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Con Edison DER Potential Study

Supplemental Report: Natural Gas Add-on Analysis

Prepared for:

Consolidated Edison Company of New York, Inc.

FINAL REPORT

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1 Summary of Work

The scope presented in this supplement report to the core distributed energy resource (DER) Potential Study includes three different tasks for natural gas energy efficiency (EE) and one for gas demand response (DR) potential analysis.

1. Adding five (5) new EE measures, not included in the core DER potential analysis
2. Reporting EE potential savings for peak day impacts, which requires defining the gas peak period
3. Reporting EE potential savings by gate station
4. Conducting a gas DR potential analysis

All methodologies and approach to the potential analysis are based on the core DER potential study. Please refer to the main report for details. This supplement only discusses the methodology and approach for the specific tasks covered in this scope.

2 Introduction

Currently, Con Edison is forecasting a shortfall in existing pipeline capacity by 2023 due to the population growth and encouraging customers to switch from fuel oil to natural gas heating.[1] This work provides additional insight into the gas savings potential for both annual reductions and peak day reduction. Furthermore, the potential results are provided by gate station to further inform Con Edison program planning efforts to reduce any future pipeline capacity constraints. As part of this effort, Con Edison increases the number of EE measures modeled and is exploring the opportunities that may be offered by gas demand DR, which is a relatively new concept in the industry.

3 Energy Efficiency Methodology and Approach

This section provides the description of the methodology and approach for the activities included in the gas potential energy efficiency add-on analysis.

3.1 New Energy Efficiency Measures

Navigant presented a list of gas energy efficiency measures to consider for inclusion into the potential analysis to Con Edison. Con Edison selected the bolded items. The biggest factor in the selection process was identifying measures that have a potential for future annual and peak day savings.

- Residential
    - a. **Hot Water Tank Blanket**
    - b. **Hot Water Set Point Reduction**
    - c. Indirect Water Heater
    - d. **Hot Water Pipe Insulation**

[1] http://globenewswire.com/news-release/2017/10/03/1140234/0/en/Con-Edison-Offers-New-Ways-to-Meet-Growing-Natural-Gas-Customer-Needs.html

e. **Weatherization Measures** – e.g., Window and Through-the-Wall Air Conditioner Cover and Gap Sealer
f. Thermostatic Shower Restriction Valve
g. Duct Sealing and Insulation
h. Furnace Tune-Up
i. Outdoor Reset Control, for Hydronic Boiler
j. Thermostatic Radiator Valve - One Pipe Steam Radiator

- Commercial and Industrial[2]
    a. Boiler Tune-Up
    b. Boiler Controls
    c. Boiler Economizers
    d. Window Film
    e. Window Glazing
    f. Indirect Water Heater
    g. Low-Flow Pre-Rinse Spray Valve
    h. Duct Sealing and Insulation
    i. Commercial Dishwashers
    j. Commercial Cooking Equipment
    k. Commercial Condenser Heat Recovery
    l. Commercial Ozone Laundry

Table 1 provides a summary of the measure characterization that Navigant conducted for the selected measures. Navigant leveraged the New York TRM v4.0[3] and any amendments, as applicable.

[2] Boiler tune up and controls are considered subsets of previously analyzed measures (retro-commissioning and energy management systems, respectively).
[3] http://www3.dps.ny.gov/W/PSCWeb.nsf/All/72C23DECFF52920A85257F1100671BDD?OpenDocument

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Table 1. Summary of Additional Gas Energy Efficiency Measures

Name	Sector	Description	Therm (Th) Savings / Year	Peak Day Impact	Cost [4]	Density / Technical Suitability	Energy Efficiency Saturation (Source)
Hot Water Tank Blanket	Residential (Single Family [SF], Multi Family [MF])	Adding 2 inch fiberglass insulating blanket around storage water heater	20.2 Th/yr. per water heater	0.067 Th per water heater	$75 per water heater	100%	11% (Xcel Potential Study 2016)
Hot Water Set Point Reduction	Residential (SF, MF)	Adjusting water heater temperature setpoint from 135°F to 120°F (standby losses only)	3.8 Th/yr. per water heater	0.013 Th per water heater	$0, add-on to direct install measures	96% SF, 80-99% MF	48% SF, 32-54% MF (Xcel Potential Study 2016)
Hot Water Pipe Insulation	Residential (SF, MF)	Adding insulation to bare metal piping serving domestic hot water and space heating applications	7.5 Th/yr. per linear foot (ft.)	0.025 Th per linear ft.	$10 per linear ft.	100%, assumes 6 linear ft. per install	30% (Average saturation from water heating measures in Xcel Potential Study 2016)
Weatherization Measures	Residential (SF, MF)	Installing insulated covers on through-the-wall air conditioning (AC) units, and performing air sealing	45-77 Th/yr. per home[5]	0.4-0.6 Th per home	$140 per home	100% SF, 50% MF	50% SF (Xcel Potential Study 2016), 79-92% MF (2017 Con Edison Density and Saturation)
Low-Flow Pre-Rinse Spray Valve	Commercial (select segments)	Installing a high efficiency pre-rinse spray valve in commercial kitchens	348 Th/yr. per spray valve	1.1-1.8 Th per spray valve	$90 per spray valve	Varies, commercial kitchen density	20% (PSE Potential Study 2015)

[4] Con Edison provided Navigant the measure costs for all measures.
[5] Per home is the same as per dwelling unit for multi-family buildings.

3.2 Peak Day Impacts

To calculate peak day impacts, Navigant determined a definition for the peak period and a methodology for calculating the peak day gas consumption. Additionally, Navigant quantified the average peak day consumption, as the demand reference case, for the potential study period.

Peak Period Definition

Con Edison's Resource Planning group designs the company's peak gas demand forecast based on a day that has a temperature variable (TV) or average daily temperature equal to 0^{o}F based on the Central Park, NY weather station. Con Edison's calculation is over a 2-day period (10 am on day 1 to 10 am on day 3). Con Edison uses a weighted average, ascribing 30% of the weight to day 1 (10 am on day to 10 am on day 2) and 70% to day 2 (10 am on day 2 to 10 am on day 3). If this TV is less than or equal to zero, then day 2 is considered a peak day.

Navigant did not use the Con Edison definition since the average temperature of 0^{o}F has not actually occurred. Additionally, it will not reflect peak day definitions for DR program planning and calculating potential savings during peak days. Therefore, Navigant used the following methodology for identifying the gas peak period.

Navigant evaluated Con Edison daily throughput data (i.e., gas purchases) from 11/1/14 through 7/30/17. Navigant assigned each day to a month and day type (weekend or weekday). Navigant calculated the average throughput values for weekdays and weekends in each month. Navigant determined that the highest average value was for weekdays in January. Navigant then compared the remaining average values to January weekdays as a percentage. February weekdays had an average throughput within 2% of January weekdays. All other values were more than 5% less than January weekdays.

Figure 2 shows that January and February have markedly higher gas throughput than other months and day types. Thus, Navigant determined that weekdays in January and February constitute the peak period.

