BROOKLYN & QUEENS
DISTRIBUTION OPERATION AREAS
BILLING UNITS


STATEN ISLAND
ZONE 3
ZONE 7
ZONE 8
KEYSPAN
KILL VAN KULL
ARTHUR KILL
THE NARROWS
RARITAN BAY
GREAT KILLS HARBOR
GREAT KILLS PARK
LA TOURETTE PARK
CLOVE LAKES PARK
N

# KEDLI Therm Zones



Date of Request: May 2, 2016 DPS Request No. DPS-476 CS-3
Due Date: May 12, 2016 KEDNY/ KEDLI Req. No. BULI-618

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, Claude Semexant

TO: National Grid, Sean Mongan

SUBJECT: **SALES PROMOTION EXPENSE - KEDNY**

Request:

1. On p. 7 of your KEDLI testimony, you identified that there are more than 400,000 residential and commercial structures in KEDLI's service territory without gas service, and another 100,000 non-heat customers. Does KEDNY have similar statistics for its service territory and to the extent that the Company has this information, distinguish between those residential and commercial structures in KEDNY's service territory that are located along existing mains and those that will require an extension to serve their needs.

2. Referring to the Companies' response to information request DPS-426, Question 2, the response shows Sales Promotion Costs associated with residential rebates regarding KEDLI, however, there is no such detail shown in the Companies' response to information request DPS-427 regarding KEDNY. Explain why rebates are not being used in the KEDNY service territory.

Response:

1. The Company regularly produces a "saturation study" that uses public real estate data and gas account information to estimate the gas conversion potential as a function of the approximate distance to main. The table below shows an excerpt from that analysis for KEDNY's service territory.

| KEDNY | | Commercial | Multi-Family | Residential | Total |
|---|---|---|---|---|---|
| Non Heat | ON MAIN | 12,122 | 5,804 | 65,664 | **83,590** |
| Prospects | ON MAIN* | 14,069 | 2,762 | 16,865 | 33,696 |

*Gas Saturation Study as of July 2015* * All buildings in NYC are assumed On Main

2. Rebates for gas conversions are utilized in KEDNY's service territory, but at a significantly lower level due to the following:

   - high saturation of natural gas in the territory; and
   - new construction is driving the market.

   The Historic Test Year shown in Mr. Mongan's testimony (Exhibit __ SPM-1) included spending on rebates of $94,900, which was for conversions. Since the vast majority of customers in KEDNY's service territory do not require a new service in connection with a conversion, no incremental spending for rebates in NYC is proposed except for the proposed incentive for NGVs. Where rebates are used to promote conversions, such rebates are predominantly provided in the Multifamily market.

Name of Respondent:
Keith Sperling/Chris Cavanagh

Date of Reply:
May 9, 2016

Date of Request: May 5, 2016
Due Date: May 16, 2016

DPS Request No. DPS-482 JS-10
KEDNY/ KEDLI Req. No. BULI-627

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, John Sano

TO: National Grid, GIOP

SUBJECT: Information Systems Issues – Gas Transportation Information System (GTIS)

Request:

Referring to the Companies' response to information request DPS-350, Staff requested and received the year-to-date fiscal year budgeted versus actual expenditure amounts related to the GTIS system, temporary bulletin board, and staffing modifications during implementation of the GTIS system beginning in 2006. See the table of information provided below:

| **GTIS Financials ($000) as of February 29, 2016** | | | | | | |
|---|---|---|---|---|---|---|
| **FY** | **O&M** | | | **Capital** | | |
| | **Sanctioned** | **Spent** | **Variance** | **Sanctioned** | **Spent** | **Variance** |
| FY10 | 196.0 | 2.1 | (193.9) | 600.0 | 599.0 | (1.0) |
| FY11 | 202.0 | 64.2 | (137.8) | 2,500.0 | 2,500.0 | 826.5 |
| FY12 | 23.0 | 3.1 | (20.0) | 2,820.0 | 3,014.1 | 194.2 |
| FY13 | 24.0 | 14.7 | (9.3) | 1,779.0 | 775.0 | (1,004.0) |
| FY14 | 404.0 | 293.5 | (110.5) | 1,110.0 | 1,631.1 | 521.1 |
| FY15 | 81.0 | 43.3 | (37.7) | 7,044.0 | 4,635.0 | (2,409.0) |
| FY16 | 267.0 | 134.5 | (132.5) | 4,852.0 | 4,215.0 | (637.0) |
| Total | 1,197.0 | 555.4 | (641.6) | 20,705.0 | 17,369.2 | (3,335.8) |
| FY17 | 365.0 | | | 995.0 | | |

Note that the total capital spend in the table above includes the $10.150 million for Customer Choice ESCO Gas project discussed in the Testimony of the Revenue Requirements Panel, as well as additional costs from other GTIS projects besides the Customer Choice ESCO Gas project

1. The Company notes the total capital spent is $17.369 million, and that is made up of costs for the Customer Choice ESCO Gas project as well as costs from other GTIS projects. The service company rent expense schedules, contained in Exhibit __ (RRP-11CU), Workpapers to Exhibit RRP-3CU, Schedule 9, Workpaper 2 for both KEDNY and KEDLI a listing of all the information services (IS) capital projects, the assets held at the service company level, and the costs expected to be incurred in rate year for either new or existing IS projects, and those that are included in the O&M rent expense cost element as well. Provide a list identifying every project (by line item) from both the attached KEDLI listing and the similar that comprises the $17.369 million shown in the table above.

2. For each project identified in response to question (1) above, provide a breakdown of costs in a format similar to the table above. The information should be broken down by specific project, and by year. Provide the information separately for KEDLI and KEDNY.

<u>Response</u>:

1) and 2)

Please see Attachment 1 for the projects that comprise $17,804,287 million in total capital spend for GTIS projects from FY2010 through February 2016. Please note that the Companies erroneously provided a total capital spend of $17.369 million in response to DPS-350. A total capital spend of $17,804,287 is reflected in the general ledger for GTIS projects, including the Customer Choice ESCO Gas project.

In the course of preparing Attachment 1, the Companies identified certain existing Service Company assets/projects that were not included in Exhibit __ (RRP-11-CU), Workpapers to Exhibit ___ (RRP-CU), Schedule 9, Workpaper 2 for both KEDNY and KEDLI. Attachment 2 identifies the missing projects and the total rent expense impact to KEDNY and KEDLI. The missing projects included three work orders for the GTIS project performed as part of investments INVP 1182 and INVP 1182B that delivered an early version of GTIS.
.

| Work Order | INVP# | Total US Spend |
|---|---|---|
| 1TXFER00099 | 1182 | $3,866,615 |
| 900000124369 | 1182 | $1,780,960 |
| 900000124375 | 1182B | $1,675,640 |

An updated Exhibit __ (RRP-11CU), Workpapers to Exhibit ___ (RRP-3CU), Schedule 9, Workpaper 2 is also included in Attachment 2.

With respect to the Customer Choice ESCO gas project in particular, of the $17,804,287 included in Attachment 1, only $10,150,478 relates to the total capital spend for the Customer Choice ESCO Gas project as shown in Exhibit_(RRP-11CU), Workpapers to RRP-3CU, Schedule 9, Workpaper 2 (line 10). In their Corrections and Updates filings, the Companies made a further adjustment to remove their share of $521,285 representing the AFUDC amount for project delays from the initial target GTIS implementation date of November 1, 2014 through the anticipated implementation date of April 30, 2016. As a result of this adjustment, the Companies' rent expense for the Customer Choice ESCO Gas project is based on a total US spend of $9,629,193.

| | |
|---|---|
| <u>Name of Respondent</u>: | <u>Date of Reply</u>: |
| Christophe Chirol | May 16, 2016 |
| Thomas Gill | |

KeySpan Gas East Corporation
d/b/a National Grid
The Brooklyn Union Gas Company
d/b/a National Grid NY
Case 16-G-0058 and 16-G-0059
Attachment 1 to DPS-482 JS-10 BULI-627
Page 1 of 1

## GTIS Financials - INVP1182

| | OPEX | | | CAPEX | | |
|---|---|---|---|---|---|---|
| | Sanctioned | Spent | Variance | Sanctioned | Spent | Variance |
| FY10 | $ 196,000 | $ 192,236 | $ (3,764) | $ 600,000 | $ 599,000 | $ (1,000) |
| FY11 | $ 202,000 | $ 64,156 | $ (137,844) | $ 1,673,000 | $ 2,028,588 | $ 355,588 |
| FY12 | $ 23,000 | $ 3,050 | $ (19,950) | $ 2,820,000 | $ 2,927,964 | $ 107,964 |
| FY13 | | | $ - | | $ 81,622 | $ 81,622 |
| FY14 | | | $ - | | $ - | $ - |
| FY15 | | | $ - | | $ 10,401 | $ 10,401 |
| Total | $ 421,000 | $ 259,442 | $ (161,558) | $ 5,093,000 | $ 5,647,575 | $ 554,575 |

## GTIS Financials - INVP1182B

| | OPEX | | | CAPEX | | |
|---|---|---|---|---|---|---|
| | Sanctioned | Spent | Variance | Sanctioned | Spent | Variance |
| FY13 (Oct&Mar) | $ 24,000 | $ 30,284 | $ 6,284 | $ 1,779,000 | $ 1,644,095 | $ (134,905) |
| FY14 | | $ 305 | $ 305 | | $ 31,545 | $ 31,545 |
| Total | $ 24,000 | $ 30,589 | $ 6,589 | $ 1,779,000 | $ 1,675,640 | $ (103,360) |

## GTIS Financials - INVP3564 (as of February 29th, 2016)

| | OPEX | | | CAPEX | | |
|---|---|---|---|---|---|---|
| | Sanctioned | Spent | Variance | Sanctioned | Spent | Variance |
| FY14 | $ 404,000 | $ 293,452 | $ (110,548) | $ 1,110,000 | $ 1,631,147 | $ 521,147 |
| FY15 | $ 81,000 | $ 43,257 | $ (37,743) | $ 7,044,000 | $ 4,634,955 | $ (2,409,045) |
| FY16 | $ 267,000 | $ 134,455 | $ (132,545) | $ 4,852,000 | $ 4,214,970 | $ (637,030) |
| Total | $ 752,000 | $ 471,163 | $ (280,837) | $ 13,006,000 | $ 10,481,072 | $ (2,524,928) |

KeySpan Gas East Corporation
d/b/a National Grid
The Brooklyn Union Gas Company
d/b/a National Grid NY
Case 16-G-0058 and 16-G-0059
Attachment 2 to DPS-482 JS-10 BULI-627


| GTIS Financials - INVP1182 | | | | | | |
|---|---|---|---|---|---|---|
| | OPEX | | | CAPEX | | |
| | Sanctioned | Spent | Variance | Sanctioned | Spent | Variance |
| FY10 | $ 196,000 | $ 192,236 | $ (3,764) | $ 600,000 | $ 599,000 | $ (1,000) |
| FY11 | $ 202,000 | $ 64,156 | $ (137,844) | $ 1,673,000 | $ 2,028,588 | $ 355,588 |
| FY12 | $ 23,000 | $ 3,050 | $ (19,950) | $ 2,820,000 | $ 2,927,964 | $ 107,964 |
| FY13 | | | $ - | | $ 81,622 | $ 81,622 |
| FY14 | | | $ - | | $ - | $ - |
| FY15 | | | $ - | | $ 10,401 | $ 10,401 |
| Total | $ 421,000 | $ 259,442 | $ (161,558) | $ 5,093,000 | $ 5,647,575 | $ 554,575 |

| GTIS Financials - INVP1182B | | | | | | |
|---|---|---|---|---|---|---|
| | OPEX | | | CAPEX | | |
| | Sanctioned | Spent | Variance | Sanctioned | Spent | Variance |
| FY13 (Oct&Mar) | $ 24,000 | $ 30,284 | $ 6,284 | $ 1,779,000 | $ 1,644,095 | $ (134,905) |
| FY14 | | $ 305 | $ 305 | | $ 31,545 | $ 31,545 |
| Total | $ 24,000 | $ 30,589 | $ 6,589 | $ 1,779,000 | $ 1,675,640 | $ (103,360) |

| GTIS Financials - INVP3564 (as of February 29th, 2016) | | | | | | |
|---|---|---|---|---|---|---|
| | OPEX | | | CAPEX | | |
| | Sanctioned | Spent | Variance | Sanctioned | Spent | Variance |
| FY14 | $ 404,000 | $ 293,452 | $ (110,548) | $ 1,110,000 | $ 1,631,147 | $ 521,147 |
| FY15 | $ 81,000 | $ 43,257 | $ (37,743) | $ 7,044,000 | $ 4,634,955 | $ (2,409,045) |
| FY16 | $ 267,000 | $ 134,455 | $ (132,545) | $ 4,852,000 | $ 4,214,970 | $ (637,030) |
| Total | $ 752,000 | $ 471,163 | $ (280,837) | $ 13,006,000 | $ 10,481,072 | $ (2,524,928) |

KeySpan Gas East Corporation
d/b/a National Grid
The Brooklyn Union Gas Company
d/b/a National Grid NY
Case 16-G-0058 and 16-G-0059
Attachment X to DPS-482 JS-10 BULI-627


**Missing Projects Adjustment - Service Company Rents**

**Information Systems Projects (As Reported in DPS-395)**

| | Rate Year 1 | Data Year 1 | Data Year 2 |
|---|---|---|---|
| KEDNY | $ 13,623,116 | $ 13,810,462 | $ 15,842,291 |
| KEDLI | $ 9,053,489 | $ 9,225,013 | $ 10,362,599 |
| **Total** | **$ 22,676,604** | **$ 23,035,474** | **$ 26,204,890** |

**Information Systems Projects (With Missing Projects)**

| | Rate Year 1 | Data Year 1 | Data Year 2 |
|---|---|---|---|
| KEDNY | $ 16,099,834 | $ 16,049,098 | $ 17,268,746 |
| KEDLI | $ 10,415,299 | $ 10,435,048 | $ 11,169,813 |
| **Total** | **$ 26,515,133** | **$ 26,484,146** | **$ 28,438,559** |

**Information Systems Projects (Difference)**

| | Rate Year 1 | Data Year 1 | Data Year 2 |
|---|---|---|---|
| KEDNY | $ 2,476,719 | $ 2,238,636 | $ 1,426,455 |
| KEDLI | $ 1,361,810 | $ 1,210,036 | $ 807,215 |
| **Total** | **$ 3,838,529** | **$ 3,448,672** | **$ 2,233,670** |

KeySpan Gas East Corporation
d/b/a National Grid
The Brooklyn Union Gas Company
d/b/a National Grid NY
Case 16-G-0058 and 16-G-0059
Attachment X to DPS-482 JS-10 BULI-627


| | | KEDNY | Rate Year | Data Year 1 | Data Year 2 |
|---|---|---|---|---|---|
| 1TXFER00099 | GAS SCADA Upgrade/Modernize | 38.38% | $ 112,432 | $ - | $ - |
| 1TXFER00099 | GTIS | 68.37% | $ 420,727 | $ 398,256 | $ 162,039 |
| 90000124369 | GTIS | 38.38% | $ 120,888 | $ 115,078 | $ 109,268 |
| 90000124368 | Meter Route Consolidation | 38.38% | $ 27,410 | $ 26,071 | $ 24,732 |
| 90000124375 | GTIS | 58.10% | $ 169,421 | $ 161,146 | $ 152,870 |
| 90000104112 | IN1656-CUST.Systems Agent desktop | 68.37% | $ 1,145,726 | $ 1,085,073 | $ 612,320 |
| 90000106246 | IN2330 ETRM Repl Nucleus-Gas Benef | 30.66% | $ 298,244 | $ 282,593 | $ 203,142 |
| 90000124371 | IN2366 LI CNI Direct HW Upgrade | 68.37% | $ 8,126 | $ 7,737 | $ 7,348 |
| 90000144051 | INVP2960C GridForce SaaS Phase 2 | 30.66% | $ 173,745 | $ 162,683 | $ 154,736 |
| | | | **$ 2,476,719** | **$ 2,238,636** | **$ 1,426,455** |