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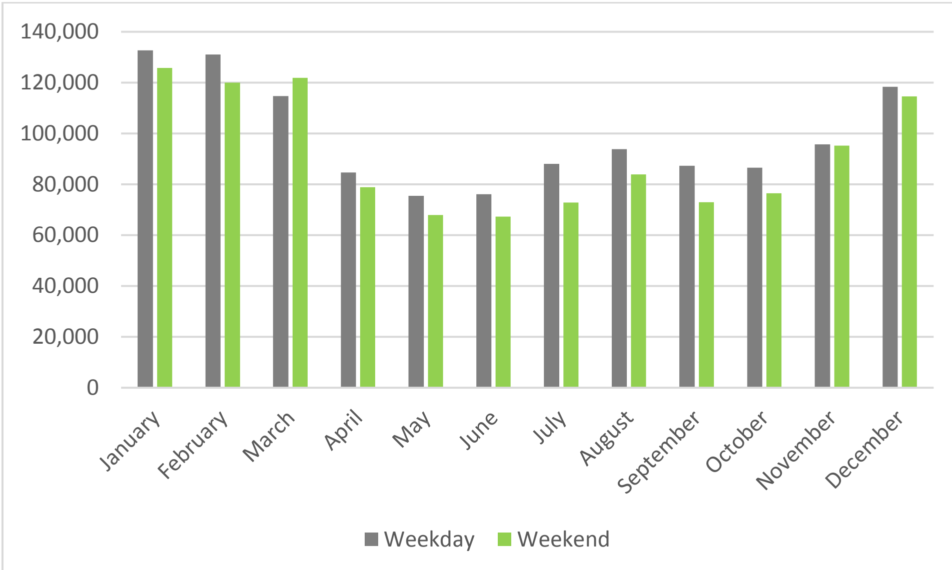
Figure 2. Gas Throughput by Month, by Day Type



Peak-Day Gas Impact Calculation Methodology

Navigant used the 8760 load shapes developed for the core DER Con Edison potential study. The report for the DER potential study[6] provides an explanation of the load shape development methodology and analysis. These load shapes leverage the DOE commercial and residential prototypical models. Navigant assigned each measure to a load shape where a unique load shape exists for each segment and end use. The defined gas end use load shapes for all building types are total facility, heating, hot water, and interior equipment. A load shape provides the hourly percentage of annual load for a specific end use, meaning that the sum of hourly fractions over one year will result in one Therm. From these load shapes, Navigant calculated a peak load shape factor for winter peak periods:

$$Peak\ Load\ Shape\ Factor = \sum_{i}^{n} Hourly\ Fractional\ Load_i$$

$$PLSF = HFL_{Hour\ 1} + HFL_{Hr\ 2} + HFL_{Hr\ 3} + HFL_{Hr\ 4} \dots + HFL_{Hr\ 959} + HFL_{Hr\ 960}$$

Where, i = the hour during peak period for n hours. For example, the winter peak period is the 24 hours starting midnight to midnight January and February for weekdays. This results in 40 days (or 960 hours) of winter peak period. The sum of the hourly fractional load during these hours multiplied by the annual Therm savings for the measure equals the measure peak impact savings.

[6] Section 2.2.1 – Load profiles and End-Use Load Shape Development

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$$Peak\ Day\ Impact\ Savings = \frac{Peak\ Load\ Shape\ Factor\ x\ Annual\ Therm\ Savings}{Peak\ Period\ Days}$$

For this methodology: PLSF/40 is equal to the percentage of a measure's energy savings that occur on a single peak day. For example, a Multifamily EMS measure, which for illustrative purposes has an average annual savings of 2,500 therms, gets assigned to the MF-Common Area + Gas Heating load shape with a PLSF of 0.3275. This yields a peak day savings percentage of approximately 0.8% of its annual savings. In other words, 32.75% (the PLSF) of the savings occur during the 40 day peak period.

$$Peak\ Day\ Impact\ Savings = 20.5\ \frac{Therms}{Day} = \frac{0.3275\ PLSF\ x\ 2{,}500\ \frac{Th}{yr}}{40\ Days}$$

Peak Day Consumption Reference Case

To provide a baseline, Navigant calculated the peak day reference case. This value was derived using the base year annual consumption of the firm customers at 149,176,129 dekatherms (DTh)/year. In using the whole building gas peak load shape factors, Navigant calculated consumption by building segments (developed for the core DER potential study customer segmentation). Table 3 provides the detailed data for developing the average peak day consumption.

Table 3. Calculating Average Peak Day Consumption

Customer Segment	Annual Consumption (DTh)	Peak Load Shape Factor	40-Day Peak Period Consumption (DTh)	Average Peak Day (DTh)
Education	1,624,421	0.2918	473,974	11,849
Grocery	1,074,657	0.2493	267,900	6,697
Hospital	937,244	0.1509	141,405	3,535
Large Multi-Family - Res	40,212,367	0.3275	13,171,413	329,285
Large Office	1,514,812	0.2098	317,872	7,947
Large Retail	805,042	0.2931	235,951	5,899
Miscellaneous/Entertainment	3,279,061	0.1945	637,655	15,941
Multi-Family - Common Area	28,909,591	0.3275	9,469,230	236,731
Nursing Home/Lodging	2,063,248	0.1467	302,662	7,567
Restaurant	7,755,882	0.1868	1,448,543	36,214
Single Family - Res	22,206,694	0.3275	7,273,721	181,843
Small Multi-Family - Res	14,670,410	0.3275	4,805,239	120,131
Small Office	13,041,811	0.2098	2,736,724	68,418
Small Retail	6,181,784	0.2921	1,805,997	45,150
Warehouse/Industrial	4,899,107	0.3221	1,578,111	39,453
Total	**149,176,130**		**44,666,396**	**1,116,660**

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Navigant forecasts the average peak day consumption (Table 4) for the project analysis period using data provided with the 2017 CECONY firm volume gas forecast.

Table 4. Peak Day Consumption Reference Forecast

Year	Growth Rate	Peak Day (Dth/day)
2017	0.028578	1,116,660
2018	0.024644	1,148,572
2019	0.015760	1,166,673
2020	0.017901	1,187,559
2021	0.004915	1,193,396
2022	0.015293	1,211,647
2023	0.012548	1,226,851
2024	0.011883	1,241,430
2025	0.010920	1,254,986
2026	0.011509	1,269,431
2027	0.009583	1,281,595
2028	0.009583	1,293,877

Source: 2017 CECONY firm volume gas forecast and Navigant analysis

3.3 Gate Station Analysis

Con Edison has concerns about localized constraints at certain distribution locations in their gas network. This supplement reports potential for each of Con Edison's gate stations to expand on Navigant's original DER potential analysis, which reported results by Westchester County and the five New York City boroughs. These results can inform Con Edison on future planning efforts.

Con Edison produced a data extract of its customers and tagged each account with the gate station that serves the customer. This tagging provided the data for annual gate station consumption. For this scope, Navigant segmented the customer data by gate station and building type for potential analysis. The data is summarized by gate station (and county) in Table 5.

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Table 5. Gate Station Consumption, Firm Customers only (DTh/year)

Gate Station Name	New York City	Westchester County
Hunts Point	41,498,493	
Lower Manhattan	14,360,584	
Queens	23,031,192	
Upper Manhattan	38,339,383	
Cortlandt		327,178
Knollwood		4,896,310
Peekskill		2,256,400
Rye		7,067,393
Sommers		88,970
White Plains		16,912,401
Yorktown		397,827
Total	**117,229,652**	**31,946,478**

4 Gas DR Research, Methodology, and Approach

Over the years, gas utilities have utilized traditional load management methods such as interruptible tariffs to accommodate various supply constraints on the gas system. But these methods are dated and do not account for more recent developments in the natural gas market, including de-regulation on the supply side and updated technologies (including controls) on the customer side. Further, these legacy programs were limited to the largest gas customers, typically non-firm industrial facilities. In this analysis, Navigant conducted benchmark research on current gas demand response (DR) efforts, collaborated with Con Edison to finalize a list of DR measures for the study, characterized the selected DR measures, and modeled the technical, economic, and achievable potential for each gate station in Con Edison's gas service territory.

4.1 Gas DR Benchmarking Research

Navigant conducted an initial review of gas demand response or demand reduction programs across the country to understand what program designs, technologies, and methods have been employed to date. Through our research, we came across the three main types of gas DR programs:

1. Residential Thermostat Gas DR
2. C&I Automatic Fuel Switching (Gas to Fuel Oil)
3. C&I Manual Fuel Switching Daily (Interruptible Natural Gas Rates)

These programs highlight some of the challenges with historical gas DR opportunities. Historically, most programs required some form of backup energy source (e.g., fuel oil, steam, etc.) to offset the natural gas demand for key pieces of equipment. Few residential and commercial gas-fired loads have had connected controls with capabilities to communicate with the outside signals. Beyond the building technologies themselves, the metering and communication hardware (e.g., telephone telemetry) was expensive and complicated. Recent trends in end-use and metering technologies have enabled more building segments and end-use loads to potentially participate in gas DR programs.

The following descriptions provide a summary of each gas DR program type:

1. Residential Thermostat Gas DR
    - Southern California Gas Company (SoCalGas) developed a program using smart thermostats connected with smart gas meters. The program makes small adjustments in temperature setpoints to provide natural gas demand savings when aggregated over a large area, similar to electric smart thermostat DR programs. Energyhub operates the program using ecobee thermostats and offers a $50 rebate to customers ($25 at signup, $25 after the heating season) Link
    - National Grid in Massachusetts is piloting a similar program with Massachusetts Department of Energy Resources (MassDOER) and Fraunhofer Center for Sustainable Energy Systems. Limited details are available currently, as the project was only awarded in June 2017. Link
2. C&I Automatic Fuel Switching (Gas to Fuel Oil)
    - Past National Grid programs (2012-2017) in New York City achieved gas peak demand reduction for C&I customers by using automatic controls to switch applicable building loads from natural gas to fuel oil. The EnerNOC program participants received a special rate structure as long as they agree to switch from natural gas to fuel oil during peak demand days in winter. Switchover occurred through a demand signal sent by EnerNOC or predetermined outside temperature setting when recorded by on-site measurement equipment. Link
3. C&I Manual Fuel Switching Daily (Interruptible Natural Gas Rates)
    - Xcel Energy, Philadelphia Gas Works (PGW), and many other gas utilities offer discounted C&I gas rates if customers participate in a manual demand reduction program, often called Interruptible Natural Gas Rates. The programs require customers to either decrease their overall consumption during certain events or shift to alternative fuels (fuel oil, steam, electricity, etc.). Some programs have variable DR event durations, whereas others are for pre-defined set periods (e.g., 6-9 am). The call is usually day ahead, but could be as short as one hour or up to 48 hours in advance. The programs use on-site metering equipment (smart gas meter, telephone telemetry) to verify participation. (Examples of traditional Interruptible Natural Gas Rate programs – Xcel (Link), PGW (Link), Colorado Springs Utilities (Link))
    - National Grid is currently conducting a pilot with 30 large C&I customers in New York City. National Grid will provide the enrolled customers with 48 hours' notice to reduce natural gas consumption between 6am and 9am. Enrolled customers have provided

National Grid with a pre-determined amount of consumption they are willing to forego if they are called upon to reduce consumption. To measure the actual reduction during the 6–9am time window, National Grid installed interval meter reading capability on the customers' natural gas meters. (Information originally provided to Navigant Research, announcement in November 2017, Link).

4.2 Gas DR Measure Characterization

Navigant developed an initial list of potential gas DR opportunities based on our research outlined above and discussions with industry experts. While each of the opportunities on this list are technically available, most do not have demonstrated performance as part of programs or pilots for natural gas utilities. In several cases, electric utilities are currently evaluating similar opportunities for their DR programs and provide guidance on any DR savings, product cost, program design, etc.

Con Edison reviewed this list (provided in Appendix A) and selected the six measures for analysis. Details on each of these six measures are described below. Details on the input assumptions (savings and costs) are provided in the Appendix B.

Thermostat / Energy Management System (EMS)

- **Applicable Sector**: C&I and Multi-Family Common Area
- **Description**: Smart thermostats or energy management systems (EMS) make slight adjustments in temperature setpoints to reduce overall space heating demand during peak hours
- **Number of Gas DR Events Per Year**: 15

Cold Climate Air Source Heat Pump (ASHP)

- **Applicable Sector**: Residential Single Family
- **Description**: Cold-climate air-source heat pumps (ASHPs) can provide space heating with COPs >1.75 at 5°F. Many single-family homes have installed ductless mini-split air conditioners and heat pumps to supplement the centralized HVAC system. For homes with both gas furnace and small ductless heat pump, this strategy adjusts the thermostat set points to decrease gas furnace operation, and increase ductless heat pump operation during peak days.
- **Number of Gas DR Events Per Year**: 15
- **Key Questions / Issues**:
    - ASHP heating performance and efficiency varies with outside temperature
    - Creates a potential fuel switching issue if increased ASHP runtime creates increased gas demand for power production
    - Feasibility of communicating with ductless mini-splits, since most products use in-room remote controls rather than a thermostat. Mitsubishi and others sell adapters that would allow to connect with other whole-home thermostats.

Water Heater Controls

- **Applicable Sector**: Residential Multi-Family (Small Multi-Family, Large Multi-Family, and Multi-Family Common Area)

- **Description**: Retrofit controller for gas storage water heaters that adjusts the temperature set point from ≥130°F to 120°F during peak events, which reduces energy consumption to heat water to supply temperature, and avoids standby losses in the storage tank.
- **Number of Gas DR Events Per Year**: 30
- **Key Questions / Issues**:
  - Navigant assumed a 5% annual savings from supply temperature reduction based on the latest field test information.[7] This is a conservative estimate relative to the 10-20% simulated savings if supply temperature was reduced for the entire year. We use 5% since customer behavior could dampen energy saving since bathroom hot water end-uses use a thermostatic mixing valve to reach a given temperature. Lower hot water temperature from water heater leads to more hot water use (less cold water) at the tap to reach a given mixed water temperature. The exact tradeoff is unknown, but current field studies suggest a 5-10% annual energy savings once including this tradeoff (link).

Smart Thermostat Gas DR

- **Applicable Sector**: All Residential
- **Description**: Smart thermostats make slight adjustments to temperature settings (e.g., 3°F) to reduce overall space heating demand during peak hours
- **Number of Gas DR Events Per Year**: 15

Process Load Controls

- **Applicable Sector**: Warehouse/Industrial
- **Description**: Controls that automatically reduce or delay certain process loads in C&I buildings during peak events. Similar to traditional fuel switching / interruptible rates, but would be potentially automatic and quicker notice
- **Number of Gas DR Events Per Year**: 15

Wastewater Treatment Schedule

- **Applicable Sector**: Warehouse/Industrial
- **Description**: Water and wastewater treatment plants use a combination of natural gas and biogas for digester boiler, on-site generation, space heating, and other processes. This measure would delay or decrease certain processes, or increase the use of biogas to decrease grid-supplied natural gas during peak days.
- **Number of Gas DR Events Per Year**: 15

Table 6 below identifies the applicable customer segments per measure.

[7] Summary of current field tests by MNCEE and GTI: Summary Page (https://www.mncee.org/resources/projects/field-study-of-intelligent,-networked,-retrofittab/), Presentation (https://www.mncee.org/resources/resource-center/presentations/field-study-of-an-intelligent,-networked,-retrofit/).