| | | KEDLI | Rate Year | Data Year 1 | Data Year 2 |
|---|---|---|---|---|---|
| 1TXFER00099 | GAS SCADA Upgrade/Modernize | 28.55% | $ 83,635 | $ - | $ - |
| 1TXFER00099 | GTIS | 31.63% | $ 194,641 | $ 184,245 | $ 74,964 |
| 90000124369 | GTIS | 28.55% | $ 89,926 | $ 85,604 | $ 81,282 |
| 90000124368 | Meter Route Consolidation | 28.55% | $ 20,389 | $ 19,394 | $ 18,398 |
| 90000124375 | GTIS | 30.27% | $ 88,268 | $ 83,957 | $ 79,645 |
| 90000104112 | IN1656-CUST.Systems Agent desktop | 31.63% | $ 530,047 | $ 501,987 | $ 283,278 |
| 90000106246 | IN2330 ETRM Repl Nucleus-Gas Benef | 22.81% | $ 221,883 | $ 210,240 | $ 151,130 |
| 90000124371 | IN2366 LI CNI Direct HW Upgrade | 31.63% | $ 3,759 | $ 3,579 | $ 3,399 |
| 90000144051 | INVP2960C GridForce SaaS Phase 2 | 22.81% | $ 129,261 | $ 121,030 | $ 115,119 |
| | | | **$ 1,361,810** | **$ 1,210,036** | **$ 807,215** |
| | **Total Impact** | | **$ 3,838,529** | **$ 3,448,672** | **$ 2,233,670** |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | ( c) Adjustments | (d) = (a)+( c) Total US Spend | ( e) In Service Date | (f) Amortization Period | (g) 12/31/2016 Balance | (h) 12/31/2017 Balance |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $60,613,682 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 57,233,751 | $ 47,694,792 |
| 2 | Gas GIS Consolidation | 2577 | $2,213,069 | G210 | | $5,573,069 | 4/1/2019 | 84 | $ - | $ - |
| 3 | AMAG Upgrades | 1172 | $3,698,542 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 5,777,818 | $ 4,921,845 |
| 4 | US CNI DKMS | 3019A | $249,414 | G098 | (249,414) | $0 | 3/1/2017 | 84 | $ - | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 451,737 | $ 354,936 |
| 6 | NE GAS LEAKS RECHECKS | 3196 | $1,244,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,682,348 | $ 1,426,802 |
| 7 | CI Services Foundation | 3492 | $2,197,232 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 2,298,028 | $ 1,920,270 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,071,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 5,408,060 | $ 4,494,022 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,902,352 | $ 1,576,235 |
| 10 | Customer Choice ESCO Gas | 3564 | $7,774,478 | C225 | (521,285) | $9,629,193 | 4/1/2016 | 84 | $ 8,597,494 | $ 7,221,895 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 495,479 | $ 409,309 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 315,447 | $ 260,587 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 1,351,287 | $ 1,122,900 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $661 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 1,181,524 | $ 1,004,296 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $556,501 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 3,620,560 | $ 3,077,476 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $144,307 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 1,249,205 | $ 1,054,524 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $3,903 | G020 | (3,903) | $0 | 1/1/2099 | 84 | $ - | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $4,206 | G020 | (4,206) | $0 | 1/1/2099 | 84 | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $0 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 1,053,333 | $ 895,333 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $3,000,805 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 5,663,117 | $ 4,813,650 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $2,363 | G020 | (2,363) | $0 | 1/1/2099 | 84 | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $27,818 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 1,305,259 | $ 1,096,417 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $0 | G020 | | $121,600 | 4/1/2016 | 84 | $ 108,571 | $ 91,200 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $0 | G020 | | $60,800 | 9/1/2016 | 84 | $ 57,905 | $ 49,219 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $0 | G020 | | $725,146 | 9/1/2016 | 84 | $ 690,615 | $ 587,023 |
| 28 | NY Retail Access | 3839 | $2,088,663 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,838,204 | $ 2,427,861 |
| 29 | US Web Initiatives 2 | 3600B | $3,402,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 3,329,775 | $ 2,782,415 |
| 30 | Capitalized Asset Replacement | 3617C | $882,109 | G084 | | $935,395 | 4/1/2016 | 84 | $ 835,175 | $ 701,547 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $134,169 | G003 | | $265,077 | 4/1/2016 | 84 | $ 236,676 | $ 198,808 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $475,000 | 4/1/2016 | 84 | $ 424,107 | $ 356,250 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | | G077 | | $480,000 | 4/1/2016 | 84 | $ 428,571 | $ 360,000 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $485,308 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ - | $ 1,041,662 |
| 35 | EHR1 - PMO | | $6,218,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 7,546,749 | $ 6,271,242 |
| 36 | EHR1 - Supply Chain | | $10,339,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 12,483,692 | $ 10,373,772 |
| 37 | EHR1 - Finance | | $15,565,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 13,646,661 | $ 11,340,183 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 2,040,672 | $ 1,695,769 |
| 39 | EHR1 - Payroll | | $10,937,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 10,301,056 | $ 8,560,033 |
| 40 | EHR1 - BPS | | $5,115,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 8,380,753 | $ 6,964,288 |
| 41 | Customer Storm Outage Credit Program | 3859 | $165,018 | 5210 | (165,018) | $0 | 3/1/2015 | 84 | $ 0 | $ 0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $41,564 | C210 | | $5,739,504 | 1/1/2019 | 84 | $ - | $ - |
| 43 | US Desktop Refresh | 2927 | $5,813,532 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 5,882,629 | $ 4,024,957 |
| 44 | Internet Explorer Upgrade | 3644 | $137,061 | G020 | | $300,090 | 3/1/2016 | 84 | $ 264,365 | $ 221,495 |
| 45 | Mobile Device for PTO | 3883 | $242,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 2,238,932 | $ 1,628,314 |
| 46 | SMI Conversion Mobilization | 3896 | $402,655 | G020 | | $2,187,292 | 7/1/2016 | 84 | $ 2,031,057 | $ 1,718,586 |
| 47 | S005242 M112 Systemic Improvement | | $843,635 | G012 | | $3,500,000 | 3/1/2016 | 12 | $ 583,333 | $ - |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 | 3/1/2016 | 12 | $ 24,482 | $ - |
| 49 | Soft Off Program | 4024 | $836,485 | C207 | | $1,278,485 | 2/1/2016 | 84 | $ 1,111,064 | $ 928,423 |
| 50 | LI CSS Stabilization | 4133 | $0 | 5230 | | $847,000 | 3/1/2016 | 84 | $ 746,167 | $ 625,167 |
| 51 | Mobile Capture of Data Fusion | 4102 | $0 | G207 | | $1,580,000 | 10/1/2016 | 84 | $ 1,523,571 | $ 1,297,857 |
| 52 | Gas GIS Upgrade | 2577C | $0 | G210 | | $1,200,000 | 10/1/2016 | 84 | $ 1,157,143 | $ 985,714 |
| 53 | NY Pipeline Safety CMS Regulatory Compliance | 3882 | $0 | G207 | | $3,374,000 | 10/1/2016 | 84 | $ 3,253,500 | $ 2,771,500 |
| 54 | Massachusetts Gas 4 Hour Appointment Window | 4074 | $32,254 | C310 | | $166,254 | 3/1/2016 | 84 | $ 146,462 | $ 122,711 |
| 55 | Voice Record Elec Control Rooms | 3851 | $0 | G186 | | $2,300,000 | 12/1/2016 | 84 | $ 2,272,619 | $ 1,944,048 |
| 56 | Team Center Replacement or Upgrade | 3958 | $0 | G236 | | $600,000 | 10/1/2016 | 84 | $ 578,571 | $ 492,857 |
| 57 | US CNI NY EMS-Conversion to MPLS | 3970 | $0 | G181 | | $160,000 | 5/1/2016 | 84 | $ 144,762 | $ 121,905 |
| 58 | Legacy VSTIG Migration and Decommission | 3538 | | G020 | | $1,501,788 | 9/1/2017 | 84 | $ - | $ 1,430,274 |
| 59 | Remote Net Metering | 4124 | | G194 | | $910,000 | 9/1/2016 | 84 | $ 866,667 | $ 736,667 |
| 60 | RI Renewable Energy Growth | 4055 | $318,786 | 5360E | | $673,000 | 4/1/2016 | 84 | $ 600,893 | $ 504,750 |
| 61 | US Mobile Device Refresh | 2935 | | G173 | | $4,000,000 | 4/1/2017 | 48 | $ - | $ 3,250,000 |
| 62 | US Mobile Device Refresh | 2935 | | G173 | | $0 | 4/1/2018 | 48 | $ - | $ - |
| 63 | US Mobile Device Refresh | 2935 | | G173 | | $0 | 4/1/2019 | 48 | $ - | $ - |
| 64 | KEDNY AMR Project - FDM Interface to CRIS | 4183 | | 5220 | | $356,000 | 9/1/2016 | 84 | $ 339,048 | $ 288,190 |
| 65 | Cross Company Customer System Enhancements | 4172 | | C246 | | $9,143,000 | 9/1/2016 | 84 | $ 8,707,619 | $ 7,401,476 |
| 66 | New Redundant SCC | 3840 | | G020 | | $900,000 | 3/1/2017 | 84 | $ - | $ 792,857 |
| 67 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $736,000 | 4/1/2017 | 84 | $ - | $ 657,143 |
| 68 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 69 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 70 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 71 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $482,000 | 4/1/2017 | 84 | $ - | $ 430,357 |
| 72 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 73 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 74 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 75 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $649,000 | 4/1/2017 | 84 | $ - | $ 579,464 |
| 76 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 77 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 78 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 80 | Field PC Refresh | 2935 | $49,570 | 5230 | | $963,188 | 2/1/2016 | 48 | $ 742,457 | $ 501,660 |
| 81 | Field PC Refresh | 2935 | $155,070 | 5220 | | $1,417,990 | 1/1/2016 | 72 | $ 1,181,658 | $ 945,327 |
| 82 | Access Violation (& Regulation) Management | 3922 | | G020 | | $290,000 | 4/1/2017 | 84 | $ - | $ 258,929 |
| 83 | Active Directory Upgrade | 4287 | | G020 | | $350,000 | 4/1/2017 | 84 | $ - | $ 312,500 |
| 84 | Advanced Analytics | 3902 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 85 | US CNI Intrusion Detection and Prevention - Phase 1 (Cyber Security) | 3863 | | G020 | | $350,000 | 4/1/2018 | 84 | $ - | $ - |
| 86 | US CNI Intrusion Detection and Prevention - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 87 | Risk Based Authentication (Cyber Security) | 3863 | | G020 | | $235,080 | 6/1/2017 | 84 | $ - | $ 215,490 |
| 88 | Enhanced Phishing Protection (Cyber Security) | 3863 | | G020 | | $120,000 | 8/1/2017 | 84 | $ - | $ 112,857 |
| 89 | Security Incident Management (SIEM) 4 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2019 | 84 | $ - | $ - |
| 90 | Security Incident Management (SIEM) 5 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2020 | 84 | $ - | $ - |
| 91 | Identity & Access Management - Role Based Access Management (Cyber Security) | 3863 | | G020 | | $1,650,000 | 10/1/2017 | 84 | $ - | $ 1,591,071 |
| 92 | Identity & Access Management - Fine Grain Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 93 | Identity & Access Management - Privileged Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 94 | Identity & Access Management - Shared Area Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 95 | US CNI Security Enhancements - CSP 2 - Phase 1 (Cyber Security) | 3863 | | G020 | | $990,000 | 11/1/2018 | 84 | $ - | $ - |
| 96 | US CNI Security Enhancements - CSP 2 - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 11/1/2021 | 84 | $ - | $ - |
| 97 | Big Data Security Analytics - Phase 1 (Cyber Security) | 3863 | | G020 | | $1,155,388 | 5/1/2019 | 84 | $ - | $ - |
| 98 | Big Data Security Analytics - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2021 | 84 | $ - | $ - |
| 99 | Enhanced DLP Gateway and Endpoint (Cyber Security) | 3863 | | G020 | | $1,305,780 | 12/1/2017 | 84 | $ - | $ 1,290,235 |
| 100 | Cloud Security (Cyber Security) | 3863 | | G020 | | $1,460,000 | 5/1/2017 | 84 | $ - | $ 1,320,952 |
| 101 | Situational Intelligence & Cyber Intelligence - Phase 1 (Cyber Security) | 3863 | | G020 | | $100,000 | 11/1/2017 | 84 | $ - | $ 97,619 |
| 102 | Situational Intelligence & Cyber Intelligence - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 11/1/2019 | 84 | $ - | $ - |
| 103 | IT/OT Discovery & Implementation - Phase 1 (Cyber Security) | 3863 | | G020 | | $0 | 10/1/2019 | 84 | $ - | $ - |
| 104 | IT/OT Discovery & Implementation - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 10/1/2021 | 84 | $ - | $ - |
| 105 | vStig Scaling - Upgrades (Cyber Security) | 3863 | | G020 | | $0 | 8/1/2018 | 84 | $ - | $ - |
| 106 | Domain Based Security - Phase 1 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 107 | Domain Based Security - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 108 | Security Research Lab (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 109 | Threat Behavior Modeling (Cyber Security) | 3863 | | G020 | | $800,000 | 3/1/2017 | 84 | $ - | $ 704,762 |
| 110 | Enterprise Content Management (ECM) - Archiving | 1134 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 111 | Enterprise Content Management (ECM) Foundation Services (US only) - Upgrade | 3995 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 112 | Global Audit System Replacement | 3673 | | G020 | | $0 | 3/1/2020 | 84 | $ - | $ - |
| 113 | Global Governance, Risk & Compliance | 2940 | | G020 | | $0 | 6/1/2019 | 84 | $ - | $ - |
| 114 | HRIS Strategy Transformation Program | 4144 | | G020 | | $0 | 4/1/2021 | 84 | $ - | $ - |
| 115 | IS Legacy Systems Archiving & Decommission | 3631 | | G020 | | $0 | 7/1/2020 | 84 | $ - | $ - |
| 116 | Mobility - Mobile Application Development Platform (MADP) (US only) | 3996 | | G020 | | $0 | 3/1/2019 | 84 | $ - | $ - |
| 117 | Mobility - Mobile Device Management (MDM) System | 3430 | | G020 | | $100,000 | 3/1/2017 | 84 | $ - | $ 88,095 |
| 118 | Office 365 | 3999 | | G020 | | $0 | 10/1/2019 | 84 | $ - | $ - |
| 119 | RAS Re-Platform/Mobile | 4269 | | G020 | | $400,000 | 4/1/2017 | 84 | $ - | $ 357,143 |
| 120 | Desktop XP to Win7 | 4308 | | G020 | | $5,960,000 | 4/1/2018 | 84 | $ - | $ - |
| 121 | Talent Management | 3674 | | G020 | | $0 | 10/1/2020 | 84 | $ - | $ - |
| 122 | UPS Replacement for Data Communication Closets | 4003 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 123 | US Global Security TWIC Compliance | 4023 | | G020 | | $270,000 | 4/1/2018 | 84 | $ - | $ - |
| 124 | US Network Improvements | 4289 | | G020 | | $350,000 | 4/1/2017 | 84 | $ - | $ 312,500 |
| 125 | VC Room/Mobile Refresh | 3424 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 126 | VSTIG Hardware Refresh | 4274 | | G020 | | $300,000 | 4/1/2017 | 84 | $ - | $ 267,857 |
| 127 | VSTIG upgrade Phase 2 | 4280 | | G020 | | $2,600,000 | 4/1/2017 | 84 | $ - | $ 2,321,429 |
| 128 | VSTIG upgrade Phase 3 | 4266 | | G020 | | $1,300,000 | 4/1/2017 | 84 | $ - | $ 1,160,714 |
| 129 | Wireless Network Expansion | 3425 | | G020 | | $1,600,000 | 6/1/2017 | 84 | $ - | $ 1,466,667 |
| 130 | Mandated Customer Systems Projects - FY16 | 4094 | | C173 | | $828,000 | 4/1/2016 | 84 | $ 739,286 | $ 621,000 |
| 131 | Mandated Customer Systems Projects - FY17 | 4207 | | C173 | | $4,000,000 | 4/1/2017 | 84 | $ - | $ 3,571,429 |
| 132 | Mandated Customer Systems Projects - FY18 | 4207 | | C173 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 133 | Mandated Customer Systems Projects - FY19 | 4207 | | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 134 | Mandated Customer Systems Projects - FY20 | 4207 | | C173 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 135 | Customer Contact Center / SDC Technology Upgrade Implement Solution | 3932 | | C173 | | $1,403,000 | 4/1/2019 | 84 | $ - | $ - |
| 136 | Meter To Cash Value Added Enhancements | 3869 | | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 137 | Meter To Cash Value Added Enhancements | 3869 | | C173 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 138 | Credit & Collections Gap Analysis and Protections | 4211 | | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 139 | Eliminate SSN from Customer Systems | 4216 | | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 140 | Credit and Collections - Bad Debt Mitigation Initiatives | 2959 | | C173 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 141 | Distributed Generation Application Tracking | 3941 | | C173 | | $600,000 | 12/1/2016 | 84 | $ 592,857 | $ 507,143 |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | ( c) Adjustments | (d) = (a)+( c) Total US Spend | ( e) In Service Date | (f) Amortization Period | (g) 12/31/2017 Balance | (h) 12/31/2018 Balance | (i) = (g+h)/2 Average Balance | (j) 9.9500% Service Co | (k) = (i)*(j) Rate Year Return | (l) = (-ac) RY Return on Accum Taxes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $66,772,709 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 47,694,792 | $ 38,155,834 | $ 42,925,313 | 9.9500% | $ 4,271,069 | $ (1,494,355) |
| 2 | Gas GIS Consolidation | 2577 | $5,573,069 | G210 | | $10,283,069 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ - |
| 3 | AMAG Upgrades | 1172 | $5,991,812 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 4,921,845 | $ 4,065,872 | $ 4,493,859 | 9.9500% | $ 447,139 | $ (159,774) |
| 4 | US CNI DKMS | 3019A | $0 | G098 | | $0 | 3/1/2017 | 84 | $ 0 | $ 0 | $ 0 | 9.9500% | $ 0 | $ (0) |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 354,936 | $ 258,135 | $ 306,536 | 9.9500% | $ 30,500 | $ (12,261) |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,788,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,426,802 | $ 1,171,255 | $ 1,299,028 | 9.9500% | $ 129,253 | $ (45,996) |
| 7 | CI Services Foundation | 3492 | $2,644,306 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 1,920,270 | $ 1,542,512 | $ 1,731,391 | 9.9500% | $ 172,273 | $ (60,438) |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,398,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 4,494,022 | $ 3,579,983 | $ 4,037,002 | 9.9500% | $ 401,682 | $ (161,476) |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,576,235 | $ 1,250,117 | $ 1,413,176 | 9.9500% | $ 140,611 | $ (56,526) |
| 10 | Customer Choice ESCO Gas | 3564 | $9,629,193 | C225 | | $9,629,193 | 4/1/2016 | 84 | $ 7,221,895 | $ 5,846,296 | $ 6,534,095 | 9.9500% | $ 650,142 | $ (229,254) |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 409,309 | $ 323,139 | $ 366,224 | 9.9500% | $ 36,439 | $ (14,649) |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 260,587 | $ 205,726 | $ 233,157 | 9.9500% | $ 23,199 | $ (9,326) |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 1,122,900 | $ 894,514 | $ 1,008,707 | 9.9500% | $ 100,366 | $ (40,347) |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $1,240,600 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 1,004,296 | $ 827,067 | $ 915,681 | 9.9500% | $ 91,110 | $ (32,490) |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $3,801,588 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 3,077,476 | $ 2,534,392 | $ 2,805,934 | 9.9500% | $ 279,190 | $ (99,560) |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $1,362,769 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 1,054,524 | $ 859,842 | $ 957,183 | 9.9500% | $ 95,240 | $ (33,743) |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ (0) |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $1,106,000 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 895,333 | $ 737,333 | $ 816,333 | 9.9500% | $ 81,225 | $ (28,965) |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $5,946,273 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 4,813,650 | $ 3,964,182 | $ 4,388,916 | 9.9500% | $ 436,697 | $ (155,728) |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $1,461,890 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 1,096,417 | $ 887,576 | $ 991,997 | 9.9500% | $ 98,704 | $ (34,805) |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $121,600 | G020 | | $121,600 | 4/1/2016 | 84 | $ 91,200 | $ 73,829 | $ 82,514 | 9.9500% | $ 8,210 | $ (2,895) |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $60,800 | G020 | | $60,800 | 9/1/2016 | 84 | $ 49,219 | $ 40,533 | $ 44,876 | 9.9500% | $ 4,465 | $ (1,592) |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $725,146 | G020 | | $725,146 | 9/1/2016 | 84 | $ 587,023 | $ 483,431 | $ 535,227 | 9.9500% | $ 53,255 | $ (18,991) |
| 28 | NY Retail Access | 3839 | $2,872,399 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,427,861 | $ 2,017,519 | $ 2,222,690 | 9.9500% | $ 221,158 | $ (79,329) |
| 29 | US Web Initiatives 2 | 3600B | $3,831,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 2,782,415 | $ 2,235,055 | $ 2,508,735 | 9.9500% | $ 249,619 | $ (87,573) |
| 30 | Capitalized Asset Replacement | 3617C | $935,395 | G084 | | $935,395 | 4/1/2016 | 84 | $ 701,547 | $ 567,919 | $ 634,733 | 9.9500% | $ 63,156 | $ (22,270) |
| 31 | UNY Capitalized Asset Replacement | 3617D | $265,077 | G003 | | $265,077 | 4/1/2016 | 84 | $ 198,808 | $ 160,940 | $ 179,874 | 9.9500% | $ 17,897 | $ (6,311) |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $475,000 | G235 | | $475,000 | 4/1/2016 | 84 | $ 356,250 | $ 288,393 | $ 322,321 | 9.9500% | $ 32,071 | $ (11,309) |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | $480,000 | G077 | | $480,000 | 4/1/2016 | 84 | $ 360,000 | $ 291,429 | $ 325,714 | 9.9500% | $ 32,409 | $ (11,428) |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $1,182,427 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ 1,041,662 | $ 872,744 | $ 957,203 | 9.9500% | $ 95,242 | $ (26,462) |
| 35 | EHR1 - PMO | | $8,928,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 6,271,242 | $ 4,995,735 | $ 5,633,489 | 9.9500% | $ 560,532 | $ (225,334) |
| 36 | EHR1 - Supply Chain | | $14,769,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 10,373,772 | $ 8,263,853 | $ 9,318,813 | 9.9500% | $ 927,222 | $ (372,743) |
| 37 | EHR1 - Finance | | $16,145,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 11,340,183 | $ 9,033,705 | $ 10,186,944 | 9.9500% | $ 1,013,601 | $ (407,468) |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 1,695,769 | $ 1,350,867 | $ 1,523,318 | 9.9500% | $ 151,570 | $ (60,931) |
| 39 | EHR1 - Payroll | | $12,187,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 8,560,033 | $ 6,819,009 | $ 7,689,521 | 9.9500% | $ 765,107 | $ (307,573) |
| 40 | EHR1 - BPS | | $9,915,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 6,964,288 | $ 5,547,823 | $ 6,256,055 | 9.9500% | $ 622,478 | $ (250,236) |
| 41 | Customer Storm Outage Credit Program | 3859 | $0 | 5210 | | $0 | 3/1/2015 | 84 | $ 0 | $ 0 | $ 0 | 9.9500% | $ 0 | $ (0) |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $5,739,504 | C210 | | $11,369,504 | 1/1/2019 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ - |
| 43 | US Desktop Refresh | 2927 | $7,430,690 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 4,024,957 | $ 2,167,285 | $ 3,096,121 | 9.9500% | $ 308,064 | $ (99,068) |
| 44 | Internet Explorer Upgrade | 3644 | $300,090 | G020 | | $300,090 | 3/1/2016 | 84 | $ 221,495 | $ 178,625 | $ 200,060 | 9.9500% | $ 19,906 | $ (7,002) |
| 45 | Mobile Device for PTO | 3883 | $2,442,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 1,628,314 | $ 1,017,696 | $ 1,323,005 | 9.9500% | $ 131,639 | $ (44,776) |
| 46 | SMI Conversion Mobilization | 3896 | $2,187,292 | G020 | | $2,187,292 | 7/1/2016 | 84 | $ 1,718,586 | $ 1,406,116 | $ 1,562,351 | 9.9500% | $ 155,454 | $ (55,200) |
| 47 | S005242 M112 Systemic Improvement | | $3,500,000 | G012 | | $3,500,000 | 3/1/2016 | 12 | $ - | $ - | $ - | 9.9500% | $ - | $ 11,669 |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 | 3/1/2016 | 12 | $ - | $ - | $ - | 9.9500% | $ - | $ 490 |
| 49 | Soft Off Program | 4024 | $1,278,485 | C207 | | $1,278,485 | 2/1/2016 | 84 | $ 928,423 | $ 745,783 | $ 837,103 | 9.9500% | $ 83,292 | $ (29,221) |
| 50 | LI CSS Stabilization | 4133 | $847,000 | 5230 | | $847,000 | 3/1/2016 | 84 | $ 625,167 | $ 504,167 | $ 564,667 | 9.9500% | $ 56,184 | $ (19,762) |
| 51 | Mobile Capture of Data Fusion | 4102 | $1,580,000 | G207 | | $1,580,000 | 10/1/2016 | 84 | $ 1,297,857 | $ 1,072,143 | $ 1,185,000 | 9.9500% | $ 117,908 | $ (42,131) |
| 52 | Gas GIS Upgrade | 2577C | $1,200,000 | G210 | | $1,200,000 | 10/1/2016 | 84 | $ 985,714 | $ 814,286 | $ 900,000 | 9.9500% | $ 89,550 | $ (31,998) |
| 53 | NY Pipeline Safety CMS Regulatory Compliance | 3882 | $3,374,000 | G207 | | $3,374,000 | 10/1/2016 | 84 | $ 2,771,500 | $ 2,289,500 | $ 2,530,500 | 9.9500% | $ 251,785 | $ (89,969) |
| 54 | Massachusetts Gas 4 Hour Appointment Window | 4074 | $166,254 | C310 | | $166,254 | 3/1/2016 | 84 | $ 122,711 | $ 98,961 | $ 110,836 | 9.9500% | $ 11,028 | $ (3,879) |
| 55 | Voice Record Elec Control Rooms | 3851 | $2,300,000 | G186 | | $2,300,000 | 12/1/2016 | 84 | $ 1,944,048 | $ 1,615,476 | $ 1,779,762 | 9.9500% | $ 177,086 | $ (63,521) |
| 56 | Team Center Replacement or Upgrade | 3958 | $600,000 | G236 | | $600,000 | 10/1/2016 | 84 | $ 492,857 | $ 407,143 | $ 450,000 | 9.9500% | $ 44,775 | $ (15,999) |
| 57 | US CNI NY EMS-Conversion to MPLS | 3970 | $160,000 | G181 | | $160,000 | 5/1/2016 | 84 | $ 121,905 | $ 99,048 | $ 110,476 | 9.9500% | $ 10,992 | $ (3,886) |
| 58 | Legacy VSTIG Migration and Decommission | 3538 | $1,501,788 | G020 | | $1,551,788 | 9/1/2017 | 84 | $ 1,477,893 | $ 1,256,209 | $ 1,367,051 | 9.9500% | $ 136,022 | $ (39,162) |
| 59 | Remote Net Metering | 4124 | $910,000 | G194 | | $910,000 | 9/1/2016 | 84 | $ 736,667 | $ 606,667 | $ 671,667 | 9.9500% | $ 66,831 | $ (23,832) |
| 60 | RI Renewable Energy Growth | 4055 | $673,000 | 5360E | | $673,000 | 4/1/2016 | 84 | $ 504,750 | $ 408,607 | $ 456,679 | 9.9500% | $ 45,440 | $ (16,023) |
| 61 | US Mobile Device Refresh | 2935 | $4,000,000 | G173 | | $4,000,000 | 4/1/2017 | 48 | $ 3,250,000 | $ 2,250,000 | $ 2,750,000 | 9.9500% | $ 273,625 | $ (69,994) |
| 62 | US Mobile Device Refresh | 2935 | $0 | G173 | | $2,000,000 | 4/1/2018 | 48 | $ - | $ 1,625,000 | $ 812,500 | 9.9500% | $ 80,844 | $ (32,498) |
| 63 | US Mobile Device Refresh | 2935 | $0 | G173 | | $0 | 4/1/2019 | 48 | $ - | $ - | $ - | 9.9500% | $ - | $ - |
| 64 | KEDNY AMR Project - FDM Interface to CRIS | 4183 | $356,000 | 5220 | | $356,000 | 9/1/2016 | 84 | $ 288,190 | $ 237,333 | $ 262,762 | 9.9500% | $ 26,145 | $ (9,323) |
| 65 | Cross Company Customer System Enhancements | 4172 | $9,143,000 | C246 | | $9,143,000 | 9/1/2016 | 84 | $ 7,401,476 | $ 6,095,333 | $ 6,748,405 | 9.9500% | $ 671,466 | $ (239,447) |
| 66 | New Redundant SCC | 3840 | $900,000 | G020 | | $900,000 | 3/1/2017 | 84 | $ 792,857 | $ 664,286 | $ 728,571 | 9.9500% | $ 72,493 | $ (20,141) |
| 67 | Capitalized Asset Replacement - Physical Security | 3617C | $736,000 | G084 | | $736,000 | 4/1/2017 | 84 | $ 657,143 | $ 552,000 | $ 604,571 | 9.9500% | $ 60,155 | $ (16,822) |
| 68 | Capitalized Asset Replacement - Physical Security | 3617C | $0 | G084 | | $797,000 | 4/1/2018 | 84 | $ - | $ 711,607 | $ 355,804 | 9.9500% | $ 35,402 | $ (14,231) |
| 69 | Capitalized Asset Replacement - Physical Security | 3617C | $0 | G084 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ - |
| 70 | Capitalized Asset Replacement - Physical Security | 3617C | $0 | G084 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% | $ - | $ - |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend |
|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $66,772,709 | G198 | | $66,772,709 |
| 2 | Gas GIS Consolidation | 2577 | $10,283,069 | G210 | | $11,633,069 |
| 3 | AMAG Upgrades | 1172 | $5,991,812 | G020 | | $5,991,812 |
| 4 | US CNI DKMS | 3019A | $0 | G098 | | $0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,788,826 | G310 | | $1,788,826 |
| 7 | CI Services Foundation | 3492 | $2,644,306 | G020 | | $2,644,306 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,398,268 | G210 | | $6,398,268 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 |
| 10 | Customer Choice ESCO Gas | 3564 | $9,629,193 | C225 | | $9,629,193 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $1,240,600 | G020 | | $1,240,600 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $3,801,588 | G020 | | $3,801,588 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $1,362,769 | G020 | | $1,362,769 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $0 | G020 | | $0 |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $0 | G020 | | $0 |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $1,106,000 | G020 | | $1,106,000 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $5,946,273 | G020 | | $5,946,273 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $0 | G020 | | $0 |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $1,461,890 | G020 | | $1,461,890 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $121,600 | G020 | | $121,600 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $60,800 | G020 | | $60,800 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $725,146 | G020 | | $725,146 |
| 28 | NY Retail Access | 3839 | $2,872,399 | G170 | | $2,872,399 |
| 29 | US Web Initiatives 2 | 3600B | $3,831,522 | C175 | | $3,831,522 |
| 30 | Capitalized Asset Replacement | 3617C | $935,395 | G084 | | $935,395 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $265,077 | G003 | | $265,077 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $475,000 | G235 | | $475,000 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | $480,000 | G077 | | $480,000 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $1,182,427 | G003 | | $1,182,427 |
| 35 | EHR1 - PMO | | $8,928,548 | G012 | | $8,928,548 |
| 36 | EHR1 - Supply Chain | | $14,769,439 | G012 | | $14,769,439 |
| 37 | EHR1 - Finance | | $16,145,346 | G012 | | $16,145,346 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 |
| 39 | EHR1 - Payroll | | $12,187,165 | G012 | | $12,187,165 |
| 40 | EHR1 - BPS | | $9,915,257 | 5020 | | $9,915,257 |
| 41 | Customer Storm Outage Credit Program | 3859 | $0 | 5210 | | $0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $11,369,504 | C210 | | $17,079,504 |
| 43 | US Desktop Refresh | 2927 | $7,430,690 | G020 | | $7,430,690 |
| 44 | Internet Explorer Upgrade | 3644 | $300,090 | G020 | | $300,090 |
| 45 | Mobile Device for PTO | 3883 | $2,442,471 | G173 | | $2,442,471 |
| 46 | SMI Conversion Mobilization | 3896 | $2,187,292 | G020 | | $2,187,292 |
| 47 | S005242 M112 Systemic Improvement | | $3,500,000 | G012 | | $3,500,000 |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 |
| 49 | Soft Off Program | 4024 | $1,278,485 | C207 | | $1,278,485 |
| 50 | LI CSS Stabilization | 4133 | $847,000 | 5230 | | $847,000 |
| 51 | Mobile Capture of Data Fusion | 4102 | $1,580,000 | G207 | | $1,580,000 |
| 52 | Gas GIS Upgrade | 2577C | $1,200,000 | G210 | | $1,200,000 |
| 53 | NY Pipeline Safety CMS Regulatory Compliance | 3882 | $3,374,000 | G207 | | $3,374,000 |
| 54 | Massachusetts Gas 4 Hour Appointment Window | 4074 | $166,254 | C310 | | $166,254 |
| 55 | Voice Record Elec Control Rooms | 3851 | $2,300,000 | G186 | | $2,300,000 |
| 56 | Team Center Replacement or Upgrade | 3958 | $600,000 | G236 | | $600,000 |
| 57 | US CNI NY EMS-Conversion to MPLS | 3970 | $160,000 | G181 | | $160,000 |
| 58 | Legacy VSTIG Migration and Decommission | 3538 | $1,551,788 | G020 | | $1,551,788 |
| 59 | Remote Net Metering | 4124 | $910,000 | G194 | | $910,000 |
| 60 | RI Renewable Energy Growth | 4055 | $673,000 | 5360E | | $673,000 |
| 61 | US Mobile Device Refresh | 2935 | $4,000,000 | G173 | | $4,000,000 |
| 62 | US Mobile Device Refresh | 2935 | $2,000,000 | G173 | | $2,000,000 |
| 63 | US Mobile Device Refresh | 2935 | $0 | G173 | | $2,000,000 |
| 64 | KEDNY AMR Project - FDM Interface to CRIS | 4183 | $356,000 | 5220 | | $356,000 |
| 65 | Cross Company Customer System Enhancements | 4172 | $9,143,000 | C246 | | $9,143,000 |
| 66 | New Redundant SCC | 3840 | $900,000 | G020 | | $900,000 |
| 67 | Capitalized Asset Replacement - Physical Security | 3617C | $736,000 | G084 | | $736,000 |
| 68 | Capitalized Asset Replacement - Physical Security | 3617C | $797,000 | G084 | | $797,000 |
| 69 | Capitalized Asset Replacement - Physical Security | 3617C | $0 | G084 | | $870,000 |
| 70 | Capitalized Asset Replacement - Physical Security | 3617C | $0 | G084 | | $0 |
| 71 | UNY Capitalized Asset Replacement - Physical Security | 3617D | $482,000 | G003 | | $482,000 |
| 72 | UNY Capitalized Asset Replacement - Physical Security | 3617D | $621,000 | G003 | | $621,000 |
| 73 | UNY Capitalized Asset Replacement - Physical Security | 3617D | $0 | G003 | | $729,000 |
| 74 | UNY Capitalized Asset Replacement - Physical Security | 3617D | $0 | G003 | | $0 |
| 75 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $649,000 | G235 | | $649,000 |
| 76 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $701,000 | G235 | | $701,000 |
| 77 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $0 | G235 | | $766,000 |
| 78 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $0 | G235 | | $0 |
| 80 | Field PC Refresh | 2935 | $963,188 | 5230 | | $963,188 |
| 81 | Field PC Refresh | 2935 | $1,417,990 | 5220 | | $1,417,990 |
| 82 | Access Violation (& Regulation) Management | 3922 | $290,000 | G020 | | $290,000 |
| 83 | Active Directory Upgrade | 4287 | $350,000 | G020 | | $350,000 |
| 84 | Advanced Analytics | 3902 | $0 | G020 | | $300,000 |
| 85 | US CNI Intrusion Detection and Prevention - Phase 1 (Cyber Security) | 3863 | $550,000 | G020 | | $550,000 |
| 86 | US CNI Intrusion Detection and Prevention - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $300,000 |
| 87 | Risk Based Authentication (Cyber Security) | 3863 | $235,080 | G020 | | $235,080 |
| 88 | Enhanced Phishing Protection (Cyber Security) | 3863 | $120,000 | G020 | | $120,000 |
| 89 | Security Incident Management (SIEM) 4 (Cyber Security) | 3863 | $633,150 | G020 | | $1,266,300 |
| 90 | Security Incident Management (SIEM) 5 (Cyber Security) | 3863 | $0 | G020 | | $0 |
| 91 | Identity & Access Management - Role Based Access Management (Cyber Security) | 3863 | $1,650,000 | G020 | | $1,650,000 |
| 92 | Identity & Access Management - Fine Grain Access Management (Cyber Security) | 3863 | $1,650,000 | G020 | | $1,650,000 |
| 93 | Identity & Access Management - Privileged Access Management (Cyber Security) | 3863 | $0 | G020 | | $1,740,000 |
| 94 | Identity & Access Management - Shared Area Access Management (Cyber Security) | 3863 | $0 | G020 | | $0 |
| 95 | US CNI Security Enhancements - CSP 2 - Phase 1 (Cyber Security) | 3863 | $2,640,000 | G020 | | $2,640,000 |
| 96 | US CNI Security Enhancements - CSP 2 - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 |
| 97 | Big Data Security Analytics - Phase 1 (Cyber Security) | 3863 | $3,466,164 | G020 | | $5,776,940 |
| 98 | Big Data Security Analytics - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 |
| 99 | Enhanced DLP Gateway and Endpoint (Cyber Security) | 3863 | $2,238,480 | G020 | | $2,238,480 |
| 100 | Cloud Security (Cyber Security) | 3863 | $1,460,000 | G020 | | $1,460,000 |
| 101 | Situational Intelligence & Cyber Intelligence - Phase 1 (Cyber Security) | 3863 | $100,000 | G020 | | $100,000 |
| 102 | Situational Intelligence & Cyber Intelligence - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $100,000 |
| 103 | IT/OT Discovery & Implementation - Phase 1 (Cyber Security) | 3863 | $3,300,000 | G020 | | $5,500,000 |
| 104 | IT/OT Discovery & Implementation - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 |
| 105 | vStig Scaling - Upgrades (Cyber Security) | 3863 | $1,000,000 | G020 | | $1,000,000 |
| 106 | Domain Based Security - Phase 1 (Cyber Security) | 3863 | $0 | G020 | | $800,000 |
| 107 | Domain Based Security - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 |
| 108 | Security Research Lab (Cyber Security) | 3863 | $325,000 | G020 | | $325,000 |
| 109 | Threat Behavior Modeling (Cyber Security) | 3863 | $800,000 | G020 | | $800,000 |
| 110 | Enterprise Content Management (ECM) - Archiving | 1134 | $0 | G020 | | $0 |
| 111 | Enterprise Content Management (ECM) Foundation Services (US only) - Upgrade | 3995 | $0 | G020 | | $0 |
| 112 | Global Audit System Replacement | 3673 | $0 | G020 | | $200,000 |
| 113 | Global Governance, Risk & Compliance | 2940 | $0 | G020 | | $480,000 |
| 114 | HRIS Strategy Transformation Program | 4144 | $0 | G020 | | $15,265,000 |
| 115 | IS Legacy Systems Archiving & Decommission | 3631 | $0 | G020 | | $0 |
| 116 | Mobility - Mobile Application Development Platform (MADP) (US only) | 3996 | $0 | G020 | | $500,000 |
| 117 | Mobility - Mobile Device Management (MDM) System | 3430 | $100,000 | G020 | | $100,000 |
| 118 | Office 365 | 3999 | $4,300,000 | G020 | | $4,700,000 |
| 119 | RAS Re-Platform/Mobile | 4269 | $400,000 | G020 | | $400,000 |
| 120 | Desktop XP to Win7 | 4308 | $11,040,000 | G020 | | $11,040,000 |
| 121 | Talent Management | 3674 | $0 | G020 | | $0 |
| 122 | UPS Replacement for Data Communication Closets | 4003 | $0 | G020 | | $20,000 |
| 123 | US Global Security TWIC Compliance | 4023 | $1,080,000 | G020 | | $1,080,000 |
| 124 | US Network Improvements | 4289 | $350,000 | G020 | | $350,000 |
| 125 | VC Room/Mobile Refresh | 3424 | $0 | G020 | | $225,000 |
| 126 | VSTIG Hardware Refresh | 4274 | $300,000 | G020 | | $300,000 |
| 127 | VSTIG upgrade Phase 2 | 4280 | $2,600,000 | G020 | | $2,600,000 |
| 128 | VSTIG upgrade Phase 3 | 4266 | $1,300,000 | G020 | | $1,300,000 |
| 129 | Wireless Network Expansion | 3425 | $1,600,000 | G020 | | $1,600,000 |
| 130 | Mandated Customer Systems Projects - FY16 | 4094 | $828,000 | C173 | | $828,000 |
| 131 | Mandated Customer Systems Projects - FY17 | 4207 | $4,000,000 | C173 | | $4,000,000 |
| 132 | Mandated Customer Systems Projects - FY18 | 4207 | $4,000,000 | C173 | | $4,000,000 |
| 133 | Mandated Customer Systems Projects - FY19 | 4207 | $0 | C173 | | $4,000,000 |
| 134 | Mandated Customer Systems Projects - FY20 | 4207 | $0 | C173 | | $0 |
| 135 | Customer Contact Center / SDC Technology Upgrade Implement Solution | 3932 | $8,417,000 | C173 | | $14,028,000 |
| 136 | Meter To Cash Value Added Enhancements | 3869 | $0 | C173 | | $1,750,000 |
| 137 | Meter To Cash Value Added Enhancements | 3869 | $0 | C173 | | $0 |
| 138 | Credit & Collections Gap Analysis and Protections | 4211 | $0 | C173 | | $400,000 |
| 139 | Eliminate SSN from Customer Systems | 4216 | $0 | C173 | | $647,000 |
| 140 | Credit and Collections - Bad Debt Mitigation Initiatives | 2959 | $400,000 | C173 | | $400,000 |
| 141 | Distributed Generation Application Tracking | 3941 | $600,000 | C173 | | $600,000 |
| 142 | Customer Interaction Channels | 4139 | $0 | C173 | | $1,000,000 |
| 143 | Mandated Customer Choice Systems Projects | 4186 | $3,100,000 | C173 | | $3,100,000 |
| 144 | Operational Requirements and Upgrades for Procurement & Supply Chain (US SAP) | 4169 | $0 | G020 | | $0 |
| 145 | Enhancement Release - EHR-H2R | 4170 | $0 | G020 | | $840,000 |
| 146 | Enhancement Release - EHR-Non-Utility Billing | 4171 | $0 | G020 | | $546,000 |
| 147 | Enhancement Release - EHR-Xfunc | 4165 | $0 | G020 | | $4,000,000 |
| 148 | PII Project - Security & Controls | 4168 | $0 | G020 | | $524,000 |
| 149 | US SAP: Business Planning Consolidation - HANA | 4217 | $3,500,000 | G020 | | $3,500,000 |
| 150 | Blanket Work Order Pilot | 4218 | $0 | G020 | | $1,500,000 |
| 151 | PowerPlan Module Enhancements | 4220 | $0 | G020 | | $700,000 |
| 152 | US SAP: Improve Performance Reporting | 4221 | $0 | G020 | | $1,050,000 |
| 153 | US Gas Enablement IS Component (US Front Office) | 2575 | $0 | G210 | | $0 |
| 154 | US Operations Infrastructure Minor Works Improvement | 3716 | $1,000,000 | G173 | | $1,000,000 |
| 155 | New Medical System | 3718 | $1,100,000 | G020 | | $1,100,000 |
| 156 | Electric and Gas Service Fulfillment Web Portal | 3946 | $0 | G173 | | $0 |
| 157 | NY Gas Audit Work Mgmt and Time Reporting | 3953 | $0 | G207 | | $0 |
| 158 | Migrate NYS DMV Inspection Stations to LAN | 3954 | $0 | G207 | | $650,000 |
| 159 | Wi-Fi for Fleet Service Diagnostic Laptops | 3956 | $0 | G173 | | $600,000 |
| 160 | ISI Follow Up Work Creation in WMS and Customer System | 3961 | $0 | G210 | | $0 |
| 161 | Contract Management Modernization | 4151 | $0 | G198 | | $2,500,000 |
| 162 | Ageing System Stabization/Upgrades/Replacements | 4188 | $1,500,000 | G020 | | $1,500,000 |
| 163 | Gas Outage Management System (GOMS) | 4237 | $0 | G210 | | $0 |
| 164 | Operations Performance Management, Data Management, and Reporting | 4247 | $0 | G210 | | $1,155,000 |
| 165 | Gas Services Database | 3948/3949 | $940,000 | G207 | | $940,000 |
| 166 | Document Management System Replacement | 3985 | $4,040,000 | G020 | | $4,040,000 |
| 167 | Cascade Electric Application Upgrade Project | 3986 | $460,000 | G198 | | $460,000 |
| 168 | EJ Ward Upgrade | 3955 | $600,000 | G107 | | $600,000 |
| 169 | Double Pole Management Database upgrade | 4045 | $432,000 | G198 | | $432,000 |
| 170 | NY REV Clifton Park Demo Information Systems Readiness | 4298 | $650,000 | G181 | | $650,000 |
| 171 | US CNI GMS-SCADA Upgrade and Consolidation | 3737 | $10,166,000 | G210 | | $15,875,000 |
| 172 | US CNI GMS-Downstate NY and LI Upgrade End-Of-Life Verizon Back-up Communication | 3730 | $1,200,000 | G225 | | $1,200,000 |
| 173 | US CNI-Infrastructure Reliability and Security Enhancements | 2881 | $600,000 | G020 | | $1,200,000 |
| 174 | US CNI Tech Services-Data Center Capacity Expansion | 2909 | $0 | G020 | | $2,000,000 |
| 175 | US CNI GMS-Operator Workstation Operating System | 3965 | $820,000 | G210 | | $820,000 |
| 176 | US Control-Wires Down for Massachusetts and NY | 4044 | $5,560,000 | G186 | | $12,080,000 |
| 177 | US Control-NE Electric Control Center Video Wall | 3966 | $650,000 | G305 | | $650,000 |
| 178 | US MDS - Itron Enterprise Edition (IEE) Consolidation | 3486 | $1,119,000 | G173 | | $3,878,000 |
| 179 | US CNI EMS and OMS-Critical Component System Refresh | 4190 | $0 | G198 | | $0 |
| 180 | US CNI EMS NY/NE-Transmission Outage Application (TOA) End-of-Life Replacement | 4191 | $0 | G220 | | $0 |
| 181 | US Control-Electroinic Bulletin Board Gas Trading Day Changes | 4244 | $2,200,000 | G210 | | $2,200,000 |
| | Subtotal | | $ 394,443,853 | | | $ 476,403,779 |