Table 6. Applicable Customer Segments per DR Measure Characterized

Customer Segment	Gas DR Measure: Com | Gas DR - C&I Thermostat / EMS	Com | Gas DR - Industrial Process Load Control	Com | Gas DR - Wastewater Treatment Scheduling	Res |Gas DR - Water Heater DR Control	Res |Gas DR – Smart Thermostat Setback	Res |Gas DR - SF Cold-Climate Ductless Heat Pump
Commercial & Industrial						
Education	✓					
Grocery	✓					
Hospital	✓					
Large Office	✓					
Large Retail	✓					
Miscellaneous/Entertainment	✓					
Multi-Family - Common Area	✓					
Nursing Home/Lodging	✓					
Restaurant	✓					
Small Office	✓					
Small Retail	✓					
Warehouse/Industrial	✓	✓	✓			
Residential						
Large Multi-Family - Res				✓	✓	
Single Family - Res					✓	✓
Small Multi-Family - Res				✓	✓	

Additional measure characteristics are described here and included in the measure characterization.

Incremental Costs

Two different cost scenarios are modeled to reflect an incremental change to make existing equipment DR-enabled or new equipment installation

- For an existing EE measure that is retrofitted to enable DR, only the incremental cost to enable DR is considered. This cost is shared 75% gas DR and 25% electric DR program for residential and commercial measures, and 50% gas DR and 50% electric DR for industrial measures[8]. Note – the avoided cost for electric DR programs are often substantially higher than gas DR programs and

[8] The majority of a plant's energy consumption is electricity for pumps, fans, aerators, and other equipment. There has been significant interest and promotion of electric DR programs for wastewater plants, particularly in California: CEC AutoDR for Wastewater Treatment http://www.energy.ca.gov/2015publications/CEC-500-2015-086/CEC-500-2015-086.pdf

would drive utility cost-effectiveness. We selected a cost share to recognize the favorable avoided cost for electric DR while also taking into account market characteristics that favor gas DR programs. For example, a joint smart thermostat DR program would be applicable for residential customers with centralized space heating (>50% market penetration) and centralized cooling systems (5-35% market penetration).

- For a new measure is installed that saves both gas energy and gas demand, the full measure cost (relative to a baseline unit) is considered. This is only applicable to the water heater measure.

Impacts

Some gas DR measures (e.g., thermostat / EMS) also save gas energy during the non-peak days. These benefits must be captured for the adoption model to work properly. However, the existing analysis assumes that most DR measures just add a new feature to an existing control system, except, for the water heater control measures. Navigant assumes it is a new installation (i.e., no existing controller) and, therefore, Navigant calculates benefits from both the peak and non-peak days for only the water heater measures. The controller can receive DR signals from a utility program and adjust temperature setpoints by itself based on learning each home's usage patterns. All other modeled measures are assumed to have only savings quantified for demand response only. Descriptions of the assumptions for calculating savings are in Appendix B.

Incentives

Both participation and performance incentives are considered.

- Performance incentives are assumed to be $5/Therm saved during the peak day event for all measures and segments.
- The participation incentive is assumed to be 30% of the incremental cost at the time of installation of the DR measure.

Applicable stock

Input assumptions of the measures include:

- Technical Suitability: The percentage of the total baseline measures that could be replaced with the efficient measure. For example, smart thermostats are not compatible with all heating system designs, particularly in multi-family buildings, so the technical suitability is lower than 100%.
- Fuel Multiplier: Designate the appropriate space heating or water heating (as applicable) fuel type applicability multiplier.
- Density: The total measure density, which is the sum of the base and efficient technology densities. For example, the measure density for a multi-family water heating measure is specified as water heaters per household.

Other assumptions

- No administrative costs are applied at the measure-level
- No O&M costs are applied

- Navigant did not include the cost of installing an AMI gas meter. It is assumed that this cost will be assessed as a standard cost of Con Edison business practices and is considered as part of the overall DR program costs.
- Program administrator costs are assumed to be $3.3 million per year.

4.3 Market Characterization

This section summarizes the sources, assumptions, and values of the financial data and market characteristics used in the study.

Peak Definition

In concert with Con Edison's Gas Supply group, the future gas DR Programs demand response events would occur on any day where there would be a need to purchase or utilize peaking contracts. Quantitatively, Con Edison expect this to happen on any winter day with an average daily temperature below 22°F, which typically is approximately 30 days per winter season. As described in section on the Peak Period Definition, the peak period is defined as weekdays in January and February.

Avoided Wholesale Gas Costs

Navigant used two sets of wholesale gas avoided costs (in $/Dth) in the DR analysis: (1) peak day gas energy prices, and (2) non-peak day gas energy price[9].

For peak days, Navigant averaged the top three[10] weekly prices in January and February of each year from NYISO data[11] for Transco Zone 6, NY to determine the expected commodity cost on peak days. On top of this price, we assumed that Con Edison could avoid a $1.00/Dth[12] reservation charge[13] starting in 2020 once the impacts from the gas DR programs are deemed reliable.

For non-peak days, Navigant applied average gas energy prices from the CARIS 2 dataset[14].

[9] Only applicable for gas DR measures that save energy on non-peak days (e.g., water heater control).
[10] Navigant chose a three-week average since the measures will be either 15 day or 30 day calls for DR activity. It is assumed that the days would be weekdays and hence 3 weeks (which may overstate the natural gas price for the 30-day measures).
[11] http://www.nyiso.com/public/webdocs/markets_operations/services/planning/Planning_Studies/Economic_Planning_Studies_(CARIS)/CARIS_Input_Assumptions/2016%20CARIS%202%20Input%20Data%20Summary.xls
[12] This price is increased at a 2% inflation rate onward from 2020.
[13] The reservation charge is the amount Con Edison pays to reserve capacity in the pipelines. This amount is set prior to the beginning of each season. The current assumption is that this reservation charge is not considered in the demand response calculations in the first two years for Con Edison to pilot the and measure the effects of gas DR.
[14] "CARIS 2 Gas_Electric Supply-CO2-Elect Capacity-04_2017-with inflation.xlsx", "Gas Supply & CO2 Values" tab, original data is in Column N for "NGas_JK". Values are converted from $/mmBTU to $/therm using a 0.1 units conversion rate multiplier. Values extended beyond 2026 using a 2% inflation rate.

The avoided wholesale energy costs used in the model are summarized in Table 7 below. The non-peak day gas energy price is based on the leftmost price column ("Avg Gas Energy Price"). The peak day gas energy price is based on the rightmost price column ("Peak Day Gas Energy Price").

Table 7. Avoided Gas Energy Prices

Year	Avg Gas Energy Price ($/Dth)	Peak Gas Energy Price – Commodity ($/Dth)	Reservation Charge ($/Dth)	Peak Day Gas Energy Price ($/Dth)
2018	3.62	10.03	0.00	10.03
2019	4.01	11.12	0.00	11.12
2020	4.33	12.00	1.00	13.00
2021	4.57	12.67	1.02	13.69
2022	4.82	13.42	1.04	14.46
2023	5.07	14.12	1.06	15.18
2024	5.33	14.85	1.08	15.93
2025	5.6	15.59	1.1	16.7
2026	5.85	16.3	1.13	17.42
2027	5.97	16.91	1.15	17.77

Retail Rates

Navigant applied the following retail rates by customer segment in the bill savings / lost revenue calculation in the model:

- Residential Heating $16.92/Dth
- Large Commercial $8.72/Dth
- Small Commercial $11.86/Dth

Market Segmentation Data

Navigant leveraged the existing database of gas customers to develop the customer counts and square footages used to scale measures to the gate station-level for firm heating and firm non-heating customers only. This dataset was received in August 2017 which included customer segment assignments and gate station disaggregation for each account. See the main DER Potential Study report for details on how this dataset was cleaned and analyzed.

For wastewater treatment facilities, we used the NAICS code field to develop the stock and sales data specific to this segment. It was identified that 7.6% of the industrial/warehouse market segment gas consumption is for the wastewater treatment facilities (1.7 MTh for water/wastewater treatment facilities out of 22.3 MTh for total warehouse/industrial sites).

5 Potential Analysis Methodology

This section summarizes the methodology applied in this study. Details are provided in the main DER Potential Study report.

Potential Types

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Navigant calculated three types of potential:

- Technical Potential – potential based on instantaneous deployment of measures that are unconstrained by budget, adoption, and cost-effectiveness.
- Economic Potential – potential based on instantaneous deployment of measures that are unconstrained by budget and adoption. Only cost-effective measures—measured by the Societal Cost Test—from the technical potential analysis are included.
- Achievable Potential – a subset of economic potential that considers the likely rate of DR acquisition given factors like simulated incentive levels, consumer willingness to adopt DR technologies, and the likely rate at which marketing activities can facilitate technology adoption.

Cost-effectiveness

Each value stream quantified in the model is assigned as either a benefit, cost, transfer, or not applicable for each cost test. The following cost tests are considered in the model:

- Total Resource Cost (TRC): measures the net benefits and costs of a program including both the participants' and the utility's benefits and costs.
- Societal Cost Test (SCT): measures the net benefits and costs of a program including both the participants' and the utility's benefits and costs as well as externalities such as emissions.
- Utility Cost Test (UCT): measures the net costs of a program as a resource option based on the costs incurred by the program administrator (including incentive costs) and excluding any net costs incurred by the participant.
- Participant Cost Test (PCT): the measure of the quantifiable benefits and costs to the customer due to participation in a program.
- Rate Impact Measure (RIM): measures what happens to customer bills or rates due to changes in utility revenues and operating costs caused by the program.

Table 8 outlines the cost test definitions used in the model.

Table 8. Cost Effectiveness Framework

Value Stream	TRC	SCT	UCT	PCT	RIM
Avoided Costs	Benefit	Benefit	Benefit	N/A	Benefit
Incentives	Transfer	Transfer	Cost	Benefit	Cost
Lost Revenue	Transfer	Transfer	N/A	Benefit	Cost
Admin Costs	Cost	Cost	Cost	Cost	N/A
Incr. Equip. Cost[15]	Cost	Cost	N/A	Cost	N/A
Externalities[16]	N/A	Benefit	N/A	N/A	N/A

[15] The incremental equipment costs assumed here do not include incentives

[16] Externalities include: Avoided Emissions Value [$/year] = Gas Savings [therms/year] * (CO2 Price [$/ton] * CO2 Intensity [ton/therm] + SOx Price [$/ton] * SOx Intensity [ton/therm] + NOx Price [$/ton] * NOx Intensity [ton/therm])

Per the BCA Handbook, measures are selected for economic potential based on societal cost test. To forecast measure adoption, Navigant used the participant cost test when applying the payback acceptance curve.

Adoption Model

The core achievable potential logic in DSM-Sim uses a Bass-diffusion adoption model along with a payback acceptance curve. Key inputs used in this adoption model include marketing coefficients, word-of-mouth coefficients, initial awareness factors, and the payback acceptance curve. For details on how each of these parameters is applied in the calculation of achievable potential, please refer to the Results section of the main DER Potential Study Report.

6 Energy Efficiency Results

In this report, Navigant only presents detailed results for programmatic and theoretical achievable potential using a code baseline and consideration for the avoided peak day costs. The programmatic scenario reflects current practices and the theoretical scenario reflects the recent Con Edison filing submission[17]. Navigant calculated results for seven potential types for the residential and commercial sectors. Navigant also developed potential estimates by specific customer segment and measure within each sector. Detailed results are provided for technical, economic, and all achievable potential scenarios by sector, customer segment, end use and measures in the workbook viewer. Results are either provided for the full potential study period or for 2023, a critical year for Con Edison gas forecast planning.[18]

6.1 New Energy Efficiency Measures

This section provides the gas energy efficiency potential for the years 2018 through 2026 for the Con Edison markets in New York City and Westchester County. Table presents cumulative energy efficiency potential across all sectors and for all modeled measures. Technical potential increased by 7% relative to the core measure list with the new energy efficiency measures. In planning for the Expanded Gas Programs, Con Edison recommended considering the 2018 potential as a starting point.

[17] http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId=%7bEBDD5DAE-ED57-4D90-BFF7-B407517BE133%7d

[18] Con Edison forecasts a shortfall in existing pipeline capacity by 2023 due to the population growth and encouraging customers to switch from fuel oil to natural gas heating. http://globenewswire.com/news-release/2017/10/03/1140234/0/en/Con-Edison-Offers-New-Ways-to-Meet-Growing-Natural-Gas-Customer-Needs.html

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Table 9. Gas Energy Efficiency Cumulative Potential Forecast by Scenario (DThYear) – Including New Energy Efficiency Measures

Model Scenarios	2018	2019	2020	2021	2022	2023	2024	2025	2026
Technical	25,939,915	25,940,451	25,940,990	25,941,532	25,942,078	25,942,627	25,943,179	25,943,734	25,944,293
Economic	18,944,248	18,944,565	18,944,885	18,945,207	18,945,530	18,945,856	18,946,183	18,946,512	18,955,912
Theoretical - High Achievable	2,207,481	4,590,319	6,838,014	8,697,014	10,071,479	11,030,409	11,707,597	12,217,489	12,632,852
Theoretical Achievable	555,769	1,173,268	1,854,312	2,599,569	3,408,090	4,276,739	5,199,539	6,167,075	7,166,492
Alternative Achievable	443,735	909,859	1,400,190	1,923,415	2,471,357	3,042,530	3,635,843	4,243,043	4,868,274
Programmatic Achievable	433,310	887,680	1,364,825	1,873,333	2,404,951	2,958,140	3,531,789	4,117,668	4,719,992
Naturally Occurring	265,430	524,333	777,231	1,024,610	1,266,913	1,504,550	1,737,896	1,967,296	2,193,066

Figure 2 provides a comparison of the incremental[19] savings the new gas measures provide for the portfolio savings potential for programmatic and theoretical achievable potential. The theoretical scenario adds 2.5 million DTh of savings in 2026 relative to the programmatic scenario.

[19] Incremental values shown for achievable potential are termed as annual incremental potential, in that they represent the incremental new potential available in each year. The total cumulative potential over the time period is the sum of each year's annual incremental achievable potential.