| Investment Name | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend |
|---|---|---|---|---|
| AIMMS Project - Bill Pool 233 | $47,097 | G220 | | $47,097 |
| Bnk Lease W MA F Optic Proj | $435,545 | G284 | | $435,545 |
| Cascade | $1,576,557 | G194 | | $1,576,557 |
| Cascade | $588,773 | G198 | | $588,773 |
| Cascade | $392,515 | G220 | | $392,515 |
| Cascade | $1,051,038 | G220 | | $1,051,038 |
| CDH Acct Initiation | $516,140 | G012 | | $516,140 |
| CM-NEW02-Simp Order Proc | $7,803 | G198 | | $7,803 |
| CNI Transformation | $114,360 | G012 | | $114,360 |
| Combine Meter Reading Routes | $364,462 | G285 | | $364,462 |
| Contact Centers Call Recording | $361,473 | G012 | | $361,473 |
| CSS Consolidation | $28,900,771 | C284 | | $28,900,771 |
| Data Center Rationalization | $793,491 | GT03 | | $793,491 |
| DECUS05-Autom for Mng Req | $1,914,655 | G198 | | $1,914,655 |
| Desktop (email, AD & SharePoint) | $1,258,446 | GT03 | | $1,258,446 |
| Desktop (refresh) | $950,271 | G012 | | $950,271 |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend | (e) In Service | (f) Amortization Period | (g) 12/31/2016 Balance | (h) 12/31/2017 Balance | (i) = (g+h)/2 Average Balance | (j) 9.9500% Service Co |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $60,613,682 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 57,233,751 | $ 47,694,792 | $ 52,464,271 | 9.9500% |
| 2 | Gas GIS Consolidation | 2577 | $2,213,069 | G210 | | $5,573,069 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 3 | AMAG Upgrades | 1172 | $3,698,542 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 5,777,818 | $ 4,921,845 | $ 5,349,832 | 9.9500% |
| 4 | US CNI DKMS | 3019A | $249,414 | G098 | -$249,414 | $0 | 3/1/2017 | 84 | $ - | $ 0 | $ 0 | 9.9500% |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 451,737 | $ 354,936 | $ 403,336 | 9.9500% |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,244,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,682,348 | $ 1,426,802 | $ 1,554,575 | 9.9500% |
| 7 | CI Services Foundation | 3492 | $2,197,232 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 2,298,028 | $ 1,920,270 | $ 2,109,149 | 9.9500% |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,071,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 5,408,060 | $ 4,494,022 | $ 4,951,041 | 9.9500% |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,902,352 | $ 1,576,235 | $ 1,739,294 | 9.9500% |
| 10 | Customer Choice ESCO Gas | 3564 | $7,774,478 | C225 | -$521,285 | $9,629,193 | 4/1/2016 | 84 | $ 8,597,494 | $ 7,221,895 | $ 7,909,694 | 9.9500% |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 495,479 | $ 409,309 | $ 452,394 | 9.9500% |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 315,447 | $ 260,587 | $ 288,017 | 9.9500% |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 1,351,287 | $ 1,122,900 | $ 1,237,094 | 9.9500% |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $661 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 1,181,524 | $ 1,004,296 | $ 1,092,910 | 9.9500% |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $556,501 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 3,620,560 | $ 3,077,476 | $ 3,349,018 | 9.9500% |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $144,307 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 1,249,205 | $ 1,054,524 | $ 1,151,864 | 9.9500% |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $3,903 | G020 | -$3,903 | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $4,206 | G020 | -$4,206 | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $0 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 1,053,333 | $ 895,333 | $ 974,333 | 9.9500% |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $3,000,805 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 5,663,117 | $ 4,813,650 | $ 5,238,384 | 9.9500% |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $2,363 | G020 | -$2,363 | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $27,818 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 1,305,259 | $ 1,096,417 | $ 1,200,838 | 9.9500% |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $0 | G020 | | $121,600 | 4/1/2016 | 84 | $ 108,571 | $ 91,200 | $ 99,886 | 9.9500% |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $0 | G020 | | $60,800 | 9/1/2016 | 84 | $ 57,905 | $ 49,219 | $ 53,562 | 9.9500% |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $0 | G020 | | $725,146 | 9/1/2016 | 84 | $ 690,615 | $ 587,023 | $ 638,819 | 9.9500% |
| 28 | NY Retail Access | 3839 | $2,088,663 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,838,204 | $ 2,427,861 | $ 2,633,033 | 9.9500% |
| 29 | US Web Initiatives 2 | 3600B | $3,402,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 3,329,775 | $ 2,782,415 | $ 3,056,095 | 9.9500% |
| 30 | Capitalized Asset Replacement | 3617C | $882,109 | G084 | | $935,395 | 4/1/2016 | 84 | $ 835,175 | $ 701,547 | $ 768,361 | 9.9500% |
| 31 | UNY Capitalized Asset Replacement | 3617D | $134,169 | G003 | | $265,077 | 4/1/2016 | 84 | $ 236,676 | $ 198,808 | $ 217,742 | 9.9500% |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $475,000 | 4/1/2016 | 84 | $ 424,107 | $ 356,250 | $ 390,179 | 9.9500% |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | | G077 | | $480,000 | 4/1/2016 | 84 | $ 428,571 | $ 360,000 | $ 394,286 | 9.9500% |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $485,308 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ - | $ 1,041,662 | $ 520,831 | 9.9500% |
| 35 | EHR1 - PMO | | $6,218,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 7,546,749 | $ 6,271,242 | $ 6,908,996 | 9.9500% |
| 36 | EHR1 - Supply Chain | | $10,339,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 12,483,692 | $ 10,373,772 | $ 11,428,732 | 9.9500% |
| 37 | EHR1 - Finance | | $15,565,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 13,646,661 | $ 11,340,183 | $ 12,493,422 | 9.9500% |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 2,040,672 | $ 1,695,769 | $ 1,868,220 | 9.9500% |
| 39 | EHR1 - Payroll | | $10,937,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 10,301,056 | $ 8,560,033 | $ 9,430,545 | 9.9500% |
| 40 | EHR1 - BPS | | $5,115,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 8,380,753 | $ 6,964,288 | $ 7,672,521 | 9.9500% |
| 41 | Customer Storm Outage Credit Program | 3859 | $165,018 | 5210 | -$165,018 | $0 | 3/1/2015 | 84 | $ 0 | $ 0 | $ 0 | 9.9500% |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $41,564 | C210 | | $5,739,504 | 1/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 43 | US Desktop Refresh | 2927 | $5,813,532 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 5,882,629 | $ 4,024,957 | $ 4,953,793 | 9.9500% |
| 44 | Internet Explorer Upgrade | 3644 | $137,061 | G020 | | $300,090 | 3/1/2016 | 84 | $ 264,365 | $ 221,495 | $ 242,930 | 9.9500% |
| 45 | Mobile Device for PTO | 3883 | $242,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 2,238,932 | $ 1,628,314 | $ 1,933,623 | 9.9500% |
| 46 | SMI Conversion Mobilization | 3896 | $402,655 | G020 | | $2,187,292 | 7/1/2016 | 84 | $ 2,031,057 | $ 1,718,586 | $ 1,874,822 | 9.9500% |
| 47 | S005242 M112 Systemic Improvement | | $843,635 | G012 | | $3,500,000 | 3/1/2016 | 12 | $ 583,333 | $ - | $ 291,667 | 9.9500% |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 | 3/1/2016 | 12 | $ 24,482 | $ - | $ 12,241 | 9.9500% |
| 49 | Soft Off Program | 4024 | $836,485 | C207 | | $1,278,485 | 2/1/2016 | 84 | $ 1,111,064 | $ 928,423 | $ 1,019,744 | 9.9500% |
| 50 | LI CSS Stabilization | 4133 | $0 | 5230 | | $847,000 | 3/1/2016 | 84 | $ 746,167 | $ 625,167 | $ 685,667 | 9.9500% |
| 51 | Mobile Capture of Data Fusion | 4102 | $0 | G207 | | $1,580,000 | 10/1/2016 | 84 | $ 1,523,571 | $ 1,297,857 | $ 1,410,714 | 9.9500% |
| 52 | Gas GIS Upgrade | 2577C | $0 | G210 | | $1,200,000 | 10/1/2016 | 84 | $ 1,157,143 | $ 985,714 | $ 1,071,429 | 9.9500% |
| 53 | NY Pipeline Safety CMS Regulatory Compliance | 3882 | $0 | G207 | | $3,374,000 | 10/1/2016 | 84 | $ 3,253,500 | $ 2,771,500 | $ 3,012,500 | 9.9500% |
| 54 | Massachusetts Gas 4 Hour Appointment Window | 4074 | $32,254 | C310 | | $166,254 | 3/1/2016 | 84 | $ 146,462 | $ 122,711 | $ 134,587 | 9.9500% |
| 55 | Voice Record Elec Control Rooms | 3851 | $0 | G186 | | $2,300,000 | 12/1/2016 | 84 | $ 2,272,619 | $ 1,944,048 | $ 2,108,333 | 9.9500% |
| 56 | Team Center Replacement or Upgrade | 3958 | $0 | G236 | | $600,000 | 10/1/2016 | 84 | $ 578,571 | $ 492,857 | $ 535,714 | 9.9500% |
| 57 | US CNI NY EMS-Conversion to MPLS | 3970 | $0 | G181 | | $160,000 | 5/1/2016 | 84 | $ 144,762 | $ 121,905 | $ 133,333 | 9.9500% |
| 58 | Legacy VSTIG Migration and Decommission | 3538 | | G020 | | $1,501,788 | 9/1/2017 | 84 | $ - | $ 1,430,274 | $ 715,137 | 9.9500% |
| 59 | Remote Net Metering | 4124 | | G194 | | $910,000 | 9/1/2016 | 84 | $ 866,667 | $ 736,667 | $ 801,667 | 9.9500% |
| 60 | RI Renewable Energy Growth | 4055 | $318,786 | 5360E | | $673,000 | 4/1/2016 | 84 | $ 600,893 | $ 504,750 | $ 552,821 | 9.9500% |
| 61 | US Mobile Device Refresh | 2935 | | G173 | | $4,000,000 | 4/1/2017 | 48 | $ - | $ 3,250,000 | $ 1,625,000 | 9.9500% |
| 62 | US Mobile Device Refresh | 2935 | | G173 | | $0 | 4/1/2018 | 48 | $ - | $ - | $ - | 9.9500% |
| 63 | US Mobile Device Refresh | 2935 | | G173 | | $0 | 4/1/2019 | 48 | $ - | $ - | $ - | 9.9500% |
| 64 | KEDNY AMR Project - FDM Interface to CRIS | 4183 | | 5220 | | $356,000 | 9/1/2016 | 84 | $ 339,048 | $ 288,190 | $ 313,619 | 9.9500% |
| 65 | Cross Company Customer System Enhancements | 4172 | | C246 | | $9,143,000 | 9/1/2016 | 84 | $ 8,707,619 | $ 7,401,476 | $ 8,054,548 | 9.9500% |
| 66 | New Redundant SCC | 3840 | | G020 | | $900,000 | 3/1/2017 | 84 | $ - | $ 792,857 | $ 396,429 | 9.9500% |
| 67 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $736,000 | 4/1/2017 | 84 | $ - | $ 657,143 | $ 328,571 | 9.9500% |
| 68 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 69 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 70 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 71 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $482,000 | 4/1/2017 | 84 | $ - | $ 430,357 | $ 215,179 | 9.9500% |
| 72 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 73 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 74 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 75 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $649,000 | 4/1/2017 | 84 | $ - | $ 579,464 | $ 289,732 | 9.9500% |
| 76 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 77 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 78 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 80 | Field PC Refresh | 2935 | $49,570 | 5230 | | $963,188 | 2/1/2016 | 48 | $ 742,457 | $ 501,660 | $ 622,059 | 9.9500% |
| 81 | Field PC Refresh | 2935 | $155,070 | 5220 | | $1,417,990 | 1/1/2016 | 72 | $ 1,181,658 | $ 945,327 | $ 1,063,493 | 9.9500% |
| 82 | Access Violation (& Regulation) Management | 3922 | | G020 | | $290,000 | 4/1/2017 | 84 | $ - | $ 258,929 | $ 129,464 | 9.9500% |
| 83 | Active Directory Upgrade | 4287 | | G020 | | $350,000 | 4/1/2017 | 84 | $ - | $ 312,500 | $ 156,250 | 9.9500% |
| 84 | Advanced Analytics | 3902 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 85 | US CNI Intrusion Detection and Prevention - Phase 1 (Cyber Security) | 3863 | | G020 | | $350,000 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 86 | US CNI Intrusion Detection and Prevention - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 87 | Risk Based Authentication (Cyber Security) | 3863 | | G020 | | $235,080 | 6/1/2017 | 84 | $ - | $ 215,490 | $ 107,745 | 9.9500% |
| 88 | Enhanced Phishing Protection (Cyber Security) | 3863 | | G020 | | $120,000 | 8/1/2017 | 84 | $ - | $ 112,857 | $ 56,429 | 9.9500% |
| 89 | Security Incident Management (SIEM) 4 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 90 | Security Incident Management (SIEM) 5 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 91 | Identity & Access Management - Role Based Access Management (Cyber Security) | 3863 | | G020 | | $1,650,000 | 10/1/2017 | 84 | $ - | $ 1,591,071 | $ 795,536 | 9.9500% |
| 92 | Identity & Access Management - Fine Grain Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 93 | Identity & Access Management - Privileged Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 94 | Identity & Access Management - Shared Area Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 95 | US CNI Security Enhancements - CSP 2 - Phase 1 (Cyber Security) | 3863 | | G020 | | $990,000 | 11/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 96 | US CNI Security Enhancements - CSP 2 - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 11/1/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 97 | Big Data Security Analytics - Phase 1 (Cyber Security) | 3863 | | G020 | | $1,155,388 | 5/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 98 | Big Data Security Analytics - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 99 | Enhanced DLP Gateway and Endpoint (Cyber Security) | 3863 | | G020 | | $1,305,780 | 12/1/2017 | 84 | $ - | $ 1,290,235 | $ 645,118 | 9.9500% |
| 100 | Cloud Security (Cyber Security) | 3863 | | G020 | | $1,460,000 | 5/1/2017 | 84 | $ - | $ 1,320,952 | $ 660,476 | 9.9500% |
| 101 | Situational Intelligence & Cyber Intelligence - Phase 1 (Cyber Security) | 3863 | | G020 | | $100,000 | 11/1/2017 | 84 | $ - | $ 97,619 | $ 48,810 | 9.9500% |
| 102 | Situational Intelligence & Cyber Intelligence - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 11/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 103 | IT/OT Discovery & Implementation - Phase 1 (Cyber Security) | 3863 | | G020 | | $0 | 10/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 104 | IT/OT Discovery & Implementation - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 10/1/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 105 | vStig Scaling - Upgrades (Cyber Security) | 3863 | | G020 | | $0 | 8/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 106 | Domain Based Security - Phase 1 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 107 | Domain Based Security - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 108 | Security Research Lab (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 109 | Threat Behavior Modeling (Cyber Security) | 3863 | | G020 | | $800,000 | 3/1/2017 | 84 | $ - | $ 704,762 | $ 352,381 | 9.9500% |
| 110 | Enterprise Content Management (ECM) - Archiving | 1134 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 111 | Enterprise Content Management (ECM) Foundation Services (US only) - Upgrade | 3995 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 112 | Global Audit System Replacement | 3673 | | G020 | | $0 | 3/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 113 | Global Governance, Risk & Compliance | 2940 | | G020 | | $0 | 6/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 114 | HRIS Strategy Transformation Program | 4144 | | G020 | | $0 | 4/1/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 115 | IS Legacy Systems Archiving & Decommission | 3631 | | G020 | | $0 | 7/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 116 | Mobility - Mobile Application Development Platform (MADP) (US only) | 3996 | | G020 | | $0 | 3/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 117 | Mobility - Mobile Device Management (MDM) System | 3430 | | G020 | | $100,000 | 3/1/2017 | 84 | $ - | $ 88,095 | $ 44,048 | 9.9500% |
| 118 | Office 365 | 3999 | | G020 | | $0 | 10/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 119 | RAS Re-Platform/Mobile | 4269 | | G020 | | $400,000 | 4/1/2017 | 84 | $ - | $ 357,143 | $ 178,571 | 9.9500% |
| 120 | Desktop XP to Win7 | 4308 | | G020 | | $5,960,000 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 121 | Talent Management | 3674 | | G020 | | $0 | 10/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 122 | UPS Replacement for Data Communication Closets | 4003 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 123 | US Global Security TWIC Compliance | 4023 | | G020 | | $270,000 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 124 | US Network Improvements | 4289 | | G020 | | $350,000 | 4/1/2017 | 84 | $ - | $ 312,500 | $ 156,250 | 9.9500% |
| 125 | VC Room/Mobile Refresh | 3424 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 126 | VSTIG Hardware Refresh | 4274 | | G020 | | $300,000 | 4/1/2017 | 84 | $ - | $ 267,857 | $ 133,929 | 9.9500% |
| 127 | VSTIG upgrade Phase 2 | 4280 | | G020 | | $2,600,000 | 4/1/2017 | 84 | $ - | $ 2,321,429 | $ 1,160,714 | 9.9500% |
| 128 | VSTIG upgrade Phase 3 | 4266 | | G020 | | $1,300,000 | 4/1/2017 | 84 | $ - | $ 1,160,714 | $ 580,357 | 9.9500% |
| 129 | Wireless Network Expansion | 3425 | | G020 | | $1,600,000 | 6/1/2017 | 84 | $ - | $ 1,466,667 | $ 733,333 | 9.9500% |
| 130 | Mandated Customer Systems Projects - FY16 | 4094 | | C173 | | $828,000 | 4/1/2016 | 84 | $ 739,286 | $ 621,000 | $ 680,143 | 9.9500% |
| 131 | Mandated Customer Systems Projects - FY17 | 4207 | | C173 | | $4,000,000 | 4/1/2017 | 84 | $ - | $ 3,571,429 | $ 1,785,714 | 9.9500% |
| 132 | Mandated Customer Systems Projects - FY18 | 4207 | | C173 | | $0 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 133 | Mandated Customer Systems Projects - FY19 | 4207 | | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 134 | Mandated Customer Systems Projects - FY20 | 4207 | | C173 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 135 | Customer Contact Center / SDC Technology Upgrade Implement Solution | 3932 | | C173 | | $1,403,000 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 136 | Meter To Cash Value Added Enhancements | 3869 | | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 137 | Meter To Cash Value Added Enhancements | 3869 | | C173 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 138 | Credit & Collections Gap Analysis and Protections | 4211 | | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 139 | Eliminate SSN from Customer Systems | 4216 | | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 140 | Credit and Collections - Bad Debt Mitigation Initiatives | 2959 | | C173 | | $0 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 141 | Distributed Generation Application Tracking | 3941 | | C173 | | $600,000 | 12/1/2016 | 84 | $ 592,857 | $ 507,143 | $ 550,000 | 9.9500% |
| 142 | Customer Interaction Channels | 4139 | | C173 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 143 | Mandated Customer Choice Systems Projects | 4186 | | C173 | | $3,100,000 | 4/1/2017 | 84 | $ - | $ 2,767,857 | $ 1,383,929 | 9.9500% |
| 144 | Operational Requirements and Upgrades for Procurement & Supply Chain (US SAP) | 4169 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 145 | Enhancement Release - EHR-H2R | 4170 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 146 | Enhancement Release - EHR-Non-Utility Billing | 4171 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 147 | Enhancement Release - EHR-Xfunc | 4165 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 148 | PII Project - Security & Controls | 4168 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 149 | US SAP: Business Planning Consolidation - HANA | 4217 | | G020 | | $3,500,000 | 4/1/2017 | 84 | $ - | $ 3,125,000 | $ 1,562,500 | 9.9500% |
| 150 | Blanket Work Order Pilot | 4218 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 151 | PowerPlan Module Enhancements | 4220 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 152 | US SAP: Improve Performance Reporting | 4221 | | G020 | | $0 | 12/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 153 | US Gas Enablement IS Component (US Front Office) | 2575 | | G210 | | $0 | 3/31/2023 | 84 | $ - | $ - | $ - | 9.9500% |
| 154 | US Operations Infrastructure Minor Works Improvement | 3716 | | G173 | | $0 | 3/31/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 155 | New Medical System | 3718 | | G020 | | $800,000 | ####### | 84 | $ - | $ 780,952 | $ 390,476 | 9.9500% |
| 156 | Electric and Gas Service Fulfillment Web Portal | 3946 | | G173 | | $0 | 1/31/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 157 | NY Gas Audit Work Mgmt and Time Reporting | 3953 | | G207 | | $0 | ####### | 84 | $ - | $ - | $ - | 9.9500% |
| 158 | Migrate NYS DMV Inspection Stations to LAN | 3954 | | G207 | | $0 | 3/31/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 159 | Wi-Fi for Fleet Service Diagnostic Laptops | 3956 | | G173 | | $0 | 2/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 160 | ISI Follow Up Work Creation in WMS and Customer System | 3961 | | G210 | | $0 | 9/30/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 161 | Contract Management Modernization | 4151 | | G198 | | $0 | 1/31/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 162 | Ageing System Stabization/Upgrades/Replacements | 4188 | | G020 | | $1,500,000 | 3/31/2017 | 84 | $ - | $ 1,339,286 | $ 669,643 | 9.9500% |
| 163 | Gas Outage Management System (GOMS) | 4237 | | G210 | | $0 | 3/31/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 164 | Operations Performance Management, Data Management, and Reporting | 4247 | | G210 | | $0 | 3/31/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 165 | Gas Services Database | 3948/3949 | | G207 | | $0 | 3/31/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 166 | Document Management System Replacement | 3985 | | G020 | | $4,040,000 | 5/31/2017 | 84 | $ - | $ 3,703,333 | $ 1,851,667 | 9.9500% |
| 167 | Cascade Electric Application Upgrade Project | 3986 | | G198 | | $0 | 3/31/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 168 | EJ Ward Upgrade | 3955 | | G107 | | $350,000 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 169 | Double Pole Management Database upgrade | 4045 | | G198 | | $432,000 | 3/31/2017 | 84 | $ - | $ 385,714 | $ 192,857 | 9.9500% |
| 170 | NY REV Clifton Park Demo Information Systems Readiness | 4298 | | G181 | | $650,000 | 4/1/2017 | 84 | $ - | $ 580,357 | $ 290,179 | 9.9500% |
| 171 | US CNI GMS-SCADA Upgrade and Consolidation | 3737 | | G210 | | $4,540,000 | 10/1/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 172 | US CNI GMS-Downstate NY and LI Upgrade End-Of-Life Verizon Back-up Communication | 3730 | | G225 | | $0 | 4/1/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 173 | US CNI-Infrastructure Reliability and Security Enhancements | 2881 | | G020 | | $0 | 3/31/2022 | 84 | $ - | $ - | $ - | 9.9500% |
| 174 | US CNI Tech Services-Data Center Capacity Expansion | 2909 | | G020 | | $0 | 3/18/2020 | 84 | $ - | $ - | $ - | 9.9500% |
| 175 | US CNI GMS-Operator Workstation Operating System | 3965 | | G210 | | $0 | 3/18/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 176 | US Control-Wires Down for Massachusetts and NY | 4044 | | G186 | | $0 | ####### | 84 | $ - | $ - | $ - | 9.9500% |
| 177 | US Control-NE Electric Control Center Video Wall | 3966 | | G305 | | $0 | 3/18/2018 | 84 | $ - | $ - | $ - | 9.9500% |
| 178 | US MDS - Itron Enterprise Edition (IEE) Consolidation | 3486 | | G173 | | $0 | 4/1/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 179 | US CNI EMS and OMS-Critical Component System Refresh | 4190 | | G198 | | $0 | 3/31/2021 | 84 | $ - | $ - | $ - | 9.9500% |
| 180 | US CNI EMS NY/NE-Transmission Outage Application (TOA) End-of-Life Replacement | 4191 | | G220 | | $0 | 3/31/2019 | 84 | $ - | $ - | $ - | 9.9500% |
| 181 | US Control-Electroinic Bulletin Board Gas Trading Day Changes | 4244 | | G210 | | $2,200,000 | 3/31/2016 | 84 | $ 1,964,286 | $ 1,650,000 | $ 1,807,143 | 9.9500% |
| | Subtotal | | $ 188,734,505 | | $ (946,189) | $ 327,804,227 | | | $ 200,629,413 | $ 202,459,155 | $ 201,544,284 | |

$ 4,482,106 Rate Year IS Projects

| Investment Name | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend | (e) In Service | (f) Amortization Period | (g) 12/31/2016 Balance | (h) 12/31/2017 Balance | (i) = (g+h)/2 Average Balance | (j) 9.9500% Service Co | (k) = (i)*(j) Rate Year Return | (l) = (-ac) RY Return on Accum Taxes | (m) = (k) + (l) Total Return | (n) Rate Year Amortization |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AIMMS Project - Bill Pool 233 | $47,097 | G220 | | $47,097 | 10/1/2010 | 84 | $5,046 | $0 | $2,523 | 9.9500% | $251 | ($101) | $150 | $5,046 |
| Bnk Lease W MA F Optic Proj | $435,545 | G284 | | $435,545 | 9/1/2010 | 84 | $41,480 | $0 | $20,740 | 9.9500% | $2,064 | ($830) | $1,234 | $41,480 |
| Cascade | $1,576,557 | G194 | | $1,576,557 | 12/1/2011 | 84 | $431,676 | $206,454 | $319,065 | 9.9500% | $31,747 | ($12,762) | $18,985 | $225,222 |
| Cascade | $588,773 | G198 | | $588,773 | 10/1/2010 | 84 | $63,083 | $0 | $31,541 | 9.9500% | $3,138 | ($1,262) | $1,877 | $63,083 |
| Cascade | $392,515 | G220 | | $392,515 | 7/1/2010 | 84 | $28,037 | $0 | $14,018 | 9.9500% | $1,395 | ($561) | $834 | $28,037 |
| Cascade | $1,051,038 | G220 | | $1,051,038 | 12/1/2011 | 84 | $287,784 | $137,636 | $212,710 | 9.9500% | $21,165 | ($8,508) | $12,656 | $150,148 |
| CDH Acct Initiation | $516,140 | G012 | | $516,140 | 3/1/2012 | 84 | $159,758 | $86,023 | $122,891 | 9.9500% | $12,228 | ($4,915) | $7,312 | $73,734 |
| CM-NEW02-Simp Order Proc | $7,803 | G198 | | $7,803 | 2/1/2014 | 84 | $4,552 | $3,437 | $3,994 | 9.9500% | $397 | ($160) | $238 | $1,115 |
| CNI Transformation | $114,360 | G012 | | $114,360 | 3/1/2014 | 120 | $81,958 | $70,522 | $76,240 | 9.9500% | $7,586 | ($3,050) | $4,536 | $11,436 |
| Combine Meter Reading Routes | $364,462 | G285 | | $364,462 | 5/1/2011 | 84 | $69,421 | $17,355 | $43,388 | 9.9500% | $4,317 | ($1,735) | $2,582 | $52,066 |
| Contact Centers Call Recording | $361,473 | G012 | | $361,473 | 3/1/2010 | 84 | $8,606 | $0 | $4,303 | 9.9500% | $428 | ($172) | $256 | $8,606 |
| CSS Consolidation | $28,900,771 | C284 | | $28,900,771 | 9/1/2010 | 87 | $3,654,120 | $0 | $1,827,060 | 9.9500% | $181,792 | ($73,081) | $108,712 | $3,654,120 |
| Data Center Rationalization | $793,491 | GT03 | | $793,491 | 3/1/2012 | 84 | $245,604 | $132,248 | $188,926 | 9.9500% | $18,798 | ($7,557) | $11,241 | $113,356 |
| DECUS05-Autom for Mtg Req | $1,914,655 | G198 | | $1,914,655 | 10/1/2011 | 84 | $478,664 | $205,142 | $341,903 | 9.9500% | $34,019 | ($13,676) | $20,344 | $273,522 |
| Desktop (email, AD & SharePoint) | $1,258,446 | GT03 | | $1,258,446 | 3/1/2012 | 84 | $389,519 | $209,741 | $299,630 | 9.9500% | $29,813 | ($11,985) | $17,828 | $179,778 |
| Desktop (refresh) | $950,271 | G012 | | $950,271 | 3/1/2012 | 84 | $294,131 | $158,378 | $226,255 | 9.9500% | $22,512 | ($9,050) | $13,462 | $135,753 |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | ( c) Adjustments | (d) = (a)+( c) Total US Spend | ( e) In Service | (f) Amortization Period | (g) 12/31/2017 Balance | (h) 12/31/2018 Balance |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $66,772,709 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 47,694,792 | $ 38,155,834 |
| 2 | Gas GIS Consolidation | 2577 | $5,573,069 | G210 | | $10,283,069 | 4/1/2019 | 84 | $ - | $ - |
| 3 | AMAG Upgrades | 1172 | $5,991,812 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 4,921,845 | $ 4,065,872 |
| 4 | US CNI DKMS | 3019A | $0 | G098 | | $0 | 3/1/2017 | 84 | $ 0 | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 354,936 | $ 258,135 |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,788,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,426,802 | $ 1,171,255 |
| 7 | CI Services Foundation | 3492 | $2,644,306 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 1,920,270 | $ 1,542,512 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,398,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 4,494,022 | $ 3,579,983 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,576,235 | $ 1,250,117 |
| 10 | Customer Choice ESCO Gas | 3564 | $9,629,193 | C225 | | $9,629,193 | 4/1/2016 | 84 | $ 7,221,895 | $ 5,846,296 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 409,309 | $ 323,139 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 260,587 | $ 205,726 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 1,122,900 | $ 894,514 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $1,240,600 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 1,004,296 | $ 827,067 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $3,801,588 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 3,077,476 | $ 2,534,392 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $1,362,769 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 1,054,524 | $ 859,842 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $1,106,000 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 895,333 | $ 737,333 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $5,946,273 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 4,813,650 | $ 3,964,182 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $1,461,890 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 1,096,417 | $ 887,576 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $121,600 | G020 | | $121,600 | 4/1/2016 | 84 | $ 91,200 | $ 73,829 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $60,800 | G020 | | $60,800 | 9/1/2016 | 84 | $ 49,219 | $ 40,533 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $725,146 | G020 | | $725,146 | 9/1/2016 | 84 | $ 587,023 | $ 483,431 |
| 28 | NY Retail Access | 3839 | $2,872,399 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,427,861 | $ 2,017,519 |
| 29 | US Web Initiatives 2 | 3600B | $3,831,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 2,782,415 | $ 2,235,055 |
| 30 | Capitalized Asset Replacement | 3617C | $935,395 | G084 | | $935,395 | 4/1/2016 | 84 | $ 701,547 | $ 567,919 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $265,077 | G003 | | $265,077 | 4/1/2016 | 84 | $ 198,808 | $ 160,940 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $475,000 | G235 | | $475,000 | 4/1/2016 | 84 | $ 356,250 | $ 288,393 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | $480,000 | G077 | | $480,000 | 4/1/2016 | 84 | $ 360,000 | $ 291,429 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $1,182,427 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ 1,041,662 | $ 872,744 |
| 35 | EHR1 - PMO | | $8,928,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 6,271,242 | $ 4,995,735 |
| 36 | EHR1 - Supply Chain | | $14,769,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 10,373,772 | $ 8,263,853 |
| 37 | EHR1 - Finance | | $16,145,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 11,340,183 | $ 9,033,705 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 1,695,769 | $ 1,350,867 |
| 39 | EHR1 - Payroll | | $12,187,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 8,560,033 | $ 6,819,009 |
| 40 | EHR1 - BPS | | $9,915,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 6,964,288 | $ 5,547,823 |
| 41 | Customer Storm Outage Credit Program | 3859 | $0 | 5210 | | $0 | 3/1/2015 | 84 | $ 0 | $ 0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $5,739,504 | C210 | | $11,369,504 | 1/1/2019 | 84 | $ - | $ - |
| 43 | US Desktop Refresh | 2927 | $7,430,690 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 4,024,957 | $ 2,167,285 |
| 44 | Internet Explorer Upgrade | 3644 | $300,090 | G020 | | $300,090 | 3/1/2016 | 84 | $ 221,495 | $ 178,625 |
| 45 | Mobile Device for PTO | 3883 | $2,442,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 1,628,314 | $ 1,017,696 |
| 46 | SMI Conversion Mobilization | 3896 | $2,187,292 | G020 | | $2,187,292 | 7/1/2016 | 84 | $ 1,718,586 | $ 1,406,116 |
| 47 | S005242 M112 Systemic Improvement | | $3,500,000 | G012 | | $3,500,000 | 3/1/2016 | 12 | $ - | $ - |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 | 3/1/2016 | 12 | $ - | $ - |
| 49 | Soft Off Program | 4024 | $1,278,485 | C207 | | $1,278,485 | 2/1/2016 | 84 | $ 928,423 | $ 745,783 |
| 50 | LI CSS Stabilization | 4133 | $847,000 | 5230 | | $847,000 | 3/1/2016 | 84 | $ 625,167 | $ 504,167 |
| 51 | Mobile Capture of Data Fusion | 4102 | $1,580,000 | G207 | | $1,580,000 | 10/1/2016 | 84 | $ 1,297,857 | $ 1,072,143 |
| 52 | Gas GIS Upgrade | 2577C | $1,200,000 | G210 | | $1,200,000 | 10/1/2016 | 84 | $ 985,714 | $ 814,286 |
| 53 | NY Pipeline Safety CMS Regulatory Compliance | 3882 | $3,374,000 | G207 | | $3,374,000 | 10/1/2016 | 84 | $ 2,771,500 | $ 2,289,500 |
| 54 | Massachusetts Gas 4 Hour Appointment Window | 4074 | $166,254 | C310 | | $166,254 | 3/1/2016 | 84 | $ 122,711 | $ 98,961 |
| 55 | Voice Record Elec Control Rooms | 3851 | $2,300,000 | G186 | | $2,300,000 | 12/1/2016 | 84 | $ 1,944,048 | $ 1,615,476 |
| 56 | Team Center Replacement or Upgrade | 3958 | $600,000 | G236 | | $600,000 | 10/1/2016 | 84 | $ 492,857 | $ 407,143 |
| 57 | US CNI NY EMS-Conversion to MPLS | 3970 | $160,000 | G181 | | $160,000 | 5/1/2016 | 84 | $ 121,905 | $ 99,048 |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend | (e) In Service | (f) Amortization Period | (g) 12/31/2018 Balance | (h) 12/31/2019 Balance |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $66,772,709 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 38,155,834 | $ 28,616,875 |
| 2 | Gas GIS Consolidation | 2577 | $10,283,069 | G210 | | $11,633,069 | 4/1/2019 | 84 | $ - | $ 10,386,668 |
| 3 | AMAG Upgrades | 1172 | $5,991,812 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 4,065,872 | $ 3,209,899 |
| 4 | US CNI DKMS | 3019A | $0 | G098 | | $0 | 3/1/2017 | 84 | $ 0 | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 258,135 | $ 161,335 |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,788,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,171,255 | $ 915,708 |
| 7 | CI Services Foundation | 3492 | $2,644,306 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 1,542,512 | $ 1,164,754 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,398,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 3,579,983 | $ 2,665,945 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,250,117 | $ 924,000 |
| 10 | Customer Choice ESCO Gas | 3564 | $9,629,193 | C225 | | $9,629,193 | 4/1/2016 | 84 | $ 5,846,296 | $ 4,470,697 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 323,139 | $ 236,968 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 205,726 | $ 150,866 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 894,514 | $ 666,127 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $1,240,600 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 827,067 | $ 649,838 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $3,801,588 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 2,534,392 | $ 1,991,308 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $1,362,769 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 859,842 | $ 665,161 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $1,106,000 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 737,333 | $ 579,333 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $5,946,273 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 3,964,182 | $ 3,114,715 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $1,461,890 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 887,576 | $ 678,735 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $121,600 | G020 | | $121,600 | 4/1/2016 | 84 | $ 73,829 | $ 56,457 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $60,800 | G020 | | $60,800 | 9/1/2016 | 84 | $ 40,533 | $ 31,848 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $725,146 | G020 | | $725,146 | 9/1/2016 | 84 | $ 483,431 | $ 379,838 |
| 28 | NY Retail Access | 3839 | $2,872,399 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,017,519 | $ 1,607,176 |
| 29 | US Web Initiatives 2 | 3600B | $3,831,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 2,235,055 | $ 1,687,694 |
| 30 | Capitalized Asset Replacement | 3617C | $935,395 | G084 | | $935,395 | 4/1/2016 | 84 | $ 567,919 | $ 434,291 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $265,077 | G003 | | $265,077 | 4/1/2016 | 84 | $ 160,940 | $ 123,072 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $475,000 | G235 | | $475,000 | 4/1/2016 | 84 | $ 288,393 | $ 220,536 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | $480,000 | G077 | | $480,000 | 4/1/2016 | 84 | $ 291,429 | $ 222,857 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $1,182,427 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ 872,744 | $ 703,826 |
| 35 | EHR1 - PMO | | $8,928,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 4,995,735 | $ 3,720,228 |
| 36 | EHR1 - Supply Chain | | $14,769,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 8,263,853 | $ 6,153,933 |
| 37 | EHR1 - Finance | | $16,145,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 9,033,705 | $ 6,727,227 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 1,350,867 | $ 1,005,965 |
| 39 | EHR1 - Payroll | | $12,187,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 6,819,009 | $ 5,077,986 |
| 40 | EHR1 - BPS | | $9,915,257 | S020 | | $9,915,257 | 12/1/2015 | 84 | $ 5,547,823 | $ 4,131,357 |
| 41 | Customer Storm Outage Credit Program | 3859 | $0 | S210 | | $0 | 3/1/2015 | 84 | $ 0 | $ 0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $11,369,504 | C210 | | $17,079,504 | 1/1/2019 | 84 | $ - | $ 14,639,575 |
| 43 | US Desktop Refresh | 2927 | $7,430,690 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 2,167,285 | $ 309,612 |
| 44 | Internet Explorer Upgrade | 3644 | $300,090 | G020 | | $300,090 | 3/1/2016 | 84 | $ 178,625 | $ 135,755 |
| 45 | Mobile Device for PTO | 3883 | $2,442,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 1,017,696 | $ 407,079 |

$ 6,379,255 Rate Year IS Projects

$ 4,790,558 Existing IS Projects

$ 11,169,813 Total RY 19 IS Projects
$ 10,435,048 RY 18 IS Projects
$ 734,765 Adjustment

KeySpan Gas East Corporation
d/b/a National Grid
The Brooklyn Union Gas Company
d/b/a National Grid NY
Case 16-G-0058 and 16-G-0059
Attachment 2 to DPS-482 JS-10 BULI-627


**Missing Projects Adjustment - Service Company Rents**

**Information Systems Projects (As Reported in DPS-395)**

| | Rate Year 1 | Data Year 1 | Data Year 2 |
|---|---|---|---|
| KEDNY | $ 13,623,116 | $ 13,810,462 | $ 15,842,291 |
| KEDLI | $ 9,053,489 | $ 9,225,013 | $ 10,362,599 |
| **Total** | **$ 22,676,604** | **$ 23,035,474** | **$ 26,204,890** |

**Information Systems Projects (With Missing Projects)**

| | Rate Year 1 | Data Year 1 | Data Year 2 |
|---|---|---|---|
| KEDNY | $ 16,099,834 | $ 16,049,098 | $ 17,268,746 |
| KEDLI | $ 10,415,299 | $ 10,435,048 | $ 11,169,813 |
| **Total** | **$ 26,515,133** | **$ 26,484,146** | **$ 28,438,559** |

**Information Systems Projects (Difference)**

| | Rate Year 1 | Data Year 1 | Data Year 2 |
|---|---|---|---|
| KEDNY | $ 2,476,719 | $ 2,238,636 | $ 1,426,455 |
| KEDLI | $ 1,361,810 | $ 1,210,036 | $ 807,215 |
| **Total** | **$ 3,838,529** | **$ 3,448,672** | **$ 2,233,670** |

KeySpan Gas East Corporation
d/b/a National Grid
The Brooklyn Union Gas Company
d/b/a National Grid NY
Case 16-G-0058 and 16-G-0059
Attachment 2 to DPS-482 JS-10 BULI-627


| | | KEDNY | Rate Year | Data Year 1 | Data Year 2 |
|---|---|---|---|---|---|
| 1TXFER00099 | GAS SCADA Upgrade/Modernize | 38.38% | $ 112,432 | $ - | $ - |
| 1TXFER00099 | GTIS | 68.37% | $ 420,727 | $ 398,256 | $ 162,039 |
| 90000124369 | GTIS | 38.38% | $ 120,888 | $ 115,078 | $ 109,268 |
| 90000124368 | Meter Route Consolidation | 38.38% | $ 27,410 | $ 26,071 | $ 24,732 |
| 90000124375 | GTIS | 58.10% | $ 169,421 | $ 161,146 | $ 152,870 |
| 90000104112 | IN1656-CUST.Systems Agent desktop | 68.37% | $ 1,145,726 | $ 1,085,073 | $ 612,320 |
| 90000106246 | IN2330 ETRM Repl Nucleus-Gas Benef | 30.66% | $ 298,244 | $ 282,593 | $ 203,142 |
| 90000124371 | IN2366 LI CNI Direct HW Upgrade | 68.37% | $ 8,126 | $ 7,737 | $ 7,348 |
| 90000144051 | INVP2960C GridForce SaaS Phase 2 | 30.66% | $ 173,745 | $ 162,683 | $ 154,736 |
| | | | **$ 2,476,719** | **$ 2,238,636** | **$ 1,426,455** |

| | | KEDLI | Rate Year | Data Year 1 | Data Year 2 |
|---|---|---|---|---|---|
| 1TXFER00099 | GAS SCADA Upgrade/Modernize | 28.55% | $ 83,635 | $ - | $ - |
| 1TXFER00099 | GTIS | 31.63% | $ 194,641 | $ 184,245 | $ 74,964 |
| 90000124369 | GTIS | 28.55% | $ 89,926 | $ 85,604 | $ 81,282 |
| 90000124368 | Meter Route Consolidation | 28.55% | $ 20,389 | $ 19,394 | $ 18,398 |
| 90000124375 | GTIS | 30.27% | $ 88,268 | $ 83,957 | $ 79,645 |
| 90000104112 | IN1656-CUST.Systems Agent desktop | 31.63% | $ 530,047 | $ 501,987 | $ 283,278 |
| 90000106246 | IN2330 ETRM Repl Nucleus-Gas Benef | 22.81% | $ 221,883 | $ 210,240 | $ 151,130 |
| 90000124371 | IN2366 LI CNI Direct HW Upgrade | 31.63% | $ 3,759 | $ 3,579 | $ 3,399 |
| 90000144051 | INVP2960C GridForce SaaS Phase 2 | 22.81% | $ 129,261 | $ 121,030 | $ 115,119 |
| | | | **$ 1,361,810** | **$ 1,210,036** | **$ 807,215** |
| | **Total Impact** | | **$ 3,838,529** | **$ 3,448,672** | **$ 2,233,670** |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend | (e) In Service Date | (f) Amortization Period | (g) 12/31/2016 Balance | (h) 12/31/2017 Balance |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $60,613,682 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 57,233,751 | $ 47,694,792 |
| 2 | Gas GIS Consolidation | 2577 | $2,213,069 | G210 | | $5,573,069 | 4/1/2019 | 84 | $ - | $ - |
| 3 | AMAG Upgrades | 1172 | $3,698,542 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 5,777,818 | $ 4,921,845 |
| 4 | US CNI DKMS | 3019A | $249,414 | G098 | (249,414) | $0 | 3/1/2017 | 84 | $ - | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 451,737 | $ 354,936 |
| 6 | NE GAS LEAKS RECHECKS | 3196 | $1,244,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,682,348 | $ 1,426,802 |
| 7 | CI Services Foundation | 3492 | $2,197,232 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 2,298,028 | $ 1,920,270 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,071,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 5,408,060 | $ 4,494,022 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,902,352 | $ 1,576,235 |
| 10 | Customer Choice ESCO Gas | 3564 | $7,774,478 | C225 | (521,285) | $9,629,193 | 4/1/2016 | 84 | $ 8,597,494 | $ 7,221,895 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 495,479 | $ 409,309 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 315,447 | $ 260,587 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 1,351,287 | $ 1,122,900 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $661 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 1,181,524 | $ 1,004,296 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $556,501 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 3,620,560 | $ 3,077,476 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $144,307 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 1,249,205 | $ 1,054,524 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $3,903 | G020 | (3,903) | $0 | 1/1/2099 | 84 | $ - | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $4,206 | G020 | (4,206) | $0 | 1/1/2099 | 84 | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $0 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 1,053,333 | $ 895,333 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $3,000,805 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 5,663,117 | $ 4,813,650 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $2,363 | G020 | (2,363) | $0 | 1/1/2099 | 84 | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $27,818 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 1,305,259 | $ 1,096,417 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $0 | G020 | | $121,600 | 4/1/2016 | 84 | $ 108,571 | $ 91,200 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $0 | G020 | | $60,800 | 9/1/2016 | 84 | $ 57,905 | $ 49,219 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $0 | G020 | | $725,146 | 9/1/2016 | 84 | $ 690,615 | $ 587,023 |
| 28 | NY Retail Access | 3839 | $2,088,663 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,838,204 | $ 2,427,861 |
| 29 | US Web Initiatives 2 | 3600B | $3,402,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 3,329,775 | $ 2,782,415 |
| 30 | Capitalized Asset Replacement | 3617C | $882,109 | G084 | | $935,395 | 4/1/2016 | 84 | $ 835,175 | $ 701,547 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $134,169 | G003 | | $265,077 | 4/1/2016 | 84 | $ 236,676 | $ 198,808 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $475,000 | 4/1/2016 | 84 | $ 424,107 | $ 356,250 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | | G077 | | $480,000 | 4/1/2016 | 84 | $ 428,571 | $ 360,000 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $485,308 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ - | $ 1,041,662 |
| 35 | EHR1 - PMO | | $6,218,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 7,546,749 | $ 6,271,242 |
| 36 | EHR1 - Supply Chain | | $10,339,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 12,483,692 | $ 10,373,772 |
| 37 | EHR1 - Finance | | $15,565,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 13,646,661 | $ 11,340,183 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 2,040,672 | $ 1,695,769 |
| 39 | EHR1 - Payroll | | $10,937,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 10,301,056 | $ 8,560,033 |
| 40 | EHR1 - BPS | | $5,115,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 8,380,753 | $ 6,964,288 |
| 41 | Customer Storm Outage Credit Program | 3859 | $165,018 | 5210 | (165,018) | $0 | 3/1/2015 | 84 | $ 0 | $ 0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $41,564 | C210 | | $5,739,504 | 1/1/2019 | 84 | $ - | $ - |
| 43 | US Desktop Refresh | 2927 | $5,813,532 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 5,882,629 | $ 4,024,957 |
| 44 | Internet Explorer Upgrade | 3644 | $137,061 | G020 | | $300,090 | 3/1/2016 | 84 | $ 264,365 | $ 221,495 |
| 45 | Mobile Device for PTO | 3883 | $242,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 2,238,932 | $ 1,628,314 |
| 46 | SMI Conversion Mobilization | 3896 | $402,655 | G020 | | $2,187,292 | 7/1/2016 | 84 | $ 2,031,057 | $ 1,718,586 |
| 47 | S005242 M112 Systemic Improvement | | $843,635 | G012 | | $3,500,000 | 3/1/2016 | 12 | $ 583,333 | $ - |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 | 3/1/2016 | 12 | $ 24,482 | $ - |
| 49 | Soft Off Program | 4024 | $836,485 | C207 | | $1,278,485 | 2/1/2016 | 84 | $ 1,111,064 | $ 928,423 |
| 50 | LI CSS Stabilization | 4133 | $0 | 5230 | | $847,000 | 3/1/2016 | 84 | $ 746,167 | $ 625,167 |
| 51 | Mobile Capture of Data Fusion | 4102 | $0 | G207 | | $1,580,000 | 10/1/2016 | 84 | $ 1,523,571 | $ 1,297,857 |
| 52 | Gas GIS Upgrade | 2577C | $0 | G210 | | $1,200,000 | 10/1/2016 | 84 | $ 1,157,143 | $ 985,714 |
| 53 | NY Pipeline Safety CMS Regulatory Compliance | 3882 | $0 | G207 | | $3,374,000 | 10/1/2016 | 84 | $ 3,253,500 | $ 2,771,500 |
| 54 | Massachusetts Gas 4 Hour Appointment Window | 4074 | $32,254 | C310 | | $166,254 | 3/1/2016 | 84 | $ 146,462 | $ 122,711 |
| 55 | Voice Record Elec Control Rooms | 3851 | $0 | G186 | | $2,300,000 | 12/1/2016 | 84 | $ 2,272,619 | $ 1,944,048 |
| 56 | Team Center Replacement or Upgrade | 3958 | $0 | G236 | | $600,000 | 10/1/2016 | 84 | $ 578,571 | $ 492,857 |
| 57 | US CNI NY EMS-Conversion to MPLS | 3970 | $0 | G181 | | $160,000 | 5/1/2016 | 84 | $ 144,762 | $ 121,905 |
| 58 | Legacy VSTIG Migration and Decommission | 3538 | | G020 | | $1,501,788 | 9/1/2017 | 84 | $ - | $ 1,430,274 |
| 59 | Remote Net Metering | 4124 | | G194 | | $910,000 | 9/1/2016 | 84 | $ 866,667 | $ 736,667 |
| 60 | RI Renewable Energy Growth | 4055 | $318,786 | 5360E | | $673,000 | 4/1/2016 | 84 | $ 600,893 | $ 504,750 |
| 61 | US Mobile Device Refresh | 2935 | | G173 | | $4,000,000 | 4/1/2017 | 48 | $ - | $ 3,250,000 |
| 62 | US Mobile Device Refresh | 2935 | | G173 | | $0 | 4/1/2018 | 48 | $ - | $ - |
| 63 | US Mobile Device Refresh | 2935 | | G173 | | $0 | 4/1/2019 | 48 | $ - | $ - |
| 64 | KEDNY AMR Project - FDM Interface to CRIS | 4183 | | 5220 | | $356,000 | 9/1/2016 | 84 | $ 339,048 | $ 288,190 |
| 65 | Cross Company Customer System Enhancements | 4172 | | C246 | | $9,143,000 | 9/1/2016 | 84 | $ 8,707,619 | $ 7,401,476 |
| 66 | New Redundant SCC | 3840 | | G020 | | $900,000 | 3/1/2017 | 84 | $ - | $ 792,857 |
| 67 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $736,000 | 4/1/2017 | 84 | $ - | $ 657,143 |
| 68 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 69 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 70 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 71 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $482,000 | 4/1/2017 | 84 | $ - | $ 430,357 |
| 72 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 73 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 74 | UNY Capitalized Asset Replacement - Physical Security | 3617D | | G003 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 75 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $649,000 | 4/1/2017 | 84 | $ - | $ 579,464 |
| 76 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 77 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 78 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 80 | Field PC Refresh | 2935 | $49,570 | 5230 | | $963,188 | 2/1/2016 | 48 | $ 742,457 | $ 501,660 |
| 81 | Field PC Refresh | 2935 | $155,070 | 5220 | | $1,417,990 | 1/1/2016 | 72 | $ 1,181,658 | $ 945,327 |
| 82 | Access Violation (& Regulation) Management | 3922 | | G020 | | $290,000 | 4/1/2017 | 84 | $ - | $ 258,929 |
| 83 | Active Directory Upgrade | 4287 | | G020 | | $350,000 | 4/1/2017 | 84 | $ - | $ 312,500 |
| 84 | Advanced Analytics | 3902 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 85 | US CNI Intrusion Detection and Prevention - Phase 1 (Cyber Security) | 3863 | | G020 | | $350,000 | 4/1/2018 | 84 | $ - | $ - |
| 86 | US CNI Intrusion Detection and Prevention - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 87 | Risk Based Authentication (Cyber Security) | 3863 | | G020 | | $235,080 | 6/1/2017 | 84 | $ - | $ 215,490 |
| 88 | Enhanced Phishing Protection (Cyber Security) | 3863 | | G020 | | $120,000 | 8/1/2017 | 84 | $ - | $ 112,857 |
| 89 | Security Incident Management (SIEM) 4 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2019 | 84 | $ - | $ - |
| 90 | Security Incident Management (SIEM) 5 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2020 | 84 | $ - | $ - |
| 91 | Identity & Access Management - Role Based Access Management (Cyber Security) | 3863 | | G020 | | $1,650,000 | 10/1/2017 | 84 | $ - | $ 1,591,071 |
| 92 | Identity & Access Management - Fine Grain Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 93 | Identity & Access Management - Privileged Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 94 | Identity & Access Management - Shared Area Access Management (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 95 | US CNI Security Enhancements - CSP 2 - Phase 1 (Cyber Security) | 3863 | | G020 | | $990,000 | 11/1/2018 | 84 | $ - | $ - |
| 96 | US CNI Security Enhancements - CSP 2 - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 11/1/2021 | 84 | $ - | $ - |
| 97 | Big Data Security Analytics - Phase 1 (Cyber Security) | 3863 | | G020 | | $1,155,388 | 5/1/2019 | 84 | $ - | $ - |
| 98 | Big Data Security Analytics - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 5/1/2021 | 84 | $ - | $ - |
| 99 | Enhanced DLP Gateway and Endpoint (Cyber Security) | 3863 | | G020 | | $1,305,780 | 12/1/2017 | 84 | $ - | $ 1,290,235 |
| 100 | Cloud Security (Cyber Security) | 3863 | | G020 | | $1,460,000 | 5/1/2017 | 84 | $ - | $ 1,320,952 |
| 101 | Situational Intelligence & Cyber Intelligence - Phase 1 (Cyber Security) | 3863 | | G020 | | $100,000 | 11/1/2017 | 84 | $ - | $ 97,619 |
| 102 | Situational Intelligence & Cyber Intelligence - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 11/1/2019 | 84 | $ - | $ - |
| 103 | IT/OT Discovery & Implementation - Phase 1 (Cyber Security) | 3863 | | G020 | | $0 | 10/1/2019 | 84 | $ - | $ - |
| 104 | IT/OT Discovery & Implementation - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 10/1/2021 | 84 | $ - | $ - |
| 105 | vStig Scaling - Upgrades (Cyber Security) | 3863 | | G020 | | $0 | 8/1/2018 | 84 | $ - | $ - |
| 106 | Domain Based Security - Phase 1 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 107 | Domain Based Security - Phase 2 (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 108 | Security Research Lab (Cyber Security) | 3863 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 109 | Threat Behavior Modeling (Cyber Security) | 3863 | | G020 | | $800,000 | 3/1/2017 | 84 | $ - | $ 704,762 |
| 110 | Enterprise Content Management (ECM) - Archiving | 1134 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 111 | Enterprise Content Management (ECM) Foundation Services (US only) - Upgrade | 3995 | | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 112 | Global Audit System Replacement | 3673 | | G020 | | $0 | 3/1/2020 | 84 | $ - | $ - |
| 113 | Global Governance, Risk & Compliance | 2940 | | G020 | | $0 | 6/1/2019 | 84 | $ - | $ - |
| 114 | HRIS Strategy Transformation Program | 4144 | | G020 | | $0 | 4/1/2021 | 84 | $ - | $ - |
| 115 | IS Legacy Systems Archiving & Decommission | 3631 | | G020 | | $0 | 7/1/2020 | 84 | $ - | $ - |
| 116 | Mobility - Mobile Application Development Platform (MADP) (US only) | 3996 | | G020 | | $0 | 3/1/2019 | 84 | $ - | $ - |
| 117 | Mobility - Mobile Device Management (MDM) System | 3430 | | G020 | | $100,000 | 3/1/2017 | 84 | $ - | $ 88,095 |
| 118 | Office 365 | 3999 | | G020 | | $0 | 10/1/2019 | 84 | $ - | $ - |
| 119 | RAS Re-Platform/Mobile | 4269 | | G020 | | $400,000 | 4/1/2017 | 84 | $ - | $ 357,143 |
| 120 | Desktop XP to Win7 | 4308 | | G020 | | $5,960,000 | 4/1/2018 | 84 | $ - | $ - |
| 121 | Talent Management | 3674 | | G020 | | $0 | 10/1/2020 | 84 | $ - | $ - |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | ( c) Adjustments | (d) = (a)+( c) Total US Spend | ( e) In Service Date | (f) Amortization Period | (g) 12/31/2017 Balance | (h) 12/31/2018 Balance |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $66,772,709 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 47,694,792 | $ 38,155,834 |
| 2 | Gas GIS Consolidation | 2577 | $5,573,069 | G210 | | $10,283,069 | 4/1/2019 | 84 | $ - | $ - |
| 3 | AMAG Upgrades | 1172 | $5,991,812 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 4,921,845 | $ 4,065,872 |
| 4 | US CNI DKMS | 3019A | $0 | G098 | | $0 | 3/1/2017 | 84 | $ 0 | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 354,936 | $ 258,135 |
| 6 | NE GAS LEAKS RECHECKS | 3196 | $1,788,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,426,802 | $ 1,171,255 |
| 7 | CI Services Foundation | 3492 | $2,644,306 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 1,920,270 | $ 1,542,512 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,398,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 4,494,022 | $ 3,579,983 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,576,235 | $ 1,250,117 |
| 10 | Customer Choice ESCO Gas | 3564 | $9,629,193 | C225 | | $9,629,193 | 4/1/2016 | 84 | $ 7,221,895 | $ 5,846,296 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 409,309 | $ 323,139 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 260,587 | $ 205,726 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 1,122,900 | $ 894,514 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $1,240,600 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 1,004,296 | $ 827,067 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $3,801,588 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 3,077,476 | $ 2,534,392 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $1,362,769 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 1,054,524 | $ 859,842 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $1,106,000 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 895,333 | $ 737,333 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $5,946,273 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 4,813,650 | $ 3,964,182 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $1,461,890 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 1,096,417 | $ 887,576 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $121,600 | G020 | | $121,600 | 4/1/2016 | 84 | $ 91,200 | $ 73,829 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $60,800 | G020 | | $60,800 | 9/1/2016 | 84 | $ 49,219 | $ 40,533 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $725,146 | G020 | | $725,146 | 9/1/2016 | 84 | $ 587,023 | $ 483,431 |
| 28 | NY Retail Access | 3839 | $2,872,399 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,427,861 | $ 2,017,519 |
| 29 | US Web Initiatives 2 | 3600B | $3,831,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 2,782,415 | $ 2,235,055 |
| 30 | Capitalized Asset Replacement | 3617C | $935,395 | G084 | | $935,395 | 4/1/2016 | 84 | $ 701,547 | $ 567,919 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $265,077 | G003 | | $265,077 | 4/1/2016 | 84 | $ 198,808 | $ 160,940 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $475,000 | G235 | | $475,000 | 4/1/2016 | 84 | $ 356,250 | $ 288,393 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | $480,000 | G077 | | $480,000 | 4/1/2016 | 84 | $ 360,000 | $ 291,429 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $1,182,427 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ 1,041,662 | $ 872,744 |
| 35 | EHR1 - PMO | | $8,928,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 6,271,242 | $ 4,995,735 |
| 36 | EHR1 - Supply Chain | | $14,769,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 10,373,772 | $ 8,263,853 |
| 37 | EHR1 - Finance | | $16,145,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 11,340,183 | $ 9,033,705 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 1,695,769 | $ 1,350,867 |
| 39 | EHR1 - Payroll | | $12,187,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 8,560,033 | $ 6,819,009 |
| 40 | EHR1 - BPS | | $9,915,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 6,964,288 | $ 5,547,823 |
| 41 | Customer Storm Outage Credit Program | 3859 | $0 | 5210 | | $0 | 3/1/2015 | 84 | $ 0 | $ 0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $5,739,504 | C210 | | $11,369,504 | 1/1/2019 | 84 | $ - | $ - |
| 43 | US Desktop Refresh | 2927 | $7,430,690 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 4,024,957 | $ 2,167,285 |
| 44 | Internet Explorer Upgrade | 3644 | $300,090 | G020 | | $300,090 | 3/1/2016 | 84 | $ 221,495 | $ 178,625 |
| 45 | Mobile Device for PTO | 3883 | $2,442,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 1,628,314 | $ 1,017,696 |