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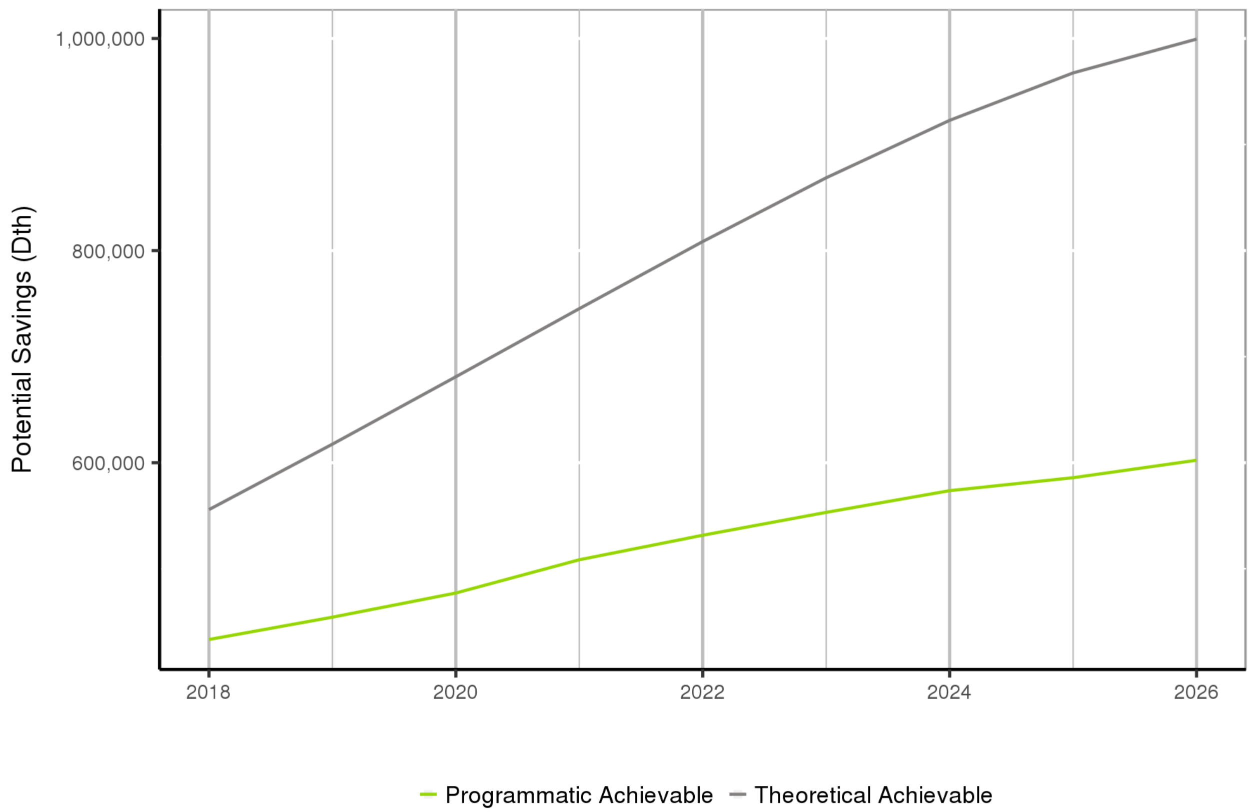
Figure 1. Incremental Programmatic and Theoretical Achievable Annual Energy Savings (Dekatherms/Year) –Including New Energy Efficiency Measures



Error! Reference source not found. 3 shows programmatic and theoretical achievable cumulative savings in 2023 for all measures. The scenario parameters affect measure adoption at different rates. However, the top measures are consistent between the two scenarios (commercial storage tank water heater and retro commissioning). Residential hot water pipe insulation and weatherization, which are both new measures in this analysis, are ranked third and fifth in savings potential.

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Figure 3. Measure Histogram of Programmatic and Theoretical Achievable Cumulative Annual Potential Savings in 2023 (DTh/Year)

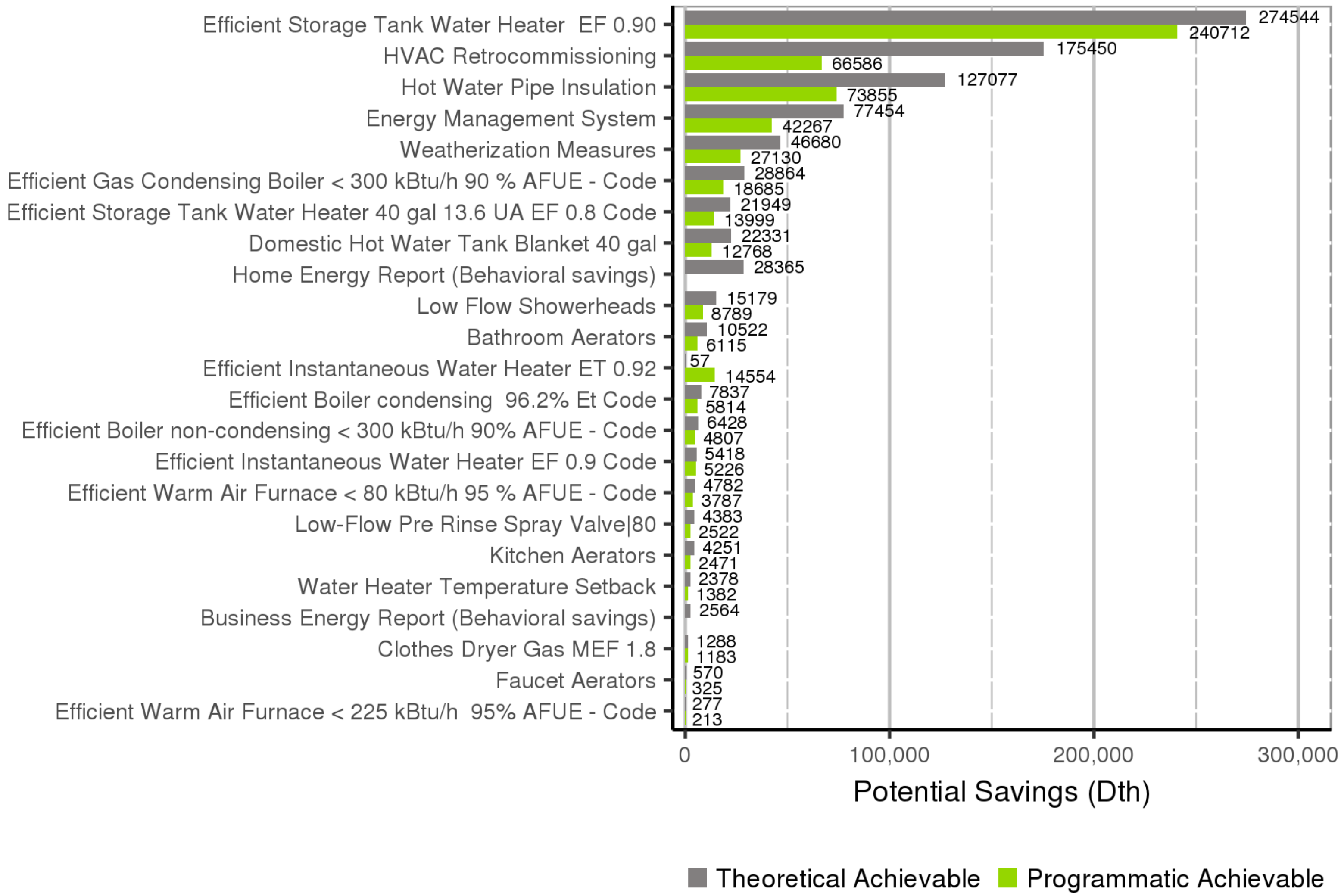

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Figure 4 and Table 10 provide the incremental annual programmatic and theoretical achievable savings as a percentage of total gas consumption. The additional gas measures offer 0.31% and 0.46% savings, on average, over the next 10 years for programmatic and theoretical potential, respectively. This results in cumulative savings of approximately 2.6% and 4% in 2026 for programmatic and theoretical potential, respectively.