$ 8,151,422 Rate Year IS Projects

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend | (e) In Service Date | (f) Amortization Period | (g) 12/31/2018 Balance | (h) 12/31/2019 Balance |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $66,772,709 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 38,155,834 | $ 28,616,875 |
| 2 | Gas GIS Consolidation | 2577 | $10,283,069 | G210 | | $11,633,069 | 4/1/2019 | 84 | $ - | $ 10,386,668 |
| 3 | AMAG Upgrades | 1172 | $5,991,812 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 4,065,872 | $ 3,209,899 |
| 4 | US CNI DKMS | 3019A | $0 | G098 | | $0 | 3/1/2017 | 84 | $ 0 | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 258,135 | $ 161,335 |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,788,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,171,255 | $ 915,708 |
| 7 | CI Services Foundation | 3492 | $2,644,306 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 1,542,512 | $ 1,164,754 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,398,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 3,579,983 | $ 2,665,945 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,250,117 | $ 924,000 |
| 10 | Customer Choice ESCO Gas | 3564 | $9,629,193 | C225 | | $9,629,193 | 4/1/2016 | 84 | $ 5,846,296 | $ 4,470,697 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 323,139 | $ 236,968 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 205,726 | $ 150,866 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 894,514 | $ 666,127 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $1,240,600 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 827,067 | $ 649,838 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $3,801,588 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 2,534,392 | $ 1,991,308 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $1,362,769 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 859,842 | $ 665,161 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $1,106,000 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 737,333 | $ 579,333 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $5,946,273 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 3,964,182 | $ 3,114,715 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $1,461,890 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 887,576 | $ 678,735 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $121,600 | G020 | | $121,600 | 4/1/2016 | 84 | $ 73,829 | $ 56,457 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $60,800 | G020 | | $60,800 | 9/1/2016 | 84 | $ 40,533 | $ 31,848 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $725,146 | G020 | | $725,146 | 9/1/2016 | 84 | $ 483,431 | $ 379,838 |
| 28 | NY Retail Access | 3839 | $2,872,399 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,017,519 | $ 1,607,176 |
| 29 | US Web Initiatives 2 | 3600B | $3,831,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 2,235,055 | $ 1,687,694 |
| 30 | Capitalized Asset Replacement | 3617C | $935,395 | G084 | | $935,395 | 4/1/2016 | 84 | $ 567,919 | $ 434,291 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $265,077 | G003 | | $265,077 | 4/1/2016 | 84 | $ 160,940 | $ 123,072 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $475,000 | G235 | | $475,000 | 4/1/2016 | 84 | $ 288,393 | $ 220,536 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | $480,000 | G077 | | $480,000 | 4/1/2016 | 84 | $ 291,429 | $ 222,857 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $1,182,427 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ 872,744 | $ 703,826 |
| 35 | EHR1 - PMO | | $8,928,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 4,995,735 | $ 3,720,228 |

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend | (e) In Service | (f) Amortization Period | (g) 12/31/2016 12/31/2016 Balance | (h) 12/31/2017 12/31/2017 Balance |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $60,613,682 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 57,233,751 | $ 47,694,792 |
| 2 | Gas GIS Consolidation | 2577 | $2,213,069 | G210 | | $5,573,069 | 4/1/2019 | 84 | $ - | $ - |
| 3 | AMAG Upgrades | 1172 | $3,698,542 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 5,777,818 | $ 4,921,845 |
| 4 | US CNI DKMS | 3019A | $249,414 | G098 | -$249,414 | $0 | 3/1/2017 | 84 | $ - | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 451,737 | $ 354,936 |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,244,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,682,348 | $ 1,426,802 |
| 7 | CI Services Foundation | 3492 | $2,197,232 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 2,298,028 | $ 1,920,270 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,071,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 5,408,060 | $ 4,494,022 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,902,352 | $ 1,576,235 |
| 10 | Customer Choice ESCO Gas | 3564 | $7,774,478 | C225 | -$521,285 | $9,629,193 | 4/1/2016 | 84 | $ 8,597,494 | $ 7,221,895 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 495,479 | $ 409,309 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 315,447 | $ 260,587 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 1,351,287 | $ 1,122,900 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $661 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 1,181,524 | $ 1,004,296 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $556,501 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 3,620,560 | $ 3,077,476 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $144,307 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 1,249,205 | $ 1,054,524 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $3,903 | G020 | -$3,903 | $0 | 1/1/2099 | 84 | $ - | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $4,206 | G020 | -$4,206 | $0 | 1/1/2099 | 84 | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $0 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 1,053,333 | $ 895,333 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $3,000,805 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 5,663,117 | $ 4,813,650 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $2,363 | G020 | -$2,363 | $0 | 1/1/2099 | 84 | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $27,818 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 1,305,259 | $ 1,096,417 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $0 | G020 | | $121,600 | 4/1/2016 | 84 | $ 108,571 | $ 91,200 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $0 | G020 | | $60,800 | 9/1/2016 | 84 | $ 57,905 | $ 49,219 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $0 | G020 | | $725,146 | 9/1/2016 | 84 | $ 690,615 | $ 587,023 |
| 28 | NY Retail Access | 3839 | $2,088,663 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,838,204 | $ 2,427,861 |
| 29 | US Web Initiatives 2 | 3600B | $3,402,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 3,329,775 | $ 2,782,415 |
| 30 | Capitalized Asset Replacement | 3617C | $882,109 | G084 | | $935,395 | 4/1/2016 | 84 | $ 835,175 | $ 701,547 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $134,169 | G003 | | $265,077 | 4/1/2016 | 84 | $ 236,676 | $ 198,808 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | | G235 | | $475,000 | 4/1/2016 | 84 | $ 424,107 | $ 356,250 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | | G077 | | $480,000 | 4/1/2016 | 84 | $ 428,571 | $ 360,000 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $485,308 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ - | $ 1,041,662 |
| 35 | EHR1 - PMO | | $6,218,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 7,546,749 | $ 6,271,242 |
| 36 | EHR1 - Supply Chain | | $10,339,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 12,483,692 | $ 10,373,772 |
| 37 | EHR1 - Finance | | $15,565,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 13,646,661 | $ 11,340,183 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 2,040,672 | $ 1,695,769 |
| 39 | EHR1 - Payroll | | $10,937,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 10,301,056 | $ 8,560,033 |
| 40 | EHR1 - BPS | | $5,115,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 8,380,753 | $ 6,964,288 |
| 41 | Customer Storm Outage Credit Program | 3859 | $165,018 | 5210 | -$165,018 | $0 | 3/1/2015 | 84 | $ 0 | $ 0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $41,564 | C210 | | $5,739,504 | 1/1/2019 | 84 | $ - | $ - |
| 43 | US Desktop Refresh | 2927 | $5,813,532 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 5,882,629 | $ 4,024,957 |
| 44 | Internet Explorer Upgrade | 3644 | $137,061 | G020 | | $300,090 | 3/1/2016 | 84 | $ 264,365 | $ 221,495 |
| 45 | Mobile Device for PTO | 3883 | $242,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 2,238,932 | $ 1,628,314 |
| 46 | SMI Conversion Mobilization | 3896 | $402,655 | G020 | | $2,187,292 | 7/1/2016 | 84 | $ 2,031,057 | $ 1,718,586 |
| 47 | S005242 M112 Systemic Improvement | | $843,635 | G012 | | $3,500,000 | 3/1/2016 | 12 | $ 583,333 | $ - |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 | 3/1/2016 | 12 | $ 24,482 | $ - |
| 49 | Soft Off Program | 4024 | $836,485 | C207 | | $1,278,485 | 2/1/2016 | 84 | $ 1,111,064 | $ 928,423 |
| 50 | LI CSS Stabilization | 4133 | $0 | 5230 | | $847,000 | 3/1/2016 | 84 | $ 746,167 | $ 625,167 |
| 51 | Mobile Capture of Data Fusion | 4102 | $0 | C207 | | $1,580,000 | 10/1/2016 | 84 | $ 1,523,571 | $ 1,297,857 |
| 52 | Gas GIS Upgrade | 2577C | $0 | G210 | | $1,200,000 | 10/1/2016 | 84 | $ 1,157,143 | $ 985,714 |
| 53 | NY Pipeline Safety CMS Regulatory Compliance | 3882 | $0 | C207 | | $3,374,000 | 10/1/2016 | 84 | $ 3,253,500 | $ 2,771,500 |
| 54 | Massachusetts Gas 4 Hour Appointment Window | 4074 | $32,254 | C310 | | $166,254 | 3/1/2016 | 84 | $ 146,462 | $ 122,711 |
| 55 | Voice Record Elec Control Rooms | 3851 | $0 | G186 | | $2,300,000 | 12/1/2016 | 84 | $ 2,272,619 | $ 1,944,048 |
| 56 | Team Center Replacement or Upgrade | 3958 | $0 | G236 | | $600,000 | 10/1/2016 | 84 | $ 578,571 | $ 492,857 |
| 57 | US CNI NY EMS-Conversion to MPLS | 3970 | $0 | G181 | | $160,000 | 5/1/2016 | 84 | $ 144,762 | $ 121,905 |
| 58 | Legacy VSTIG Migration and Decommission | 3538 | | G020 | | $1,501,788 | 9/1/2017 | 84 | $ - | $ 1,430,274 |
| 59 | Remote Net Metering | 4124 | | G194 | | $910,000 | 9/1/2016 | 84 | $ 866,667 | $ 736,667 |
| 60 | RI Renewable Energy Growth | 4055 | $318,786 | 5360E | | $673,000 | 4/1/2016 | 84 | $ 600,893 | $ 504,750 |
| 61 | US Mobile Device Refresh | 2935 | | G173 | | $4,000,000 | 4/1/2017 | 48 | $ - | $ 3,250,000 |
| 62 | US Mobile Device Refresh | 2935 | | G173 | | $0 | 4/1/2018 | 48 | $ - | $ - |
| 63 | US Mobile Device Refresh | 2935 | | G173 | | $0 | 4/1/2019 | 48 | $ - | $ - |
| 64 | KEDNY AMR Project - FDM Interface to CRIS | 4183 | | 5220 | | $356,000 | 9/1/2016 | 84 | $ 339,048 | $ 288,190 |
| 65 | Cross Company Customer System Enhancements | 4172 | | C246 | | $9,143,000 | 9/1/2016 | 84 | $ 8,707,619 | $ 7,401,476 |
| 66 | New Redundant SCC | 3840 | | G020 | | $900,000 | 3/1/2017 | 84 | $ - | $ 792,857 |
| 67 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $736,000 | 4/1/2017 | 84 | $ - | $ 657,143 |
| 68 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2018 | 84 | $ - | $ - |
| 69 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 70 | Capitalized Asset Replacement - Physical Security | 3617C | | G084 | | $0 | 4/1/2020 | 84 | $ - | $ - |

**$ 4,482,106 Rate Year IS Projects**

**$ 5,933,193 Existing IS Projects**

**$ 10,415,299 Total RY 17 IS Projects**
**$ 6,317,433 Test Year IS Projects**
**$ 4,097,866 Adjustment**

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend | (e) In Service | (f) Amortization Period | (g) 12/31/2017 Balance | (h) 12/31/2018 Balance |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $66,772,709 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 47,694,792 | $ 38,155,834 |
| 2 | Gas GIS Consolidation | 2577 | $5,573,069 | G210 | | $10,283,069 | 4/1/2019 | 84 | $ - | $ - |
| 3 | AMAG Upgrades | 1172 | $5,991,812 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 4,921,845 | $ 4,065,872 |
| 4 | US CNI DKMS | 3019A | $0 | G098 | | $0 | 3/1/2017 | 84 | $ 0 | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 354,936 | $ 258,135 |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,788,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,426,802 | $ 1,171,255 |
| 7 | CI Services Foundation | 3492 | $2,644,306 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 1,920,270 | $ 1,542,512 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,398,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 4,494,022 | $ 3,579,983 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,576,235 | $ 1,250,117 |
| 10 | Customer Choice ESCO Gas | 3564 | $9,629,193 | C225 | | $9,629,193 | 4/1/2016 | 84 | $ 7,221,895 | $ 5,846,296 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 409,309 | $ 323,139 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 260,587 | $ 205,726 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 1,122,900 | $ 894,514 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $1,240,600 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 1,004,296 | $ 827,067 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $3,801,588 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 3,077,476 | $ 2,534,392 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $1,362,769 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 1,054,524 | $ 859,842 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $1,106,000 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 895,333 | $ 737,333 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $5,946,273 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 4,813,650 | $ 3,964,182 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $1,461,890 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 1,096,417 | $ 887,576 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $121,600 | G020 | | $121,600 | 4/1/2016 | 84 | $ 91,200 | $ 73,829 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $60,800 | G020 | | $60,800 | 9/1/2016 | 84 | $ 49,219 | $ 40,533 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $725,146 | G020 | | $725,146 | 9/1/2016 | 84 | $ 587,023 | $ 483,431 |
| 28 | NY Retail Access | 3839 | $2,872,399 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,427,861 | $ 2,017,519 |
| 29 | US Web Initiatives 2 | 3600B | $3,831,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 2,782,415 | $ 2,235,055 |
| 30 | Capitalized Asset Replacement | 3617C | $935,395 | G084 | | $935,395 | 4/1/2016 | 84 | $ 701,547 | $ 567,919 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $265,077 | G003 | | $265,077 | 4/1/2016 | 84 | $ 198,808 | $ 160,940 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $475,000 | G235 | | $475,000 | 4/1/2016 | 84 | $ 356,250 | $ 288,393 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | $480,000 | G077 | | $480,000 | 4/1/2016 | 84 | $ 360,000 | $ 291,429 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $1,182,427 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ 1,041,662 | $ 872,744 |
| 35 | EHR1 - PMO | | $8,928,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 6,271,242 | $ 4,995,735 |
| 36 | EHR1 - Supply Chain | | $14,769,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 10,373,772 | $ 8,263,853 |
| 37 | EHR1 - Finance | | $16,145,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 11,340,183 | $ 9,033,705 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 1,695,769 | $ 1,350,867 |
| 39 | EHR1 - Payroll | | $12,187,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 8,560,033 | $ 6,819,009 |
| 40 | EHR1 - BPS | | $9,915,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 6,964,288 | $ 5,547,823 |
| 41 | Customer Storm Outage Credit Program | 3859 | $0 | 5210 | | $0 | 3/1/2015 | 84 | $ 0 | $ 0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $5,739,504 | C210 | | $11,369,504 | 1/1/2019 | 84 | $ - | $ - |
| 43 | US Desktop Refresh | 2927 | $7,430,690 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 4,024,957 | $ 2,167,285 |
| 44 | Internet Explorer Upgrade | 3644 | $300,090 | G020 | | $300,090 | 3/1/2016 | 84 | $ 221,495 | $ 178,625 |
| 45 | Mobile Device for PTO | 3883 | $2,442,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 1,628,314 | $ 1,017,696 |
| 46 | SMI Conversion Mobilization | 3896 | $2,187,292 | G020 | | $2,187,292 | 7/1/2016 | 84 | $ 1,718,586 | $ 1,406,116 |
| 47 | S005242 M112 Systemic Improvement | | $3,500,000 | G012 | | $3,500,000 | 3/1/2016 | 12 | $ - | $ - |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 | 3/1/2016 | 12 | $ - | $ - |
| 49 | Soft Off Program | 4024 | $1,278,485 | C207 | | $1,278,485 | 2/1/2016 | 84 | $ 928,423 | $ 745,783 |
| 50 | LI CSS Stabilization | 4133 | $847,000 | 5230 | | $847,000 | 3/1/2016 | 84 | $ 625,167 | $ 504,167 |
| 51 | Mobile Capture of Data Fusion | 4102 | $1,580,000 | G207 | | $1,580,000 | 10/1/2016 | 84 | $ 1,297,857 | $ 1,072,143 |
| 52 | Gas GIS Upgrade | 2577C | $1,200,000 | G210 | | $1,200,000 | 10/1/2016 | 84 | $ 985,714 | $ 814,286 |
| 53 | NY Pipeline Safety CMS Regulatory Compliance | 3882 | $3,374,000 | G207 | | $3,374,000 | 10/1/2016 | 84 | $ 2,771,500 | $ 2,289,500 |
| 54 | Massachusetts Gas 4 Hour Appointment Window | 4074 | $166,254 | C310 | | $166,254 | 3/1/2016 | 84 | $ 122,711 | $ 98,961 |
| 55 | Voice Record Elec Control Rooms | 3851 | $2,300,000 | G186 | | $2,300,000 | 12/1/2016 | 84 | $ 1,944,048 | $ 1,615,476 |
| 56 | Team Center Replacement or Upgrade | 3958 | $600,000 | G236 | | $600,000 | 10/1/2016 | 84 | $ 492,857 | $ 407,143 |
| 57 | US CNI NY EMS-Conversion to MPLS | 3970 | $160,000 | G181 | | $160,000 | 5/1/2016 | 84 | $ 121,905 | $ 99,048 |
| 58 | Legacy VSTIG Migration and Decommission | 3538 | $1,501,788 | G020 | | $1,551,788 | 9/1/2017 | 84 | $ 1,477,893 | $ 1,256,209 |
| 59 | Remote Net Metering | 4124 | $910,000 | G194 | | $910,000 | 9/1/2016 | 84 | $ 736,667 | $ 606,667 |
| 60 | RI Renewable Energy Growth | 4055 | $673,000 | 5360E | | $673,000 | 4/1/2016 | 84 | $ 504,750 | $ 408,607 |
| 61 | US Mobile Device Refresh | 2935 | $4,000,000 | G173 | | $4,000,000 | 4/1/2017 | 48 | $ 3,250,000 | $ 2,250,000 |
| 62 | US Mobile Device Refresh | 2935 | $0 | G173 | | $2,000,000 | 4/1/2018 | 48 | $ - | $ 1,625,000 |
| 63 | US Mobile Device Refresh | 2935 | $0 | G173 | | $0 | 4/1/2019 | 48 | $ - | $ - |
| 64 | KEDNY AMR Project - FDM Interface to CRIS | 4183 | $356,000 | 5220 | | $356,000 | 9/1/2016 | 84 | $ 288,190 | $ 237,333 |
| 65 | Cross Company Customer System Enhancements | 4172 | $9,143,000 | C246 | | $9,143,000 | 9/1/2016 | 84 | $ 7,401,476 | $ 6,095,333 |
| 66 | New Redundant SCC | 3840 | $900,000 | G020 | | $900,000 | 3/1/2017 | 84 | $ 792,857 | $ 664,286 |
| 67 | Capitalized Asset Replacement - Physical Security | 3617C | $736,000 | G084 | | $736,000 | 4/1/2017 | 84 | $ 657,143 | $ 552,000 |
| 68 | Capitalized Asset Replacement - Physical Security | 3617C | $0 | G084 | | $797,000 | 4/1/2018 | 84 | $ - | $ 711,607 |
| 69 | Capitalized Asset Replacement - Physical Security | 3617C | $0 | G084 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 70 | Capitalized Asset Replacement - Physical Security | 3617C | $0 | G084 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 71 | UNY Capitalized Asset Replacement - Physical Security | 3617D | $482,000 | G003 | | $482,000 | 4/1/2017 | 84 | $ 430,357 | $ 361,500 |
| 72 | UNY Capitalized Asset Replacement - Physical Security | 3617D | $0 | G003 | | $621,000 | 4/1/2018 | 84 | $ - | $ 554,464 |
| 73 | UNY Capitalized Asset Replacement - Physical Security | 3617D | $0 | G003 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 74 | UNY Capitalized Asset Replacement - Physical Security | 3617D | $0 | G003 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 75 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $649,000 | G235 | | $649,000 | 4/1/2017 | 84 | $ 579,464 | $ 486,750 |
| 76 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $0 | G235 | | $701,000 | 4/1/2018 | 84 | $ - | $ 625,893 |
| 77 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $0 | G235 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 78 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $0 | G235 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 80 | Field PC Refresh | 2935 | $963,188 | 5230 | | $963,188 | 2/1/2016 | 48 | $ 501,660 | $ 260,863 |
| 81 | Field PC Refresh | 2935 | $1,417,990 | 5220 | | $1,417,990 | 1/1/2016 | 72 | $ 945,327 | $ 708,995 |
| 82 | Access Violation (& Regulation) Management | 3922 | $290,000 | G020 | | $290,000 | 4/1/2017 | 84 | $ 258,929 | $ 217,500 |
| 83 | Active Directory Upgrade | 4287 | $350,000 | G020 | | $350,000 | 4/1/2017 | 84 | $ 312,500 | $ 262,500 |
| 84 | Advanced Analytics | 3902 | $0 | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 85 | US CNI Intrusion Detection and Prevention - Phase 1 (Cyber Security) | 3863 | $350,000 | G020 | | $550,000 | 4/1/2018 | 84 | $ - | $ 491,071 |
| 86 | US CNI Intrusion Detection and Prevention - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 87 | Risk Based Authentication (Cyber Security) | 3863 | $235,080 | G020 | | $235,080 | 6/1/2017 | 84 | $ 215,490 | $ 181,907 |
| 88 | Enhanced Phishing Protection (Cyber Security) | 3863 | $120,000 | G020 | | $120,000 | 8/1/2017 | 84 | $ 112,857 | $ 95,714 |
| 89 | Security Incident Management (SIEM) 4 (Cyber Security) | 3863 | $0 | G020 | | $633,150 | 5/1/2019 | 84 | $ - | $ - |
| 90 | Security Incident Management (SIEM) 5 (Cyber Security) | 3863 | $0 | G020 | | $0 | 5/1/2020 | 84 | $ - | $ - |
| 91 | Identity & Access Management - Role Based Access Management (Cyber Security) | 3863 | $1,650,000 | G020 | | $1,650,000 | 10/1/2017 | 84 | $ 1,591,071 | $ 1,355,357 |
| 92 | Identity & Access Management - Fine Grain Access Management (Cyber Security) | 3863 | $0 | G020 | | $1,650,000 | 4/1/2018 | 84 | $ - | $ 1,473,214 |
| 93 | Identity & Access Management - Privileged Access Management (Cyber Security) | 3863 | $0 | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 94 | Identity & Access Management - Shared Area Access Management (Cyber Security) | 3863 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 95 | US CNI Security Enhancements - CSP 2 - Phase 1 (Cyber Security) | 3863 | $990,000 | G020 | | $2,640,000 | 11/1/2018 | 84 | $ - | $ 2,577,143 |
| 96 | US CNI Security Enhancements - CSP 2 - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 | 11/1/2021 | 84 | $ - | $ - |
| 97 | Big Data Security Analytics - Phase 1 (Cyber Security) | 3863 | $1,155,388 | G020 | | $3,466,164 | 5/1/2019 | 84 | $ - | $ - |
| 98 | Big Data Security Analytics - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 | 5/1/2021 | 84 | $ - | $ - |
| 99 | Enhanced DLP Gateway and Endpoint (Cyber Security) | 3863 | $1,305,780 | G020 | | $2,238,480 | 12/1/2017 | 84 | $ 2,211,831 | $ 1,892,049 |
| 100 | Cloud Security (Cyber Security) | 3863 | $1,460,000 | G020 | | $1,460,000 | 5/1/2017 | 84 | $ 1,320,952 | $ 1,112,381 |
| 101 | Situational Intelligence & Cyber Intelligence - Phase 1 (Cyber Security) | 3863 | $100,000 | G020 | | $100,000 | 11/1/2017 | 84 | $ 97,619 | $ 83,333 |
| 102 | Situational Intelligence & Cyber Intelligence - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 | 11/1/2019 | 84 | $ - | $ - |
| 103 | IT/OT Discovery & Implementation - Phase 1 (Cyber Security) | 3863 | $0 | G020 | | $3,300,000 | 10/1/2019 | 84 | $ - | $ - |
| 104 | IT/OT Discovery & Implementation - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 | 10/1/2021 | 84 | $ - | $ - |
| 105 | vStig Scaling - Upgrades (Cyber Security) | 3863 | $0 | G020 | | $1,000,000 | 8/1/2018 | 84 | $ - | $ 940,476 |
| 106 | Domain Based Security - Phase 1 (Cyber Security) | 3863 | $0 | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 107 | Domain Based Security - Phase 2 (Cyber Security) | 3863 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 108 | Security Research Lab (Cyber Security) | 3863 | $0 | G020 | | $325,000 | 4/1/2020 | 84 | $ - | $ - |
| 109 | Threat Behavior Modeling (Cyber Security) | 3863 | $800,000 | G020 | | $800,000 | 3/1/2017 | 84 | $ 704,762 | $ 590,476 |
| 110 | Enterprise Content Management (ECM) - Archiving | 1134 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 111 | Enterprise Content Management (ECM) Foundation Services (US only) - Upgrade | 3995 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 112 | Global Audit System Replacement | 3673 | $0 | G020 | | $0 | 3/1/2020 | 84 | $ - | $ - |
| 113 | Global Governance, Risk & Compliance | 2940 | $0 | G020 | | $0 | 6/1/2019 | 84 | $ - | $ - |
| 114 | HRIS Strategy Transformation Program | 4144 | $0 | G020 | | $0 | 4/1/2021 | 84 | $ - | $ - |
| 115 | IS Legacy Systems Archiving & Decommission | 3631 | $0 | G020 | | $0 | 7/1/2020 | 84 | $ - | $ - |
| 116 | Mobility - Mobile Application Development Platform (MADP) (US only) | 3996 | $0 | G020 | | $0 | 3/1/2019 | 84 | $ - | $ - |
| 117 | Mobility - Mobile Device Management (MDM) System | 3430 | $100,000 | G020 | | $100,000 | 3/1/2017 | 84 | $ 88,095 | $ 73,810 |
| 118 | Office 365 | 3999 | $0 | G020 | | $4,300,000 | 10/1/2019 | 84 | $ - | $ - |
| 119 | RAS Re-Platform/Mobile | 4269 | $400,000 | G020 | | $400,000 | 4/1/2017 | 84 | $ 357,143 | $ 300,000 |
| 120 | Desktop XP to Win7 | 4308 | $5,960,000 | G020 | | $11,040,000 | 4/1/2018 | 84 | $ - | $ 9,857,143 |
| 121 | Talent Management | 3674 | $0 | G020 | | $0 | 10/1/2020 | 84 | $ - | $ - |
| 122 | UPS Replacement for Data Communication Closets | 4003 | $0 | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 123 | US Global Security TWIC Compliance | 4023 | $270,000 | G020 | | $1,080,000 | 4/1/2018 | 84 | $ - | $ 964,286 |
| 124 | US Network Improvements | 4289 | $350,000 | G020 | | $350,000 | 4/1/2017 | 84 | $ 312,500 | $ 262,500 |
| 125 | VC Room/Mobile Refresh | 3424 | $0 | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 126 | VSTIG Hardware Refresh | 4274 | $300,000 | G020 | | $300,000 | 4/1/2017 | 84 | $ 267,857 | $ 225,000 |
| 127 | VSTIG upgrade Phase 2 | 4280 | $2,600,000 | G020 | | $2,600,000 | 4/1/2017 | 84 | $ 2,321,429 | $ 1,950,000 |
| 128 | VSTIG upgrade Phase 3 | 4266 | $1,300,000 | G020 | | $1,300,000 | 4/1/2017 | 84 | $ 1,160,714 | $ 975,000 |
| 129 | Wireless Network Expansion | 3425 | $1,600,000 | G020 | | $1,600,000 | 6/1/2017 | 84 | $ 1,466,667 | $ 1,238,095 |
| 130 | Mandated Customer Systems Projects - FY16 | 4094 | $828,000 | C173 | | $828,000 | 4/1/2016 | 84 | $ 621,000 | $ 502,714 |
| 131 | Mandated Customer Systems Projects - FY17 | 4207 | $4,000,000 | C173 | | $4,000,000 | 4/1/2017 | 84 | $ 3,571,429 | $ 3,000,000 |
| 132 | Mandated Customer Systems Projects - FY18 | 4207 | $0 | C173 | | $4,000,000 | 4/1/2018 | 84 | $ - | $ 3,571,429 |
| 133 | Mandated Customer Systems Projects - FY19 | 4207 | $0 | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 134 | Mandated Customer Systems Projects - FY20 | 4207 | $0 | C173 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 135 | Customer Contact Center / SDC Technology Upgrade Implement Solution | 3932 | $1,403,000 | C173 | | $8,417,000 | 4/1/2019 | 84 | $ - | $ - |
| 136 | Meter To Cash Value Added Enhancements | 3869 | $0 | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 137 | Meter To Cash Value Added Enhancements | 3869 | $0 | C173 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 138 | Credit & Collections Gap Analysis and Protections | 4211 | $0 | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 139 | Eliminate SSN from Customer Systems | 4216 | $0 | C173 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 140 | Credit and Collections - Bad Debt Mitigation Initiatives | 2959 | $0 | C173 | | $400,000 | 4/1/2018 | 84 | $ - | $ 357,143 |
| 141 | Distributed Generation Application Tracking | 3941 | $600,000 | C173 | | $600,000 | 12/1/2016 | 84 | $ 507,143 | $ 421,429 |
| 142 | Customer Interaction Channels | 4139 | $0 | C173 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 143 | Mandated Customer Choice Systems Projects | 4186 | $3,100,000 | C173 | | $3,100,000 | 4/1/2017 | 84 | $ 2,767,857 | $ 2,325,000 |
| 144 | Operational Requirements and Upgrades for Procurment & Supply Chain (US SAP) | 4169 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 145 | Enhancement Release - EHR-H2R | 4170 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 146 | Enhancement Release - EHR-Non-Utility Billing | 4171 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 147 | Enhancement Release - EHR-Xfunc | 4165 | $0 | G020 | | $0 | 4/1/2020 | 84 | $ - | $ - |
| 148 | PII Project - Security & Controls | 4168 | $0 | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 149 | US SAP: Business Planning Consolidation - HANA | 4217 | $3,500,000 | G020 | | $3,500,000 | 4/1/2017 | 84 | $ 3,125,000 | $ 2,625,000 |
| 150 | Blanket Work Order Pilot | 4218 | $0 | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 151 | PowerPlan Module Enhancements | 4220 | $0 | G020 | | $0 | 4/1/2019 | 84 | $ - | $ - |
| 152 | US SAP: Improve Performance Reporting | 4221 | $0 | G020 | | $0 | 12/1/2018 | 84 | $ - | $ - |
| 153 | US Gas Enablement IS Component (US Front Office) | 2575 | $0 | G210 | | $0 | 3/31/2023 | 84 | $ - | $ - |
| 154 | US Operations Infrastructure Minor Works Improvement | 3716 | $0 | G173 | | $1,000,000 | 3/31/2018 | 84 | $ - | $ 892,857 |
| 155 | New Medical System | 3718 | $800,000 | G020 | | $1,100,000 | ######## | 84 | $ 1,073,810 | $ 916,667 |
| 156 | Electric and Gas Service Fulfillment Web Portal | 3946 | $0 | G173 | | $0 | 1/31/2021 | 84 | $ - | $ - |
| 157 | NY Gas Audit Work Mgmt and Time Reporting | 3953 | $0 | G207 | | $0 | ######## | 84 | $ - | $ - |
| 158 | Migrate NYS DMV Inspection Stations to LAN | 3954 | $0 | G207 | | $0 | 3/31/2020 | 84 | $ - | $ - |
| 159 | Wi-Fi for Fleet Service Diagnostic Laptops | 3956 | $0 | G173 | | $0 | 2/1/2020 | 84 | $ - | $ - |
| 160 | ISI Follow Up Work Creation in WMS and Customer System | 3961 | $0 | G210 | | $0 | 9/30/2021 | 84 | $ - | $ - |
| 161 | Contract Management Modernization | 4151 | $0 | G198 | | $0 | 1/31/2020 | 84 | $ - | $ - |
| 162 | Ageing System Stabization/Upgrades/Replacements | 4188 | $1,500,000 | G020 | | $1,500,000 | 3/31/2017 | 84 | $ 1,339,286 | $ 1,125,000 |
| 163 | Gas Outage Management System (GOMS) | 4237 | $0 | G210 | | $0 | 3/31/2021 | 84 | $ - | $ - |
| 164 | Operations Performance Management, Data Management, and Reporting | 4247 | $0 | G210 | | $0 | 3/31/2020 | 84 | $ - | $ - |
| 165 | Gas Services Database | 3948/3949 | $0 | G207 | | $940,000 | 3/31/2018 | 84 | $ - | $ 839,286 |
| 166 | Document Management System Replacement | 3985 | $4,040,000 | G020 | | $4,040,000 | 5/31/2017 | 84 | $ 3,703,333 | $ 3,126,190 |
| 167 | Cascade Electric Application Upgrade Project | 3986 | $0 | G198 | | $460,000 | 3/31/2018 | 84 | $ - | $ 410,714 |
| 168 | EJ Ward Upgrade | 3955 | $350,000 | G107 | | $600,000 | 4/1/2018 | 84 | $ - | $ 535,714 |
| 169 | Double Pole Management Database upgrade | 4045 | $432,000 | G198 | | $432,000 | 3/31/2017 | 84 | $ 385,714 | $ 324,000 |
| 170 | NY REV Clifton Park Demo Information Systems Readiness | 4298 | $650,000 | G181 | | $650,000 | 4/1/2017 | 84 | $ 580,357 | $ 487,500 |
| 171 | US CNI GMS-SCADA Upgrade and Consolidation | 3737 | $4,540,000 | G210 | | $10,166,000 | 10/1/2020 | 84 | $ - | $ - |
| 172 | US CNI GMS-Downstate NY and LI Upgrade End-Of-Life Verizon Back-up Communication | 3730 | $0 | G225 | | $1,200,000 | 4/1/2018 | 84 | $ - | $ 1,071,429 |
| 173 | US CNI-Infrastructure Reliability and Security Enhancements | 2881 | $0 | G020 | | $600,000 | 3/31/2022 | 84 | $ - | $ - |
| 174 | US CNI Tech Services-Data Center Capacity Expansion | 2909 | $0 | G020 | | $0 | 3/18/2020 | 84 | $ - | $ - |
| 175 | US CNI GMS-Operator Workstation Operating System | 3965 | $0 | G210 | | $820,000 | 3/18/2018 | 84 | $ - | $ 732,143 |
| 176 | US Control-Wires Down for Massachusetts and NY | 4044 | $0 | G186 | | $5,560,000 | ######## | 84 | $ - | $ - |
| 177 | US Control-NE Electric Control Center Video Wall | 3966 | $0 | G305 | | $650,000 | 3/18/2018 | 84 | $ - | $ 580,357 |
| 178 | US MDS - Itron Enterprise Edition (IEE) Consolidation | 3486 | $0 | G173 | | $1,119,000 | 4/1/2021 | 84 | $ - | $ - |
| 179 | US CNI EMS and OMS-Critical Component System Refresh | 4190 | $0 | G198 | | $0 | 3/31/2021 | 84 | $ - | $ - |
| 180 | US CNI EMS NY/NE-Transmission Outage Application (TOA) End-of-Life Replacement | 4191 | $0 | G220 | | $0 | 3/31/2019 | 84 | $ - | $ - |
| 181 | US Control-Electroinic Bulletin Board Gas Trading Day Changes | 4244 | $2,200,000 | G210 | | $2,200,000 | 3/31/2016 | 84 | $ 1,650,000 | $ 1,335,714 |
| | Subtotal | | $ 327,804,227 | | $ - | $394,443,853 | | | $203,721,227 | $192,267,536 |

$ 4,966,362 Rate Year IS Projects

$ 5,468,686 Existing IS Projects

$ 10,435,048 Total RY 18 IS Projects
$ 10,415,299 RY 17 IS Projects
$ 19,750 Adjustment

**Service Company Capital Software allocated to Operating Companies as Rent Expense**

| | Investment Name | INVP # | (a) Inception to Date $ | (b) Bill Pool | (c) Adjustments | (d) = (a)+(c) Total US Spend | (e) In Service | (f) Amortization Period | (g) 12/31/2018 Balance | (h) 12/31/2019 Balance | (i) = (g+h)/2 Average Balance | (j) 9.9500% Service Co | (k) = (i)*(j) Rate Year Return |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | DMS/OMS Replacement | 1185 | $66,772,709 | G198 | | $66,772,709 | 1/1/2016 | 84 | $ 38,155,834 | $ 28,616,875 | $ 33,386,355 | 9.9500% | $ 3,321,942 |
| 2 | Gas GIS Consolidation | 2577 | $10,283,069 | G210 | | $11,633,069 | 4/1/2019 | 84 | $ - | $ 10,386,668 | $ 5,193,334 | 9.9500% | $ 516,737 |
| 3 | AMAG Upgrades | 1172 | $5,991,812 | G020 | | $5,991,812 | 10/1/2016 | 84 | $ 4,065,872 | $ 3,209,899 | $ 3,637,886 | 9.9500% | $ 361,970 |
| 4 | US CNI DKMS | 3019A | $0 | G098 | | $0 | 3/1/2017 | 84 | $ 0 | $ 0 | $ 0 | 9.9500% | $ 0 |
| 5 | Street Light Outage Improvement | 3237 | $677,605 | G198 | | $677,605 | 9/1/2014 | 84 | $ 258,135 | $ 161,335 | $ 209,735 | 9.9500% | $ 20,869 |
| 6 | NE GAS LEAKS RECHECKS | 3136 | $1,788,826 | G310 | | $1,788,826 | 8/1/2016 | 84 | $ 1,171,255 | $ 915,708 | $ 1,043,482 | 9.9500% | $ 103,826 |
| 7 | CI Services Foundation | 3492 | $2,644,306 | G020 | | $2,644,306 | 2/1/2016 | 84 | $ 1,542,512 | $ 1,164,754 | $ 1,353,633 | 9.9500% | $ 134,686 |
| 8 | US CNI Frame Relay Replacement | 2495H | $6,398,268 | G210 | | $6,398,268 | 12/1/2015 | 84 | $ 3,579,983 | $ 2,665,945 | $ 3,122,964 | 9.9500% | $ 310,735 |
| 9 | Cascade System for Gas | 3629 | $2,282,823 | G210 | | $2,282,823 | 11/1/2015 | 84 | $ 1,250,117 | $ 924,000 | $ 1,087,058 | 9.9500% | $ 108,162 |
| 10 | Customer Choice ESCO Gas | 3564 | $9,629,193 | C225 | | $9,629,193 | 4/1/2016 | 84 | $ 5,846,296 | $ 4,470,697 | $ 5,158,496 | 9.9500% | $ 513,270 |
| 11 | CRIS Migration | 2583 | $28,617,090 | C343 | | $28,617,090 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - |
| 12 | Challenge the Limits XML | 3375B | $603,192 | G179 | | $603,192 | 10/1/2015 | 84 | $ 323,139 | $ 236,968 | $ 280,053 | 9.9500% | $ 27,865 |
| 13 | Challenge Limits Letters | 3375D | $384,023 | C434 | | $384,023 | 10/1/2015 | 84 | $ 205,726 | $ 150,866 | $ 178,296 | 9.9500% | $ 17,740 |
| 14 | IAM Ph2: Federated Identity (Cyber Security) | 3614A1 | $1,598,706 | G020 | | $1,598,706 | 12/1/2015 | 84 | $ 894,514 | $ 666,127 | $ 780,321 | 9.9500% | $ 77,642 |
| 15 | IAM Ph3 Identity Administration - (Cyber Security) | 3614A2 | $1,240,600 | G020 | | $1,240,600 | 9/1/2016 | 84 | $ 827,067 | $ 649,838 | $ 738,453 | 9.9500% | $ 73,476 |
| 16 | CNI Separation of Test & Prod - (Cyber Security) | 3614B2 | $152 | G020 | | $152 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - |
| 17 | CNI Network Security - (Cyber Security) | 3614B7 | $3,801,588 | G020 | | $3,801,588 | 9/1/2016 | 84 | $ 2,534,392 | $ 1,991,308 | $ 2,262,850 | 9.9500% | $ 225,154 |
| 18 | Security Incident & Event Monitoring (SIEM) 2 - (Cyber Security) | 3614E3 | $1,362,769 | G020 | | $1,362,769 | 6/1/2016 | 84 | $ 859,842 | $ 665,161 | $ 762,502 | 9.9500% | $ 75,869 |
| 19 | CNI Patch Management - (Cyber Security) | 3614B11 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - |
| 20 | CNI Network Security Controls - (Cyber Security) | 3614B13 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - |
| 21 | CNI SIEM - (Cyber Security) | 3614B14 | $1,106,000 | G020 | | $1,106,000 | 9/1/2016 | 84 | $ 737,333 | $ 579,333 | $ 658,333 | 9.9500% | $ 65,504 |
| 22 | Enterprise Network Security - (Cyber Security) | 3614D1 | $5,946,273 | G020 | | $5,946,273 | 9/1/2016 | 84 | $ 3,964,182 | $ 3,114,715 | $ 3,539,448 | 9.9500% | $ 352,175 |
| 23 | Network Risk & Compliance - (Cyber Security) | 3614D2 | $0 | G020 | | $0 | 1/1/2099 | 84 | $ - | $ - | $ - | 9.9500% | $ - |
| 24 | Security Operations Center - (Cyber Security) | 3614E2 | $1,461,890 | G020 | | $1,461,890 | 4/1/2016 | 84 | $ 887,576 | $ 678,735 | $ 783,155 | 9.9500% | $ 77,924 |
| 25 | End user initiated secure file & email transfer - (Cyber Security) | 3614C1 | $121,600 | G020 | | $121,600 | 4/1/2016 | 84 | $ 73,829 | $ 56,457 | $ 65,143 | 9.9500% | $ 6,482 |
| 26 | Security Reference Architecture - (Cyber Security) | 3614G1 | $60,800 | G020 | | $60,800 | 9/1/2016 | 84 | $ 40,533 | $ 31,848 | $ 36,190 | 9.9500% | $ 3,601 |
| 27 | Cyber Security prioritised investments - (Cyber Security) | 3614 | $725,146 | G020 | | $725,146 | 9/1/2016 | 84 | $ 483,431 | $ 379,838 | $ 431,635 | 9.9500% | $ 42,948 |
| 28 | NY Retail Access | 3839 | $2,872,399 | G170 | | $2,872,399 | 12/1/2016 | 84 | $ 2,017,519 | $ 1,607,176 | $ 1,812,347 | 9.9500% | $ 180,329 |
| 29 | US Web Initiatives 2 | 3600B | $3,831,522 | C175 | | $3,831,522 | 2/1/2016 | 84 | $ 2,235,055 | $ 1,687,694 | $ 1,961,375 | 9.9500% | $ 195,157 |
| 30 | Capitalized Asset Replacement | 3617C | $935,395 | G084 | | $935,395 | 4/1/2016 | 84 | $ 567,919 | $ 434,291 | $ 501,105 | 9.9500% | $ 49,860 |
| 31 | UNY Capitalized Asset Replacement | 3617D | $265,077 | G003 | | $265,077 | 4/1/2016 | 84 | $ 160,940 | $ 123,072 | $ 142,006 | 9.9500% | $ 14,130 |
| 32 | DSNY Capitalized Equipment Installs - Physical Security | 3617B | $475,000 | G235 | | $475,000 | 4/1/2016 | 84 | $ 288,393 | $ 220,536 | $ 254,464 | 9.9500% | $ 25,319 |
| 33 | Pelco Video System Conversion - Physical Security | 3841 | $480,000 | G077 | | $480,000 | 4/1/2016 | 84 | $ 291,429 | $ 222,857 | $ 257,143 | 9.9500% | $ 25,586 |
| 34 | NMPC C-Cure Conversion to AMAG | 3853 | $1,182,427 | G003 | | $1,182,427 | 3/1/2017 | 84 | $ 872,744 | $ 703,826 | $ 788,285 | 9.9500% | $ 78,434 |
| 35 | EHR1 - PMO | | $8,928,548 | G012 | | $8,928,548 | 12/1/2015 | 84 | $ 4,995,735 | $ 3,720,228 | $ 4,357,982 | 9.9500% | $ 433,619 |
| 36 | EHR1 - Supply Chain | | $14,769,439 | G012 | | $14,769,439 | 12/1/2015 | 84 | $ 8,263,853 | $ 6,153,933 | $ 7,208,893 | 9.9500% | $ 717,285 |
| 37 | EHR1 - Finance | | $16,145,346 | G012 | | $16,145,346 | 12/1/2015 | 84 | $ 9,033,705 | $ 6,727,227 | $ 7,880,466 | 9.9500% | $ 784,106 |
| 38 | EHR1 - IT Delivery | | $2,414,316 | G012 | | $2,414,316 | 12/1/2015 | 84 | $ 1,350,867 | $ 1,005,965 | $ 1,178,416 | 9.9500% | $ 117,252 |
| 39 | EHR1 - Payroll | | $12,187,165 | G012 | | $12,187,165 | 12/1/2015 | 84 | $ 6,819,009 | $ 5,077,986 | $ 5,948,497 | 9.9500% | $ 591,875 |
| 40 | EHR1 - BPS | | $9,915,257 | 5020 | | $9,915,257 | 12/1/2015 | 84 | $ 5,547,823 | $ 4,131,357 | $ 4,839,590 | 9.9500% | $ 481,539 |
| 41 | Customer Storm Outage Credit Program | 3859 | $0 | 5210 | | $0 | 3/1/2015 | 84 | $ 0 | $ 0 | $ 0 | 9.9500% | $ 0 |
| 42 | US CNI GMS SCADA Upgrade | 3737 | $11,369,504 | C210 | | $17,079,504 | 1/1/2019 | 84 | $ - | $ 14,639,575 | $ 7,319,787 | 9.9500% | $ 728,319 |
| 43 | US Desktop Refresh | 2927 | $7,430,690 | G020 | | $7,430,690 | 3/1/2016 | 48 | $ 2,167,285 | $ 309,612 | $ 1,238,448 | 9.9500% | $ 123,226 |
| 44 | Internet Explorer Upgrade | 3644 | $300,090 | G020 | | $300,090 | 3/1/2016 | 84 | $ 178,625 | $ 135,755 | $ 157,190 | 9.9500% | $ 15,640 |
| 45 | Mobile Device for PTO | 3883 | $2,442,471 | G173 | | $2,442,471 | 9/1/2016 | 48 | $ 1,017,696 | $ 407,079 | $ 712,388 | 9.9500% | $ 70,883 |
| 46 | SMI Conversion Mobilization | 3896 | $2,187,292 | G020 | | $2,187,292 | 7/1/2016 | 84 | $ 1,406,116 | $ 1,093,646 | $ 1,249,881 | 9.9500% | $ 124,363 |
| 47 | S005242 M112 Systemic Improvement | | $3,500,000 | G012 | | $3,500,000 | 3/1/2016 | 12 | $ - | $ - | $ - | 9.9500% | $ - |
| 48 | Cadency Account Reconciliation Tool | | $146,894 | G012 | | $146,894 | 3/1/2016 | 12 | $ - | $ - | $ - | 9.9500% | $ - |
| 49 | Soft Off Program | 4024 | $1,278,485 | C207 | | $1,278,485 | 2/1/2016 | 84 | $ 745,783 | $ 563,142 | $ 654,462 | 9.9500% | $ 65,119 |
| 50 | LI CSS Stabilization | 4133 | $847,000 | 5230 | | $847,000 | 3/1/2016 | 84 | $ 504,167 | $ 383,167 | $ 443,667 | 9.9500% | $ 44,145 |

$ 6,379,255 Rate Year IS Projects

| | (l) = (-ac) RY Return on Accum Taxes | (m) = (k) + (l) Total Return | (n) Rate Year Amortization | (o) 5230G KEDLI Allocation | (p) = (m)*(n) KEDLI Rate Year Rent-Return | (q) = (n)*(o) KEDLI Rate Year Rent - Depn | (r) Amortization Period | Tax Expensing | Bonus Depreciation | (t) 12/31/2018 Balance | (u) 12/31/2019 Balance | Average Balance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subtotal | $ (7,622,947) | ######### | $ 53,671,210 | | $ 1,240,933 | $ 5,138,322 | | $ - | $177,383,406 | $314,137,717 | $348,755,727 | |

$ 4,790,558 Existing IS Projects

$ 11,169,813 Total RY 19 IS Projects
$ 10,435,048 RY 18 IS Projects
$ 734,765 Adjustment

Date of Request: May 9, 2016 DPS Request No. DPS-487 JL-8
Due Date: May 19, 2016 KEDNY/ KEDLI Req. No. BULI-661

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: NYPSC, James Lyons

TO: National Grid, Sean Mongan

SUBJECT: Research and Development Costs for KEDNY

Request:

Provide the following:

1. For KEDNY, KEDLI, and Niagara Mohawk Power Corporation, d/b/a National Grid (NMPC), reconcile the information provided in the National Grid Triennial R&D Report 2016 by program area, as follows, National Grid Internal Program, Millennium and NYSERDA, with the Companies' response to information requests DPS-420 and DPS-421, Attachment 1 for calendar years 2014 and 2015. Provide with the reconciliation a breakdown of the following for each company by program and by year:

   a. Budget;

   b. Annual Customer Surcharge per Dth;

   c. Total Revenue Collected;

   d. Total Expenditures;

   e. End of year balance; and

   f. Reconcile total balance by year (*e.g.,* previous year program balance plus current year program balance).

2. National Grid's Triennial R&D Report 2016 provides aggregated information for KEDNY, KEDLI, and NMPC by program area with limited detail regarding customer contributions and program expenditures broken-out for each company. Typically, these programs and related costs are reported by the individual company in relation to a given company's customer surcharges and their R&D program participation. Explain or provide the authority for aggregating this information as it is presented in the April 2016 Triennial R&D Report?

3. If the Utilization Technology Development (UTD) program and associated proposals are approved, describe the differentiation between the projects that are included in UTD program and any associated programmatic costs from projects associated with or funded through the current internal R&D program.

4. Will implementation of the UTD R&D programs change the funding currently required for the internal R&D program projects supported by the companies?

Response:

1. Attachment 1 is a reconciliation of the 2016 Triennial R&D Report ("R&D Report") by program area for NMPC, KEDNY, and KEDLI for Calendar Years ("CY") 2014 and 2015. In preparing the attachment, the Company identified two errors in the R&D Report. First, the R&D Report reflected a "NYSERDA Assessment" of $3.565 million for CY 2014 and $4.906 million for CY 2015. However, the amounts shown as CY 2015 were actually Fiscal Year amounts and not CY amounts. The amounts shown as CY 2014 were incorrect and did not represent the final ERDA assessments billed by NYS. Attachment 1 contains the actual "NYSERDA Assessment" amounts of $1.702 million and $4.514 million for CYs 2014 and 2015, respectively. Attachment 2 shows the reconciliation of these amounts by operating company. Second, the "National Grid Internal Program Operations" line item of $28,476 for CY 2015 was misstated in the R&D Report. The correct amount is $94,923, as shown in Attachment 1.

   Attachment 3 provides the Millennium surcharges per Dth for NMPC, KEDNY, and KEDLI for calendar years 2014 and 2015. Attachment 4 contains the reconciliation of the R&D Millennium program. The variance between the ending deferral balance and general ledger balance represents a difference between actual project expenditures and project expenditures recorded to the deferral. The Company is currently reviewing the variances shown.

2. From inception of the Millennium program, National Grid's Gas RD&D reports have been filed as a single combined report that shows a total research program and total financial investment rather than by individual operating company.

3. On the programmatic side, the projects approved by the UTD Board exclusively support the development of technologies that benefit customers after the meter. Projects include advanced energy using technologies such as distributed generation, advanced heat and cooling, transportation technologies, and industrial process improvements. KEDNY and KEDLI's current internal program supports the development of technologies on the

company's side of the meter that improve the safety, reliability or cost effectiveness of gas distribution operations.

On the cost side, UTD projects that proceed will include co-funding from other companies as well as GTI and any other sources GTI may obtain.  By contrast, projects in the Companies' internal program may or may not have co-funders based on the level of interest from other companies and the perceived importance of the project to National Grid.  With regard to programmatic or management costs, the Companies' internal program is managed by internal staff while UTD projects are managed by GTI's staff.   GTI's costs are embedded in the project costs and listed in each proposal.

4. No, the request to fund the UTD program is supplementary to the current internal program and no changes to funding are anticipated.

Name of Respondent:
Mary Holzmann, Chris Cavanagh, Keith Sperling

Date of Reply:
May 18, 2016

National Grid Gas R&D Spending
KEDLI, KEDNY and NMPC

| Calendar Year Expenditures ($) | 2014 | | | | 2015 | | | |
|---|---|---|---|---|---|---|---|---|
| Year | Total | KEDLI | KEDNY | NMPC | Total | KEDLI | KEDNY | NMPC |
| National Grid Internal Program* | | | | | | | | |
| Utilization | $104,800 | $43,243 | $43,739 | $17,819 | $211,426 | $211,426 | $0 | $0 |
| Operations | $57,708 | $9,455 | $20,438 | $27,814 | $94,923 | $12,010 | $54,437 | $28,476 |
| Ngrid Labor and Expenses | $229,692 | $55,126 | $114,846 | $59,720 | $184,741 | $29,947 | $64,807 | $31,184 |
| TOTAL INTERNAL | $392,200 | $107,824 | $179,023 | $105,352 | $491,090 | $253,383 | $119,244 | $59,660 |
| National Grid Millennium Program | | | | | | | | |
| NYSEARCH Projects | $2,265,234 | $329,180 | $637,868 | $1,298,186 | $1,311,235 | $218,935 | $690,217 | $402,083 |
| OTD Projects | $750,000 | $175,000 | $380,000 | $195,000 | $870,279 | $295,279 | $380,000 | $195,000 |
| National Grid Projects | $40,000 | $20,568 | $9,516 | $9,916 | $103,502 | $18,675 | $65,367 | $19,460 |
| TOTAL MILLENNIUM | $3,055,234 | $524,748 | $1,027,384 | $1,503,102 | $2,285,016 | $532,889 | $1,135,584 | $616,543 |
| TOTAL MILLENNIUM AND INTERNAL | $3,447,434 | $632,572 | $1,206,407 | $1,608,455 | $2,776,106 | $786,272 | $1,254,828 | $676,203 |
| NYSERDA Assessment | $1,701,900 | $542,324 | $814,840 | $344,736 | $4,514,020 | $1,063,547 | $1,995,469 | $1,455,004 |
| TOTAL R&D PROGRAM | $5,149,334 | $1,174,896 | $2,021,247 | $1,953,190 | $7,290,126 | $1,849,819 | $3,250,296 | $2,131,207 |

* "Utilization" and "Internal" are not funded through the Millenium Fund.
* As discussed with Staff, the Company reflected the total payments of $211,426 made for residential methane detector research to show that these costs are being separately funded by KEDLI.