Figure 4. Incremental Programmatic and Theoretical Achievable Potential as a Percentage of Total Gas Consumption (%) – Including New Energy Efficiency Measures

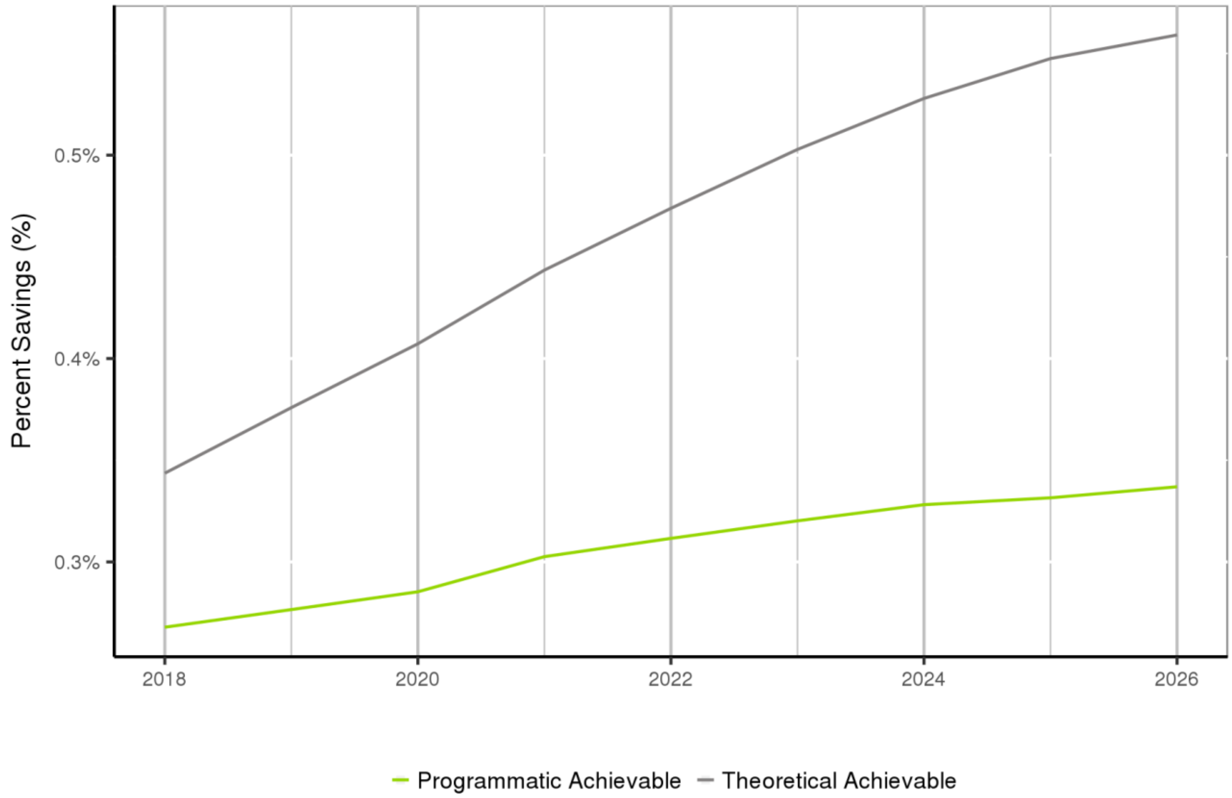

Table 10. Incremental Programmatic and Theoretical Achievable as a Percentage of Total Gas Consumption (%) – Including New Energy Efficiency Measures

Scenario	2018	2019	2020	2021	2022	2023	2024	2025	2026
Programmatic Achievable	0.27%	0.28%	0.29%	0.30%	0.31%	0.32%	0.33%	0.33%	0.34%
Theoretical Achievable	0.34%	0.38%	0.41%	0.44%	0.47%	0.50%	0.53%	0.55%	0.56%

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6.2 Budget

The following table provides the estimated program costs per year for programmatic and theoretical achievable scenarios. The theoretical scenario is 37% and 25% higher cost per annual DTh and Peak Day DTh, respectively in 2018.

Table 11. Gas Energy Efficiency Program Costs per Year by Scenario

Scenario	Programmatic Achievable			Theoretical Achievable		
Year	Budget	$/Annual DTh	$/Peak Day DTh	Budget	$/Annual DTh	$/Peak Day DTh
2018	$15,385,350	$36	$7,850	$27,000,418	$49	$9,836
2019	$16,374,744	$36	$7,884	$30,742,725	$50	$9,933
2020	$17,497,518	$37	$7,950	$34,838,248	$51	$10,057
2021	$18,845,757	$37	$7,996	$39,261,317	$53	$10,206
2022	$20,105,592	$38	$8,088	$43,933,773	$54	$10,379
2023	$21,396,690	$39	$8,195	$48,727,840	$56	$10,575
2024	$22,726,018	$40	$8,312	$53,457,540	$58	$10,791
2025	$23,948,914	$41	$8,471	$57,878,868	$60	$11,022
2026	$25,311,289	$42	$8,624	$61,781,217	$62	$11,288

6.3 Peak Day Impacts

The following set of figures and tables provide the average peak day savings potential based on the assumed peak period of January and February weekdays.

Table 12 provides the potential forecast by scenario for peak day savings. The technical and economic potential are 14% and 9%, respectively, of the reference forecast for peak day consumption in 2018. The new gas measures provide an increase of 13-19% savings over the planning period. For planning purposes, Con Edison recommended considering the 2018 potential as a starting point.

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Table 12. Gas Energy Efficiency Peak Day Cumulative Potential Forecast by Scenario (DTh/Peak Day)

Scenario	2018	2019	2020	2021	2022	2023	2024	2025	2026
Technical	155,515	155,518	155,521	155,524	155,527	155,531	155,534	155,537	155,540
Economic	98,803	98,804	98,805	98,807	98,808	98,809	98,811	98,812	98,875
Theoretical - High Achievable	12,957	26,876	39,957	50,656	58,381	63,545	66,973	69,380	71,227
Theoretical Achievable	2,745	5,840	9,304	13,151	17,384	21,992	26,946	32,197	37,670
Alternative Achievable	2,043	4,213	6,519	8,993	11,609	14,363	17,253	20,250	23,367
Programmatic Achievable	1,960	4,037	6,238	8,595	11,081	13,692	16,426	19,253	22,188
Naturally Occurring	979	1,937	2,876	3,798	4,705	5,596	6,475	7,342	8,198

Figure 5 and Table 13 show an overview of the peak day impacts for all gas measures, including the new energy efficiency measures.

Figure 5. Incremental Programmatic and Theoretical Achievable Peak Day Savings (DTh/Peak Day) – Including New Energy Efficiency Measures