Keyspan Gas East Corporation d/b/a National Grid
The Brooklyn Union Gas Company d/b/a National Grid NY
Case Nos. 16-G-0058 and 16-G-0059
Attachment 2 to DPS-487
Page 1 of 1

| | CY 2014 ERDA | | | | |
|---|---|---|---|---|---|
| | KEDLI | KEDNY | NMPC | Totals | |
| Description | CY 2014 | CY 2014 | CY 2014 | CY 2014 | |
| Revenues (Included in Base Rates) | $1,056,054 | $1,835,525 | $681,060 | $3,572,639 | |
| Expense | $542,324 | $814,840 | $344,736 | $1,701,900 | **C** |
| Variance (Expense vs Revenues) | ($513,730) | ($1,020,685) | ($336,324) | ($1,870,739) | **A,B** |

| | CY 2015 ERDA | | | | |
|---|---|---|---|---|---|
| | KEDLI | KEDNY | NMPC | Totals | |
| Description | CY 2015 | CY 2015 | CY 2015 | CY 2015 | |
| Revenues (Included in Base Rates) | $1,056,054 | $1,835,525 | $681,060 | $3,572,639 | |
| Expense | $1,063,547 | $1,995,469 | $1,455,004 | $4,514,020 | **C** |
| Variance (Expense vs Revenues) | $7,493 | $159,944 | $773,944 | $941,382 | **B** |

**A** The Companies received a refund from NYS for ERDA during calendar year 2014
**B** Please note that there is no reconciliation/true up for NYSERDA expenditures

| **C:** | KEDLI | KEDNY | NMPC | Totals |
|---|---|---|---|---|
| Per Final NYS Assessment FY14 | $1,093,832 | $1,686,648 | $848,133 | $3,628,613 |
| Per Final NYS Assessment FY15 | $1,015,204 | $1,570,166 | $752,584 | $3,337,954 |
| Per Final NYS Assessment FY16 | $1,079,661 | $2,137,236 | $1,689,145 | $4,906,042 |
| | | | | |
| Monthly Amortization: | | | | |
| Per Final NYS Assessment FY14 | $91,153 | $140,554 | $70,678 | $302,384 |
| Per Final NYS Assessment FY15 | $84,600 | $130,847 | $62,715 | $278,163 |
| Per Final NYS Assessment FY16 | $89,972 | $178,103 | $140,762 | $408,837 |
| | | | | |
| Calendar Year Expense: | | | | |
| 2014 (3 Months of FY14 and 9 months of FY15) | $1,034,861 | $1,599,287 | $776,471 | $3,410,619 |
| Refund from NYS posted to ERDA expenditures | $492,537 | $784,446 | $431,736 | $1,708,719 |
| Net CY 2014 | $542,324 | $814,840 | $344,736 | $1,701,900 |
| | | | | |
| 2015 (3 Months of FY15 and 9 months of FY16) | $1,063,547 | $1,995,469 | $1,455,004 | $4,514,020 |

| | KEDNY (per Dth) | KEDLI (per Dth) | NIMO (per Dth) |
|---|---|---|---|
| **Jan-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Feb-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Mar-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Apr-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **May-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Jun-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Jul-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Aug-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Sep-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Oct-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Nov-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| **Dec-2014** | $ 0.01740 | $ 0.01240 | $ 0.01067 |
| | | | |
| **Jan-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Feb-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Mar-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Apr-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **May-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Jun-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Jul-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Aug-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Sep-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Oct-2015** | $ 0.00670 | $ - | $ 0.01214 |
| **Nov-2015** | $ - | $ - | $ 0.01214 |
| **Dec-2015** | $ - | $ - | $ 0.01214 |

| | 2014 Millennium Fund Deferral Account | | |
|---|---|---|---|
| | KEDLI | KEDNY | NMPC |
| Activity | CY 2014 | CY 2014 | CY 2014 |
| Beginning Balance | ($1,255,371) | ($124,403) | ($556,031) |
| Collections | ($1,226,719) | ($2,559,962) | ($1,163,093) |
| Expenditures Charged | $524,748 | $1,027,384 | $1,503,102 |
| Ending balance | ($1,957,342) | ($1,656,982) | ($216,021) |
| Balance Per G/L | ($2,059,672) | ($1,917,378) | ($272,401) |
| Variance [1] | $102,330 | $260,396 | $56,380 |

| | 2015 Millennium Fund Deferral Account | | |
|---|---|---|---|
| | KEDLI | KEDNY | NMPC |
| Activity | CY 2015 | CY 2015 | CY 2015 |
| Beginning Balance | ($2,059,672) | ($1,917,378) | ($272,401) |
| Collections | ($19,973) | ($799,032) | ($1,723,532) |
| Expenditures Charged | $532,889 | $1,135,584 | $616,543 |
| Ending balance | ($1,546,756) | ($1,580,827) | ($1,379,390) |
| Balance Per G/L | ($1,755,136) | ($1,705,513) | ($1,041,975) |
| Variance [1] | $208,380 | $124,686 | ($337,415) |

| | 2016 Millennium Fund Deferral Account | | | |
|---|---|---|---|---|
| | KEDLI | KEDNY | NMPC | |
| Activity | CY 2016 | CY 2016 | CY 2016 | As of March 2016 |
| Beginning Balance | ($1,755,136) | ($1,705,513) | ($1,041,975) | |
| Collections | ($6) | - | ($76,352) | |
| Expenditures Charged | $221,146 | $820,785 | $247,460 | |
| Ending balance | ($1,533,996) | ($884,728) | ($870,866) | |
| Balance Per G/L | ($1,533,996) | ($884,728) | ($870,866) | |
| Variance | $0 | $0 | $0 | |

[1] The Company is currently reconciling project expenditures relating to the Millennium Fund Deferral

Date of Request: March 30, 2016 LIPA Request No. LIPA-7 RS-7
Due Date: April 11, 2016 KEDNY/ KEDLI Req. No. BULI-390

KEYSPAN GAS EAST CORPORATION d/b/a NATIONAL GRID
THE BROOKLYN UNION GAS COMPANY d/b/a NATIONAL GRID NY

Case 16-G-0058 KeySpan Gas East Corporation d/b/a National Grid
Case 16-G-0059 The Brooklyn Union Gas Company d/b/a National Grid NY

Request for Information

FROM: LIPA, Rick Shansky

TO: National Grid, Rate Design Panel

SUBJECT: **GENERATOR TRANSPORTATION RATES**

Request:

7. Please provide a comparison of the components of the transportation rates, and the precise rates in each element, between KEDNY's and KEDLI's SC-14 services and the equivalent services offered by Consolidated Edison.

Response:

Please see Attachment 1 for a comparison of the rate components of KEDLI's SC-14 and KEDNY's SC-20 service classifications. Please refer to Consolidated Edison's tariff for its rates and services.

Name of Respondent:
Pamela Dise

Date of Reply:
April 8, 2016

Keyspan Gas East Corporation
The Brooklyn Union Gas Company
Cases 16-G-0058 and 16-G-0059
Attachment 1 to LIPA-7 RS-7 BULI-390
Page 1 of 1

| | **KEDLI SC14, Rate Schedule 1** | **KEDNY SC20, Rate Schedule 1** |
|---|---|---|
| On-System Transportation Charge | | |
| 1) Contribution to Fixed Costs | $.10 / dth | $.10 / dth |
| 2) Unitized Long Run Marginal Costs | $.14 / dth | $.10 / dth |
| Value Added Charge | Variable - Determined in accordance with Leaf No. 194 | Variable - Determined in accordance with Leaf 427.12 |
| Daily Balancing Service Demand Charge | $.01 / dth | $.01 / dth |
| The sum of the per dekatherm charges listed in (a), (b) and (c) above shall not exceed the per dekatherm charge of the otherwise applicable interruptible transportation service. If this condition exists, the Company shall reduce the Value Added Charge such that the sum of these charges is capped at the applicable interruptible transportation service rate. | | |
| Annual Minimum Bill Obligation | 50% of the facility's MAQ, multiplied by all charges payable under this Service Classification, whether such quantity is actually transported. | 50% of the facility's MAQ, multiplied by all charges payable under this Service Classification, whether such quantity is actually transportated. |
| Daily Balancing Charge | Per Leaf 190 and 191 | Per Leaf 427.8 and 427.9 |

Note: 1) On-System Transportation Charge is tariffed
Note: 2) Daily Balancing Service Demand Charge stated in Seller Statement

FMI™

# Skills Shortages in a Booming Market:
## The Big Oil and Gas Challenge

The strains on labor capacity in oil and gas construction markets worldwide are becoming increasingly well known. These strains continue to affect projected project costs, and several large capital projects have already been delayed or cancelled (see Shell's Louisiana GTL plant as an example) as a result of rising costs and questionable long-term profitability projections. As demand continues to increase in the face of the LNG export gold rush, construction firms are faced with unprecedented pressures to retain and grow talent.

To keep up with this extremely dynamic and competitive – if not unprecedented – business environment, U.S. energy infrastructure construction firms need to develop a robust talent pipeline to tackle the industry's many business challenges in the coming years. In 2008 just 3.8 percent of the total construction workforce was engaged in direct oil and gas construction. By 2012, 6.4 percent – nearly double 2008's number – of that workforce was engaged in direct oil and gas construction. According to FMI's estimates, by 2017 nearly 10 percent of the total U.S. construction workforce will have moved over to this burgeoning segment of the industry.

Fierce competition for talent in this sector is already driving construction companies to think about their human capital needs and the strategies required to optimize their access to – and retention of – qualified and experienced workers. Questions that are starting to move up company executives' strategic agendas include, "How do we prevent knowledge loss with a large percentage of experienced workers preparing for retirement?" and "How do we anticipate and prepare for the workforce depletion and adapt to a shifting employee culture?"

Scott Duncan, vice president with FMI Capital Advisors, states, "The oil and gas construction market remains vibrant, and many firms are seeking new ways to expand and grow their market presence. As competition for limited resources intensifies, labor and talent management are quickly becoming a key differentiator in company performance and overall company value. Companies seeking to build a presence in this market need to ensure they have the systems and processes in place to maximize productivity and retain top talent."

This article provides oil and gas construction demand and labor supply forecasts, presents key labor dynamics in today's U.S. oil and gas construction industry, and summarizes recommendations on how to prepare for the imminent labor and knowledge void. Information was collected through 25 in-depth interviews with executives of energy infrastructure construction firms as well as with select FMI industry experts.

The article also presents three case studies, including ARB, Inc.; Kiewit; and Henkels & McCoy, and describes how these companies are dealing with long-term talent management and resource planning issues.

FMI Corporation Locations

**Raleigh - Headquarters**
5171 Glenwood Avenue
Suite 200
Raleigh, NC 27612
Tel: 919.787.8400
Fax: 919.785.9320

**Denver**
210 University Boulevard
Suite 800
Denver, CO 80206
Tel: 303.377.4740
Fax: 303.398.7291

**Scottsdale**
14500 N. Northsight Boulevard
Suite 313
Scottsdale, AZ 85260
Tel: 602.381.8108
Fax: 602.381.8228

**Tampa**
308 South Boulevard
Tampa, FL 33606
Tel: 813.636.1364
Fax: 813.636.9601

**www.fminet.com**

*The refinement of hydraulic fracturing technology has allowed the United States to go from an increasingly dependent buyer of foreign oil to the second-leading producer of oil in the world.*

## Overview of the U.S. Oil and Gas Construction Boom

In 2008 approximately 60 percent of the crude oil produced in the United States came from one of three places: the Gulf of Mexico, Texas or Alaska. Domestic production was on the decline, having decreased about 2 percent annually on average since 1970. Imports from foreign nations filled the gap, bringing with them significant political and economic implications for the country.

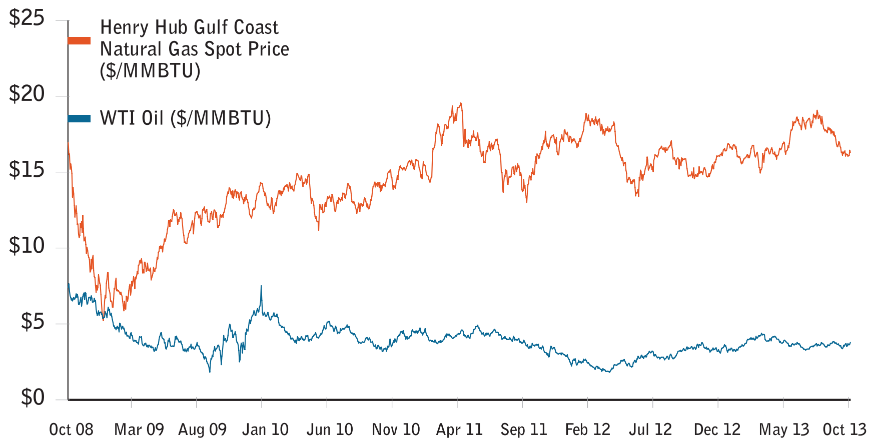
In the five years following, the refinement of hydraulic fracturing technology has allowed the United States to go from an increasingly dependent buyer of foreign oil to the second-leading producer of oil in the world. The technology has also given energy companies the ability to exploit huge natural gas reserves across the country. While traditionally much of the country's oil and gas infrastructure lies along the Gulf Coast, shale development is now taking place across the country in states like Pennsylvania, West Virginia, Ohio, Oklahoma, Colorado and North Dakota, increasing oil and gas production at previously unfathomable rates. Located deep beneath Pennsylvania and West Virginia, the Marcellus Shale has increased natural gas production by six times in just four years. If the Marcellus were its own country, it would be the 8th-largest gas producer in the world. Ten years ago this was unimaginable.

**Figure 1. Lower 48 States Shale Plays**


Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

This dramatic production increase has affected prices. The rush to produce natural gas from formations like the Marcellus began to have a significant effect in 2012, when the price of natural gas fell to an all-time low of $1.82 per MMBTU on April 20, effectively making it one of the cheapest energy resources in the world. Oil prices also began to exhibit some very peculiar behavior: In early 2011, oil produced in the United States began to trade at a substantial discount to oil produced overseas. With so much oil production in far-off places of the country, surpluses were developing at storage and transportation hubs unable to get to market. As a result, prices declined and refiners rejoiced.

**Figure 2. The Cost of Energy — Oil versus Natural Gas**




**Source: Energy Information Administration**

In just five years, the United States has witnessed an energy revolution. Production of oil and gas is increasing, prices are falling, and entrepreneurs nationwide are finding newer and better ways to take advantage of this dynamic. The biggest challenge for all of them comes down to one issue: infrastructure.

Due to infrastructure constraints, domestically produced oil has traded at a discount, and natural gas prices have declined precipitously. There is tremendous profit incentive for companies that can liquefy natural gas and transport it overseas, and for companies that can transport oil from overstocked hubs in the Bakken shale and other oil-rich areas.

FMI estimates that capital expenditures on oil and gas construction projects in the United States will exceed $55 billion in 2013, up 11 percent from 2012. We estimate this growth will continue at an average of 17 percent through 2017 as the construction of refineries, petrochemical facilities, pipelines, liquefied natural gas facilities and related infrastructure projects heats up. What is not included in these figures is the effect that cheaper energy prices will have on industrial spending nationwide. Already, utilities across the country are switching from coal-powered electricity generation to gas, and other energy-intensive industries are examining whether natural gas is a more affordable commodity. All of this will require new investment and new construction.

In all, FMI estimates more than $330 billion will be spent on oil- and gas-related construction during the next four years, nearly double the amount that has been spent in the past four years. As oil and gas producers increase drilling efficiencies and place greater pressure on prices (particularly in natural gas markets), we expect this figure to increase as the United States begins to return to its manufacturing and industrial roots.

# The Looming Gap: Oil & Gas Construction Demand and Labor Supply

## Full Throttle Ahead

The oil and gas sector has experienced an era of intense and accelerated growth over the last few years. Even as many other industries have fallen prey to the economic recession and other negative impacts, this particular industry has remained strong and steadfast; that is not expected to change anytime soon. Through 2017, in fact, the rate of growth in oil and gas is projected to be more than twice that of the construction industry as a whole (Table 1).

The fact that many construction employees have gravitated to the growing oil and gas sector should come as no surprise. In 2008 just 3.8 percent of the total construction workforce was engaged in direct oil and gas construction. By 2012, 6.4 percent – nearly double 2008's number – of that workforce was engaged in direct oil and gas construction. According to FMI's estimates, by 2017 nearly 10 percent of the total U.S. construction workforce will have moved over to this burgeoning segment of the industry (Table 2).

**Table 1. U.S. Construction Volume Put in Place and Construction Spending in the U.S. Oil and Gas Industry**

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013e | 2014e | 2015e | 2016e | 2017e | Total % Change |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Residential Buildings | 357,746 | 253,930 | 249,113 | 252,658 | 286,523 | 338,163 | 379,599 | 420,452 | 465,383 | 505,941 | 41% |
| Nonresidential Buildings | 499,702 | 432,196 | 346,488 | 336,438 | 354,202 | 352,509 | 369,070 | 392,102 | 418,454 | 446,789 | -11% |
| Non-Building Structures | 210,118 | 217,078 | 208,959 | 198,918 | 216,228 | 218,971 | 228,435 | 238,879 | 252,080 | 267,411 | 27% |
| Total | 1,067,566 | 903,204 | 804,560 | 788,014 | 856,953 | 909,643 | 977,104 | 1,051,433 | 1,135,917 | 1,220,141 | 14% |
| % Change from prior year | na | -15% | -11% | -2% | 9% | 6% | 7% | 8% | 8% | 7% | |

Construction Spending in the Oil & Gas Industry
Estimated for the United States
*Millions of Current Dollars*
September 2013

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013e | 2014e | 2015e | 2016e | 2017e | Total % Change |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 35,878 | 38,314 | 40,536 | 43,855 | 48,897 | 55,008 | 63,680 | 75,264 | 89,181 | 102,784 | 186% |
| % Change from prior year | na | 7% | 6% | 8% | 11% | 12% | 16% | 18% | 18% | 15% | |

**Source: FMI Projections**

**According to FMI's definition, the oil and gas industry comprises the following projects:**

- New buildings and structures related to extraction, processing/refining. Storage, transmission and distribution of oil and gas products.
- Similar buildings and structures within the chemical industry, which are wholly dedicated to petroleum-based chemicals.
- Additions, alterations, conversions, expansions, reconstruction, renovations, rehabilitations and major replacements.
- Site preparation and outside construction of fixed structures or facilities such as petroleum and gas pipelines, sidewalks, on-site streets, parking lots, utility connections and similar facilities that are built into or fixed to the land.
- Fixed, largely site-fabricated equipment not housed in a building, primarily for petroleum refineries and chemical plants, but also including storage tanks, refrigeration systems, etc.

**The following are excluded from FMI's definition of the oil and gas industry:**

- Maintenance and repairs to existing structures or service facilities.
- Cost and installation of production machinery and equipment items not specifically covered above, such as heavy industrial machinery.
- Drilling of gas and oil wells, including construction of offshore drilling platforms.
- Land acquisition.
- Ancillary construction that supports the oil and gas industry, including rail, ports, streets and highways, commercial buildings and housing.

**Table 2. Total Construction Employment Demand — All Segments**

Estimated for the United States

*Thousands of Full-Time Workers*

September 2013

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013e | 2014e | 2015e | 2016e | 2017e |
|---|---|---|---|---|---|---|---|---|---|---|
| Carpet, Floor and Tile Installers and Finishers | 79.4 | 68.0 | 62.1 | 538.7 | 61.3 | 60.6 | 63.6 | 66.9 | 70.2 | 74.6 |
| Sheet Metal Workers | 107.9 | 95.3 | 87.8 | 77.6 | 87.5 | 85.7 | 92.1 | 104.5 | 113.6 | 127.7 |
| Brickmasons, Blockmasons and stonemasons | 110.5 | 91.3 | 86.3 | 75.2 | 84.5 | 85.9 | 89.8 | 102.1 | 114.7 | 121.3 |
| Roofers | 113.5 | 105.6 | 93.1 | 82.2 | 94.1 | 99.5 | 107.2 | 119.3 | 130.3 | 142.4 |
| General and Operations Managers | 121.2 | 107.4 | 98.6 | 84.7 | 96.5 | 110.8 | 119.8 | 133.3 | 145.2 | 153.1 |
| Cost Estimators | 128.0 | 111.0 | 102.8 | 91.1 | 101.1 | 107.1 | 114.2 | 126.6 | 137.4 | 154.6 |
| Drywall Installers, Tapers, Ceiling Tile Installers | 151.3 | 124.9 | 109.3 | 96.8 | 109.4 | 114.4 | 122.6 | 134.4 | 147.3 | 162.1 |
| Construction Managers | 176.9 | 154.0 | 142.2 | 122.9 | 139.8 | 150.7 | 161.9 | 183.2 | 195.9 | 215.0 |
| Cement Masons, Concrete Finishers and Terrazzo Workers | 184.7 | 155.7 | 140.3 | 122.3 | 138.6 | 152.0 | 166.6 | 182.8 | 199.2 | 219.2 |
| Painters and Paperhangers | 197.6 | 168.3 | 155.5 | 135.6 | 153.4 | 157.5 | 172.3 | 187.0 | 204.4 | 217.3 |
| Engineering & Design Occupations | 265.7 | 235.6 | 216.7 | 189.0 | 209.8 | 219.3 | 232.8 | 252.5 | 272.2 | 292.5 |
| Construction Equipment Operators | 297.5 | 257.4 | 238.0 | 209.3 | 239.3 | 241.6 | 253.4 | 272.1 | 291.6 | 315.4 |
| Helpers, Construction Trades | 349.2 | 303.3 | 275.1 | 240.4 | 272.1 | 274.5 | 287.4 | 304.8 | 326.3 | 361.4 |
| Pipelayers, Plumbers, Pipefitters and Steamfitters | 398.0 | 358.3 | 324.2 | 286.5 | 331.1 | 330.8 | 353.3 | 374.2 | 399.9 | 425.9 |
| First-Line Supervisors/Managers | 442.1 | 392.8 | 359.8 | 309.0 | 349.5 | 349.5 | 370.1 | 398.6 | 423.4 | 445.7 |
| Electricians | 484.0 | 427.0 | 394.8 | 342.7 | 394.4 | 394.3 | 408.0 | 434.5 | 461.4 | 493.5 |
| Carpenters | 721.0 | 598.6 | 525.8 | 459.5 | 524.8 | 530.0 | 565.3 | 593.7 | 616.1 | 647.2 |
| Construction Laborers | 771.0 | 663.3 | 594.7 | 520.5 | 581.6 | 577.4 | 603.6 | 628.2 | 657.9 | 694.1 |
| Total | 5,099.5 | 4,418.0 | 4,007.0 | 3,983.7 | 3,968.9 | 4,041.6 | 4,283.8 | 4,598.7 | 4,907.0 | 5,263.0 |
| % Change from Prior Year | | -13% | -9% | -1% | 0% | 2% | 6% | 7% | 7% | 7% |

**Source: FMI Projections**

Growth, of course, is good. However, this particular expansion could come at the expense of other construction sectors that are now experiencing their own recoveries and the growth associated with such revival. It could also affect the oil and gas industry itself. The growth in the sector's share of total workers, for instance, is taking place despite concurrent double-digit growth in the U.S. residential sector. This fact alone could put constraints on the rebirth of residential construction across the nation as contractors scramble to fill positions.

Across the 17 craft categories that FMI tracks, the total number of workers required across all categories within the oil and gas industry was 254,600 in 2012 (Table 3). By 2017 this demand will have approximately doubled, leaving more than 247,000 skilled positions unfilled. As any top construction firm understands, mitigating shortages through additional hours and workers often leads to limitations and can take a toll on safety, quality and productivity. And while required skill sets are readily transferable in some cases (i.e., roofers, masons, painters and operators), the oil and gas industry will find itself competing with other construction sectors for available talent while also trying to develop new talent.

**The Value of Construction Put in Place. This is a measure of the value of construction as it is installed or erected at the site during a given period. For an individual project, this includes:**

- Cost of materials installed or erected.
- Cost of labor (both by contractors and force account) and a proportionate share of the cost of construction equipment rental.
- Contractor's profit.
- Cost of architectural and engineering work.
- Miscellaneous overhead and office costs chargeable to the project on the owner's books.
- Interest and taxes paid during construction (except for state and locally owned projects).

**Table 3. Total Construction Employment Demand — Oil and Gas Segment**

## Estimated for the United States

*Thousands of Full-Time Workers*

September 2013

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013e | 2014e | 2015e | 2016e | 2017e |
|---|---|---|---|---|---|---|---|---|---|---|
| Carpet, Floor and Tile Installers and Finishers | 0.5 | 0.6 | 0.6 | 0.6 | 0.7 | 0.8 | 0.9 | 1.1 | 1.2 | 1.4 |
| Sheet Metal Workers | 4.4 | 4.6 | 4.8 | 5.2 | 5.7 | 6.4 | 7.3 | 8.5 | 9.9 | 11.3 |
| Brickmasons, Blockmasons and stonemasons | 1.2 | 1.3 | 1.4 | 1.5 | 1.6 | 1.8 | 2.1 | 2.4 | 2.8 | 3.2 |
| Roofers | 26.7 | 28.3 | 29.7 | 31.8 | 35.1 | 39.0 | 44.6 | 52.1 | 60.5 | 69.2 |
| General and Operations Managers | 4.9 | 5.2 | 5.5 | 5.9 | 6.5 | 7.2 | 8.2 | 9.6 | 11.2 | 12.8 |
| Cost Estimators | 4.9 | 5.2 | 5.5 | 5.9 | 6.5 | 7.2 | 8.3 | 9.6 | 11.2 | 12.8 |
| Drywall Installers, Tapers, Ceiling Tile Installers | 1.1 | 1.2 | 1.2 | 1.3 | 1.5 | 1.6 | 1.9 | 2.2 | 2.5 | 2.9 |
| Construction Managers | 6.8 | 7.2 | 7.5 | 8.1 | 8.9 | 9.9 | 11.3 | 13.2 | 15.3 | 17.5 |
| Cement Masons, Concrete Finishers and Terrazzo Workers | 6.2 | 6.6 | 6.9 | 7.4 | 8.2 | 9.1 | 10.4 | 12.1 | 14.1 | 16.1 |
| Painters and Paperhangers | 4.8 | 5.0 | 5.3 | 5.7 | 6.3 | 6.9 | 7.9 | 9.3 | 10.8 | 12.3 |
| Engineering & Design Occupations | 13.7 | 14.5 | 15.2 | 16.3 | 18.0 | 20.0 | 22.9 | 26.8 | 31.1 | 35.6 |
| Construction Equipment Operators | 10.6 | 11.2 | 11.7 | 12.6 | 13.9 | 15.4 | 17.7 | 20.6 | 23.9 | 27.4 |
| Helpers, Construction Trades | 11.7 | 12.4 | 13.0 | 14.0 | 15.4 | 17.1 | 19.6 | 22.9 | 26.5 | 30.4 |
| Pipelayers, Plumbers, Pipefitters and Steamfitters | 28.2 | 29.9 | 31.3 | 33.6 | 37.1 | 41.2 | 47.1 | 55.0 | 63.8 | 73.1 |
| First-Line Supervisors/Managers | 14.9 | 15.7 | 16.5 | 17.7 | 19.5 | 21.7 | 24.8 | 29.0 | 33.6 | 38.5 |
| Electricians | 15.4 | 16.3 | 17.1 | 18.3 | 20.2 | 22.5 | 25.7 | 30.0 | 34.8 | 39.8 |
| Carpenters | 15.0 | 15.8 | 16.6 | 17.8 | 19.7 | 21.8 | 25.0 | 29.2 | 33.9 | 38.8 |
| Construction Laborers | 22.7 | 24.0 | 25.2 | 27.0 | 29.8 | 33.1 | 37.9 | 44.2 | 51.3 | 58.8 |
| Total | 193.8 | 205.1 | 215.0 | 230.5 | 254.6 | 282.8 | 323.6 | 377.6 | 438.3 | 501.8 |
| % Change from Prior Year | | 6% | 5% | 7% | 10% | 11% | 14% | 17% | 16% | 14% |

## Estimated Composition of Engineering and Design Demand

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Petroleum Engineers | 8.9 | 9.5 | 9.9 | 10.6 | 11.7 | 13.0 | 14.9 | 17.4 | 20.2 | 23.2 |
| Other Engineering and Design | 4.8 | 5.1 | 5.3 | 5.7 | 6.3 | 7.0 | 8.0 | 9.3 | 10.8 | 12.4 |
| Total | 13.7 | 14.5 | 15.2 | 16.3 | 18.0 | 20.0 | 22.9 | 26.8 | 31.1 | 35.6 |

## Estimated Composition of Pipelayers, Plumbers, Pipefitters and Steamfitters

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pipefitters | 16.4 | 17.4 | 18.2 | 19.6 | 21.6 | 24.0 | 27.5 | 32.1 | 37.2 | 42.6 |
| Welders | 10.7 | 11.3 | 11.8 | 12.7 | 14.0 | 15.6 | 17.8 | 20.8 | 24.1 | 27.6 |
| Other | 1.1 | 1.2 | 1.2 | 1.3 | 1.4 | 1.6 | 1.8 | 2.1 | 2.5 | 2.8 |
| Total | 28.2 | 29.9 | 31.3 | 33.6 | 37.1 | 41.2 | 47.1 | 55.0 | 63.8 | 73.1 |

**Source: FMI Projections**

In other instances, the severity of labor shortages is compounded by required skill sets that are more specific to the oil and gas industry. Petroleum engineers, pipefitters, welders, controls electricians, supervisors and managers, for example, will all be in high demand during the next four years, according to FMI's research. One executive of a large global EPC company confirms, "Just like electricity is sold on the spot market when there's an emergency or a hurricane, the price of labor is going to go sky-high. It's a basic supply-demand model. The open-shop-certified welders right now have pushed the rate to $35 per hour and $70 per diem. That's the going rate on the Gulf Coast, up from about $28 per hour a year or two ago." During the five-year period 2012 to 2017, key shortages will include:

| | |
|---|---|
| Petroleum Engineers: | 11,500 |
| Pipefitters: | 21,100 |
| Welders: | 13,600 |
| Supervisors: | 19,000 |

In each case, the demand for these workers will approach twice the current supply. This will require employers to sharpen their focus both in terms of recruiting, training and retaining new talent as well as developing a long-term comprehensive human resource strategy. Without these and other initiatives in place, firms will risk missing this period of impressive growth and expansion within the industry. The rewards are sure to be substantial for those companies that focus on growing and nurturing their talent pools, and challenging, at best, for those firms that take a more languid approach to their human capital.

## The Changing Face of Today's Oil and Gas Industry

### Preparing for the Next Big Labor Squeeze

Industry experts and company leaders alike have been talking about the looming construction labor shortages for years now. The Great Recession has exacerbated this concern due to the thousands of workers that have left the construction industry. Today, the depleted skills and knowledge pool has left contractors across the nation and abroad scrambling for skilled workers to build quality work on time and on budget.

Stephen E. Sandherr, CEO of the Associated General Contractors (AGC) of America, says, "With many former construction workers now employed in other industries, a number of firms are likely to have an increasingly hard time finding enough skilled workers if employment continues to expand."

The U.S. oil and gas construction industry, which did not track the typical slowdown of other construction sectors, is bracing itself for unprecedented labor shortages, particularly in the U.S. Gulf Coast region. An executive at a large international EPCM firm states, "If all the build-out projects driven by the natural gas supply become a reality, then there's going to be a major shortfall of qualified, skilled trades on the Gulf Coast, both for union and open-shop contractors."

These near-term skill shortages will likely peak in 2014 and 2015, when oil and gas construction projects around the Gulf Coast are expected to come online, specifically in the Lake Charles, La., area. Several industry experts pointed out that there were distinct similarities between the work and labor dynamics in today's Lake Charles area and the oil sands region of Fort McMurray, Alberta, Canada, in the mid-2000s. Dan Lumma of Kiewit's Energy Group says, "There is a natural ceiling to the amount of craft, resources, infrastructure, engineering, equipment, etc., that you can apply in one location at one time. It's a self-regulating phenomenon, and clients naturally adjust their schedules to react to those circumstances."

Although craft labor shortages are a regional phenomenon, they can still create a ripple effect across the globe in today's flat and shrinking world. As one labor relations manager for a large global industrial contractor says, "There is a huge skilled international workforce from India and the Philippines that has filled the industry's jobs in the Middle East and Africa for the past decade. Today, this workforce is being lured to countries like Australia, Chile and Canada where they can increase its salary tenfold. This is starting to have an impact on international companies' ability to staff their work in lower-paying regions of the world."

*"I've never known a project that didn't get built because construction firms couldn't find enough labor. Now it may take longer and it may cost more, but we're a pretty innovative nation and we always find a way to get things done."*

– Executive of a large international EPCM firm

## Time to Rethink Old Business Paradigms

Based on these widespread global implications, the need for long-term resource planning and comprehensive risk assessment is becoming ever more important. Construction firms that operate in a direct-perform general contractor role as part of a larger EPC team, for example, have the opportunity to plan for future labor needs well in advance. Kiewit is a good example of a company that places qualified individuals in its clients' and engineering partners' offices. Lumma states, "This is a fairly new strategy that's working out well for the company, particularly with progressive clients who have a long-term vision and strategy."

Several participants in this study pointed out the need for better industrywide coordination in terms of long-term resource planning and project development. As one executive at a large international EPCM firm states, "Company A is doing one thing. Company B is doing something else. In addition, company C is working on five other things. Everyone is stuck in their own corner with their hands over their eyes so that nobody can see or read anything. What's really needed is more transparency and an open dialogue among both contractors and owners industrywide."

Eddie Clayton, contracting strategies manager for the Southern Company Generation, confirms this sentiment, "Companies need to work together to solve these long-term resource problems. If owners are going to leave it solely up to the contractors, then they're going to be sadly mistaken. Owners should develop a craft labor strategy that includes their engagement in workforce development activities. Not only will appropriate involvement help to mitigate project staffing risks but it will also benefit the communities and regions that they serve."

## Changing Labor Dynamics

With the current oil and gas boom ramping up in the United States, many projects are underway, and many more will be kicking off over the coming months. "If all those projects happen, the peak workforce would have to multiply five to six times about what it is right now. The fact is, that's not going to happen," states Lumma. "We're heading into a very, very significant demographic issue."[1]

Under these unprecedented levels of labor pressure, industry participants must acknowledge that, in these transformational times, not all of the previous forms of labor models and business approaches will continue to be appropriate. The changing competitive landscape, combined with emerging technologies and ideas about how to ramp up and organize companies, has become a real force influencing the oil and gas industry. As such, we will likely see more union labor re-entering high-growth markets such as the Gulf Coast area, with owners scrambling to get projects off the ground. As one industry executive points out, "There's a reluctance on the part of the owners to bring back the unions into the market (in the Gulf Coast area), but that needs to be transcended with the pragmatic reality that you cannot get these facilities built all open-shop or all union. It's going to take a combination of the two."

In addition, numerous U.S. construction companies are looking to bring on foreign workers to fill some of the labor void. However, the topic of immigration in the U.S. remains highly

[1] Energy Industry Faced with Possible Workforce Shortage. The Energy Collective. Sarah Battaglia. March 23, 2013.

complicated and controversial, and is unlikely going to solve the immediate labor requirements for the oil and gas industry.

## Success Stories: Preparing for the Next Big Boom

### ARB, Inc.: Stepping Up to the Plate

For Greg Dahl of ARB, Inc., the current labor shortage is less about not being able to find individuals to fill specific job roles and more about not being able to locate ample skilled labor who are properly trained and qualified to do the work at hand. To ward off any challenges that could be coming down the labor pike, Dahl, vice president, says ARB consistently cross-trains its employees, thus creating a "fully diversified" workforce that can handle myriad tasks and responsibilities.

"As a company, we do all types of pipeline work, not only oil and gas, but also pipeline rehabilitation and water work. You name it, we do it," says Dahl. "In order to hold on to a competent workforce to handle all of that, we're always cross-training. That allows us to identify future needs and, ideally, have the employees working on other projects until the need arises." The fact that the U.S. workforce is aging – and that millions of baby boomers are heading into retirement – also challenges companies like ARB, which is bringing in younger workers to offset the exodus. That younger blood creates an entirely new set of challenges, according to Dahl. "Most of them would rather be in front of computers," says Dahl, "and doing less physical work."

### Developing Stability and Continuity

A union shop, ARB is signatory to contracts with the building trades and the United Association, which includes welders, plumbers and pipefitters. As such, the company has partners when it comes to finding skilled labor. Ultimately though, ARB is responsible for the quality and competency of its workforce. The challenges are many: seeking out individuals who have the potential to succeed, contribute and grow; outlining the opportunities that will exist for those who are prepared; and providing ongoing training in all aspects of pipeline construction, jobsite management, behavior-based safety initiatives, awareness of environmental best practices, and importantly, offering feedback on performance, naming just a few of them. Like most companies in the oil and gas sector, ARB wants to develop and maintain a stable workforce. To make that happen, ARB will in some cases pay higher than union scale, depending on skill and experience levels. "I've never had a case where a union objected to us paying its people more than the scale wage," says Dahl.

The company also provides incentives to employees who "show initiative and leadership qualities," says Dahl. "We feel like we offer the best environment, opportunities and compensation to retain the people and the workforce that we need. That commitment has served us well." As a result, ARB's workforce has been trained and shaped over years and understands how to be highly productive, safe and make money on jobs. "Some of our people, I've worked with for more than 20 years. They're more productive compared to workforces of other companies that tend to go through cycles of hiring and firing," explains Dahl.

### New Regulations, New Training Requirements

Looking ahead, Dahl expects the cost of getting a new employee up, running and productive to increase due to new operator qualification requirements, certifications and safety standards. "The level of training, knowledge and awareness expected of an individual who worked on pipelines 10-20 years ago wouldn't be acceptable today," Dahl points out. "There's just so much more that you have to know and such extensive training to undergo."

Safety, for example, was not understood as a key component of productivity. Today it is an integral part of everything companies like ARB do. In fact, Dahl says there are direct correlations between productivity, safety and lower costs. "Everything these days is integrated as a comprehensive approach to performing the work," says Dahl, "so it costs a lot more to put a competent worker out in the field."

The industry's commitment to safety and increased regulation is not going away and neither is the anticipated labor shortage. These two trends will continue to put pressure on companies like ARB to build long-term, reliable workforces that stay in place as long as possible and that get the job done in a timely, productive and safe manner. "We're constantly trying to understand and work through issues regarding regulations, certification requirements, new safety standards, etc., and make sure that everyone is correctly trained," says Dahl. "We're working our way through all of that now."

### Kiewit: Getting in on the Ground Floor

Labor constraints are taking their toll on the oil and gas industry, where executives like Dan Lumma of Kiewit's Energy Group work harder these days to get in on the "ground floor" with client projects. Operating in a direct-perform general contractor role as part of a larger EPC team – as opposed to working in a subcontractor role – Kiewit often gets involved with jobs several years before they even break ground.

"That gives us the opportunity to plan for future labor needs well in advance," says Lumma, senior vice president. During the months or years leading up to a new project, for example, Kiewit places qualified individuals in its clients' and engineering partners' offices. Lumma says this is a fairly new strategy that is working out well for the company, particularly with progressive clients who have a long-term vision and strategy.

For Kiewit, that level of labor planning takes on several forms. The company establishes relationships with the respective entities years before the project even starts, including working with local union halls, and talking to them about our manpower peaks over time," Lumma explains.

### Keeping Workers Safe and Engaged

To help manage the war for skilled craft labor, Kiewit focuses on the long-term, safe, controlled work environment that it can provide. "On good project sites that extend over time," says Lumma, "we usually don't have much of a problem with high turnover."

With approximately 10,000 staff members, Kiewit hires anywhere from 1,200-1,400 new employees annually. Most are graduate engineers and business managers right out of college, says Lumma. Those individuals are trained and developed by the company's senior managers and supervisors, many of whom have been with the company for 15-20 years. "A portion of their job responsibility is to develop new employees, from senior managers all the way down to first-line supervisors," says Lumma, who expects that internal commitment to training will be an important strategy as the labor market heats up even further over the coming years.
For craft labor, Kiewit aims to retain highly skilled workers whenever possible. "We try to take them to the next project," says Lumma, "instead of letting them sit on the bench for months at a time in between projects."

### Changing the Business Paradigm

Pointing to the Lake Charles, La., region, Lumma says the area looks a lot like the Fort McMurray, Alberta, region did back in the mid-2000s. "Lake Charles is going to be one of the most overheated regions in the near future," says Lumma. When that happens, he says there will be a natural ceiling to the amount of labor, resources, infrastructure and staff that can be mobilized in a single location at any given time. "It's a self-regulating phenomenon that we saw happen at Fort McMurray," says Lumma, "and clients naturally adjusted their schedules to react to those shortages."

Lumma points out that the industry as a whole needs to change the way these types of projects are planned and carried out in the future. "I don't think the industry should approach these new projects in a business-as-usual sort of way, but instead everyone ought to take on a more progressive, long-term view of how to approach these projects in the planning stage, engaging people early on so that they can help overcome these resource challenges," says Lumma.

### Henkels & McCoy, Inc.: Bracing for the Next Big Surge

With the national construction market solidly in recovery mode, the leadership team at Henkels & McCoy, Inc. knows it is only a matter of time before finding skilled workers to fill field positions becomes a challenge. Finding experienced construction management superintendents and project managers will not be any easier, predicts John Harrower, vice president and division manager of the pipeline construction division, namely because so many of these individuals exited the industry during the economic recession.

"Individuals who can implement and manage project controls, manage cost controls and forecasting, and handle scheduling are already in short, short supply," says Harrower, who is also seeing a dearth in the number of experienced "front-end" professionals who can deftly assess potential projects and submit bids when applicable. These "basic estimating skill sets" have been hard to come by for several years, according to Harrower, who sees that early, upfront work as an essential component for successful projects.

At this point, Henkels & McCoy is covering its projects across all areas where employees are getting harder to find and recruit. "We have good control over what we already have in-house right now," says Harrower, "but if we had more candidates in each of the three areas (superintendents, project managers and front-end types), we'd be able to undertake a lot more work as the market continues to heat up."

### Shifting Positions

One way Henkels & McCoy is offsetting the labor shortage issue is transferring administrative professionals into its estimating group and building up the latter in a way that will allow the company to bid on more projects. On the project management side, the company relies on an in-house job rotation and management training program called Growth Opportunities for Leadership Development (GOLD), which focuses on candidates who already have some level of construction management expertise but want to fast-track their project management development. GOLD participants rotate through assignments in seven different operations platforms over a 21-month period, allowing them to take on larger responsibility upon graduation from GOLD more quickly than those who have not gone through the program.

"Where it used to take 15-20 years to build a senior project manager, we're now able to fast-track them within six to eight years," Harrower explains. The GOLD program incorporates a pipeline division sponsor who also heads up the project management group. Responsible for bringing in new talent, evaluating the candidates every three to four months and then rotating individuals through different assignments on a quarterly basis, the sponsor helps candidates get an "overall perspective of everything that they need to manage, and within a much shorter time frame," says Harrower. He adds, "That way they get an overall perspective of everything they need to manage a lot quicker than they normally would in their career."

As part of this development program, Henkels & McCoy is very strategic about promoting foremen into assistant superintendent roles – in an effort to build more superintendents organically. "That takes some time to cultivate," says Harrower, "but it's a solution that we're using on several of our larger projects right now."

Finally, Harrower says Henkels & McCoy has taken a closer look at the specific skill sets needed within the pipeline division and the role that those skill sets play within the various projects that the company undertakes. This exercise has helped the company build "pools" of employees who can cover specific aspects of a project while also giving individuals more job options. A new employee, for example, can get his/her feet wet doing less complicated work, while a senior project manager would take on a larger role within a bigger project. "That effort is part of an ever-changing commitment to continuous improvement that's underway here at any given moment," says Harrower.

### Reputation Counts

Growing organically is one thing, but attracting new blood to the workforce requires a different level of effort. To keep its new employee pipeline growing, Henkels & McCoy leans on its reputation of 90 years as a privately held, large company in its field. "We have an incredible reputation for maintaining people and continuity," says Harrower. "Our average management tenure is very high and our attention to safety is very well-known."

Harrower says Henkels & McCoy's attention to safety and commitment to running a best-in-class organization will help tackle the looming labor crunch. "We're definitely on the right road, with a focus on project management and project controls on our jobs that wasn't seen in the pipeline sector for many generations," says Harrower. "As clients become more sophisticated and jobs more complicated and expensive, we'll be gearing up to handle the project backlogs that we're seeing and bracing ourselves for an interesting second half of the year."

## Top Business Imperatives for Energy Infrastructure Construction Firms

Following is a summary of the top-five business fundamentals pulled from 25 in-depth interviews with executives of energy infrastructure construction firms and select FMI industry experts.

1) **Develop comprehensive in-house training programs and build long-term knowledge pipelines.** The recent expansion of the U.S. oil and gas industry coupled with the retirement of many experienced supervisors is causing overstretched construction firms to rethink their training and succession plans. Successful companies are developing comprehensive knowledge transfer programs, shifting knowledge from senior (and soon-to-be-retiring) employees to the next generation and leveraging organizational expertise and best practices across the business.

   Fast-track leadership programs are also becoming critical as experienced craft workers move into leadership and mentor roles, training less experienced employees in a very short time frame. As one industry executive explains, "With the limited amount of skilled labor available, we took many of our company's highly skilled craftsmen and turned them into supervisors to help manage less experienced workers. These skilled craftsmen went from being welders one month to foremen the next month, which doesn't necessarily mean they're good-quality supervisors. Leadership and mentoring skills are very different from technical expertise."

   In the fast-paced oil and gas industry, a purposeful approach to training and knowledge transfer will not only significantly increase the readiness and skill sets of the employees, but also will attract new talent to the industry with the compelling story of commitment to the individual employee. For energy infrastructure construction firms to succeed, they will have to effectively attract, develop and retain human resources. Developing a long-term strategy to address these human talent issues and following through with diligence and consistency on the execution of that strategy will become the key competitive differentiators among firms in the oil and gas sector.

*"With the limited amount of skilled labor available, we took many of our company's highly skilled craftsmen and turned them into supervisors to help manage less experienced workers. These skilled craftsmen went from being welders one month to foremen the next month, which doesn't necessarily mean they're good-quality supervisors. Leadership and mentoring skills are very different from technical expertise."*

— Industry Executive

*"In construction there's a lot of emphasis on individual achievement. As a result, rather than rewarding soft skills around leadership or mentoring, we often tend to look at individual performance. It's definitely an area where the industry as a whole needs to transform in the coming years."*

— CEO of a pipeline construction company

2) **Engage your people and provide a healthy, safe work environment.** In an industry that is constantly in flux and characterized by extreme working conditions, company executives must keep their employees engaged and devoted on a daily basis. Industry leaders who have established a good reputation over the years with corporate cultures focused around safety, education and employee well-being find themselves at an advantage in the war for talent. Rena Lo, human resources manager at AMEC Oil and Gas, Inc., states, "If we're talking about retention, then two things are very important: Employees have to like what they do and also like the people they work with/for."

   Motivation, reward management and performance appraisal largely drive employee retention and satisfaction. Even when offered higher salaries and/or compensation packages, for example, the most engaged and trained employees are less likely to jump ship.

   Cory Jodoin, president at Jen-Col Construction, confirms, "It really must be more than just the dollars. Every single person in my company can find a job elsewhere that will pay more than what they earn here at Jen-Col. So you need a culture where people value more than dollars. That's the challenge: coming up with a plan for retention, training, development and making every job meaningful. Just really creating opportunity, growth and development for people – that is key."

   Another industry executive adds, "A key focus for us is succession, and we try to keep our people engaged at all times. You have to treat people right, and these days many companies don't seem to invest enough in their people."

   In addition to the methods mentioned above, the oil and gas sector is using techniques like e-learning to retain current employees and recruit new ones. Also playing a key role in both retention and recruitment are fundamentals such as safety culture, working conditions, supervision, co-workers/interpersonal relationships, job security and organizational policies.

3) **Integrate HR with other core business functions.** Look at your organizational structure and re-evaluate how all the different departments and business units are performing – both together and separately. Over the last few years, CEOs in the construction industry have started to look for synergies among functional areas, finding ways to leverage support functions, such as HR, IT and finance, to be "fit for a purpose" and ensure that they are more closely aligned with the overall enterprise strategy. Jason Baumgarten, FMI's Western consulting group manager, explains, "I see a lot of stand-alone systems work counter to each other. It can be very inefficient. For example, if you have a strong HR department and are hiring great people but have no systems in place – such as a strong career path or effective incentive-based compensation program – then you'll end up being a prime target for your competitors to recruit from."

   In the oil and gas sector, specifically, this could not be more accurate. Human capital has become a hurdle, and overcoming that obstacle requires buy-in from technical, operating and HR leaders. From the board down to the individual operating company level, new attention is being paid to human resource functions whose operational objectives must be linked to the firm's overall operating targets. Aligning different business functions in more integrated ways will help increase communication across the organization and push employees to work collaboratively and more effectively toward common strategic goals.

4) **Understand your (human) risk**. According to the Bureau of Labor Statistics, the U.S. oil and gas industry lost a record number of workers on the job in 2012 – the same year that industry fatalities increased to 138 from 112 (in 2011). This represents a 23 percent increase and the largest number of oil and gas worker fatalities since the current data series for the BLS Census of Fatal Occupational Injuries (CFOI) began in 2003.

   These numbers echo the rapid pace at which the oil and gas industry has been expanding in recent months. As energy infrastructure construction firms scramble for skilled workers to keep up with demand, companies are more apt to hire less experienced workers who lack the necessary safety training or technical skills. An executive of a large EPC firm states, "We've seen brokers recruit people who worked as fishermen in the past and say they can weld and now they're applying for offshore welding jobs. Most of these people don't have any experience working in safe environments, and it's a huge risk for a company like ours to hire them on our projects."

   To circumvent this whole frenzy and scramble for last-minute "bodies," construction firms and end users/owners must rethink their collaboration efforts. Progressive energy infrastructure construction firms are already looking into innovative partnering approaches as witnessed in the case of Kiewit, where the company establishes relationships with the respective entities years before the project even starts, including working with local union halls and talking to them about their labor peaks over time.

   In the oil and gas industry, where owners demand rigorous safety standards and thorough risk management practices, construction companies cannot afford to make any mistakes. A competent workforce – particularly skilled supervision – will become ever more crucial in managing risk and productivity on oil and gas construction projects. Mark Breslin, CEO of United Contractors and author, adds, "In five to seven years, I believe a contractor's ability to grow will hinge on their ability to procure competent field supervision. The boomer retirement curve is going to be painful. It won't be bonding, capital or the market – but contractors' ability to provide qualified foremen superintendents who can build work in a risk-averse environment."

5) **Work smarter and increase project management capacity.** Oil and gas projects worldwide are increasing in complexity and scope as more companies discover new frontiers and invest in non-traditional exploration methods. Environmental impact, employee safety and strict adherence to budgets and schedules top the list of stakeholder concerns. Successful energy infrastructure construction companies are investing heavily in building their project management capacity by innovating in areas such as prefabrication, technology, knowledge management, communication, among other things. In the coming years, clients will focus on construction companies that can limit rework orders; optimize labor, equipment and materials scheduling; and use a modular approach to project management. These tactics will help improve productivity and manage costs in a tight labor market – two key concerns for owners in this sector.

*"In five to seven years, I believe a contractor's ability to grow will hinge on their ability to procure competent field supervision. The boomer retirement curve is going to be painful. It won't be bonding, capital or the market – but contractors' ability to provide qualified foremen superintendents who can build work in a risk-averse environment."*

— Mark Breslin, CEO of United Contractors and Author

*"If construction firms active in the oil and gas sector had invested in hiring and training talent back in 2010-11, they would be significantly more profitable today. Instead, most firms are today confronted with a chronic shortage of engineers, project managers and skilled tradesmen. And odds are that situation will worsen in the years ahead."*

— Michael Mangum, Senior Consultant with FMI's Center for Strategic Leadership

Brian Johnson, executive vice president at Michels Corporation, states, "Due to the current shortage of skilled welders as a result of the increased volume of pipeline work throughout the country, we are taking a harder look at automated welding systems to offset the needs that our clients are requiring of us. Although this only helps in the larger diameter pipe sizes."

Don Thorn, president at Welded Construction, adds, "We're seeing some advancements of processes and equipment through the use of technology. The long, large-diameter pipes will probably be done with mechanized welding in the future, and that will certainly help with the craft shortages to some extent. As a result, we will need people with experience utilizing mechanized welding equipment and increased training activity from our labor forces."

## Planning for Future Labor Needs

The U.S. oil and gas industry is on the brink of its largest human capital shortfall as it faces one of the most significant expansion periods in its history. If companies do not figure out how to transfer knowledge from soon-to-be-retiring employees to younger generations of workers, decades of industry wisdom and expertise will be lost forever over the next five to seven years. Fierce competition for talent in this sector is already driving energy infrastructure construction firms to rethink their human capital needs and optimize access to – and retention of – qualified and experienced workers. Some firms have circumvented the crisis by simply poaching talent from competing firms or leaning even more heavily on their veteran workers. Unfortunately, these are stopgap measures at best.

Successful companies are thinking long term and building new talent pipelines, developing targeted interventions, assessing the business impact of skills shortages and considering the options available to build competency. While there is no silver bullet to solve significant skills shortages (the ongoing nursing shortage is a good example of this), tactical combinations of programs and new paradigms will become the standard as the U.S. oil and gas industry labor shortages exacerbate. Potential implications for the industry might include higher wage-push inflation, potential decreases in international competitiveness and even the erosion of future domestic oil production capacity.

In Canada, for example, FMI consultants have observed a shifting HR strategy to finding/hiring talent regardless of current project demands or needs. Put simply, progressive companies are actively building their benches in anticipation of future projects and are willing to take a P&L hit to avoid labor crunches. As Michael Mangum, senior consultant with FMI's Center for Strategic Leadership, explains, "If construction firms active in the oil and gas sector had invested in hiring and training talent back in 2010-11, they would be significantly more profitable today. Instead, most firms are today confronted with a chronic shortage of engineers, project managers and skilled tradesmen. And odds are that situation will worsen in the years ahead."

It is time to tie HR objectives directly to business objectives and build continuous feedback loops that help improve management techniques and ultimately influence strategy. Through these and other efforts, oil and gas infrastructure construction firms will find themselves better positioned to tackle the labor shortages and move beyond to ongoing success. Without these proactive moves, the U.S. oil and gas construction industry will struggle to right itself during a period of unprecedented labor shortages.

For more information please contact: Sabine Huynen Hoover, Senior Research Consultant, at 303.398.7238 or via email at shoover@fminet.com

Scott Duncan, Vice President, at 303.398.7250 or via email at sduncan@fminet.com

W. Christopher Daum, Senior Managing Director, at 919.785.9264 or via email at cdaum@fminet.com

# About FMI

FMI is a leading provider of management consulting, investment banking† and research to the engineering and construction industry. We work in all segments of the industry providing clients with value-added business solutions, including:

- Strategic Advisory
- Market Research and Business Development
- Leadership and Talent Development
- Project and Process Improvement
- Mergers, Acquisitions and Financial Consulting†
- Compensation Benchmarking and Consulting
- Risk Management Consulting

Founded by Dr. Emol A. Fails in 1953, FMI has professionals in offices across the U.S. We deliver innovative, customized solutions to contractors, construction materials producers, manufacturers and suppliers of building materials and equipment, owners and developers, engineers and architects, utilities, and construction industry trade associations. FMI is an advisor you can count on to build and maintain a successful business, from your leadership to your site managers.

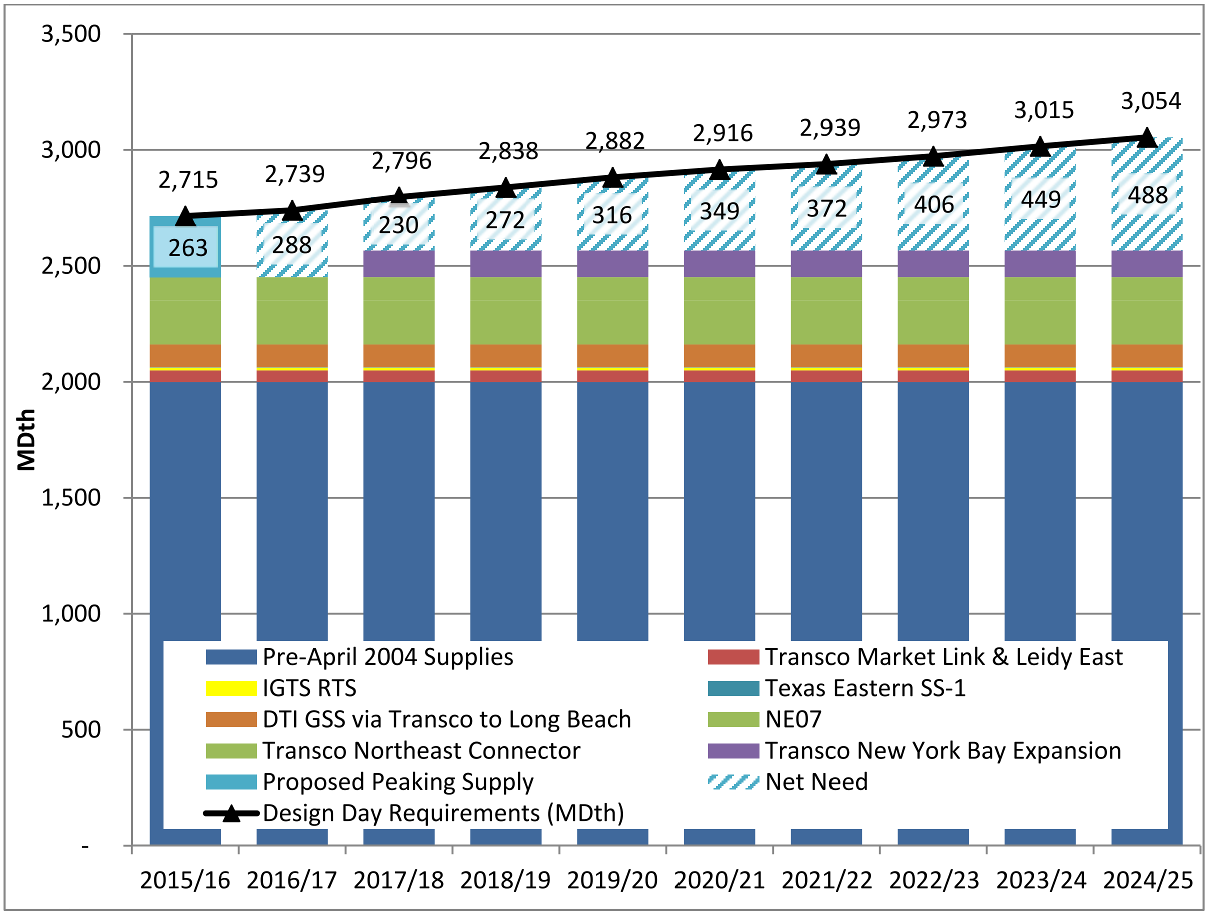
FMI

*Sixty Years*



*† Investment banking services provided by FMI Capital Advisors, Inc., a registered broker-dealer and wholly owned subsidiary of FMI.*

Downstate NY Supply/Demand Balance




For the 2015/16 design day, the portfolio will require approximately 263 MDth of city gate delivered supplies to meet forecast customer requirements. This need for incremental supplies grows to 288 MDth in 2016/17. However, for the 2017/18 winter, the Company expects that the Transco New York Bay Extension project will be in service, providing an additional 115 MDth/day of capacity to the Company's Transco city gates (as discussed further in response to Question 29). Therefore, the need for city gate delivered supplies is reduced to 230 MDth in 2017/18.

Beyond 2017/18, forecast customer requirements continue to grow. Although the Company intends to rely on city gate delivered supplies to meet a portion of customer requirements, National Grid is also exploring options to build incremental capacity to the Downstate NY region. The parties and potential projects are identified in the response to Question 32.