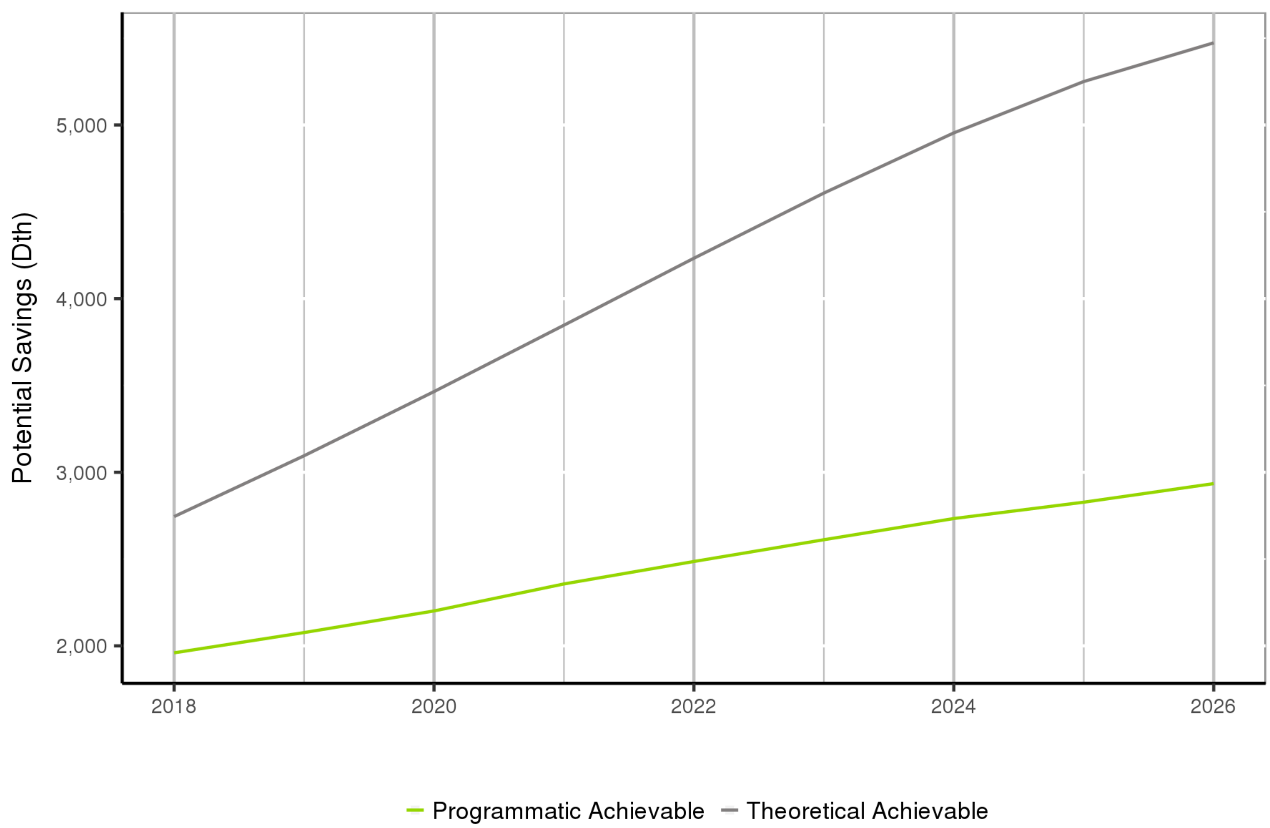

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Table 13. Gas Energy Efficiency Programmatic and Theoretical Achievable Peak Day Cumulative Savings (DTh/Peak Day) – Including New Energy Efficiency Measures

Scenario	2018	2019	2020	2021	2022	2023	2024	2025	2026
Forecasted Peak Consumption	1,148,572	1,166,673	1,187,559	1,193,396	1,211,647	1,226,851	1,241,430	1,254,986	1,269,431
Programmatic Achievable	1,960	4,037	6,238	8,595	11,081	13,692	16,426	19,253	22,188
Theoretical Achievable	2,745	5,840	9,304	13,151	17,384	21,992	26,946	32,197	37,670

Figure 6 shows programmatic and theoretical achievable savings in 2023 for all measures. The top two measures for annual savings are the same for peak day but swapped in order (i.e., retro commissioning is first and commercial storage tank water heater is second). Two new measures (residential pipe insulation and weatherization) provide the fourth and fifth highest peak day savings, respectively.

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Figure 6. Measure Histogram of Incremental Programmatic and Theoretical Achievable Peak Day Savings in 2023 (DTh/PeakDay)

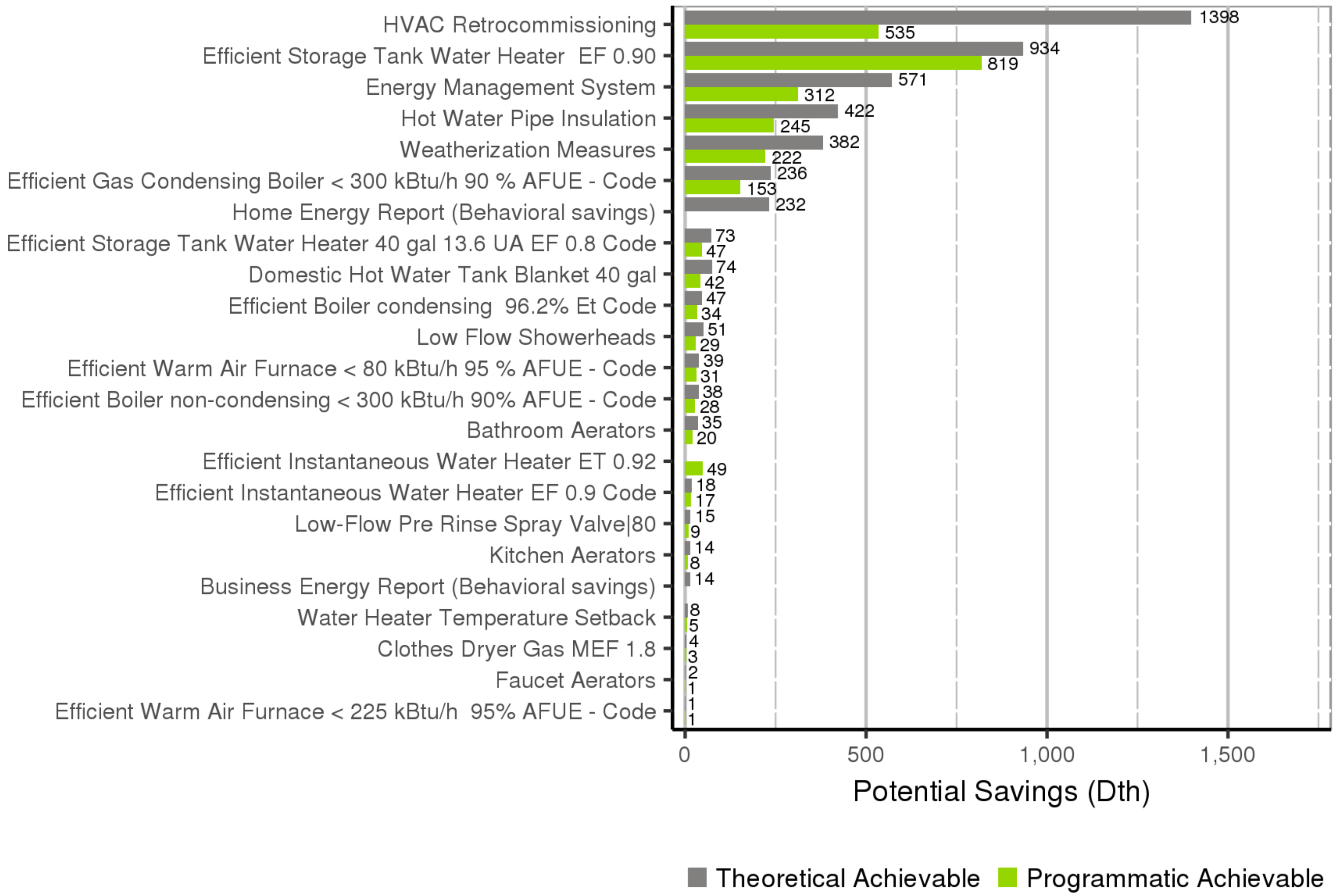

Figure 7 and Table 14 provide the incremental programmatic and theoretical achievable of the core and add-on measures as a percentage of peak day gas consumption. In 2023-2026, theoretical achievable has approximately twice the impact of programmatic for peak day savings at 0.44% in 2026. The cumulative impacts are 1.7% and 3% of the peak day consumption for programmatic and theoretical scenarios, respectively.

Figure 7. Incremental Programmatic and Theoretical Achievable as a Percentage of Peak Day Gas Consumption (%) – Including New Energy Efficiency Measures

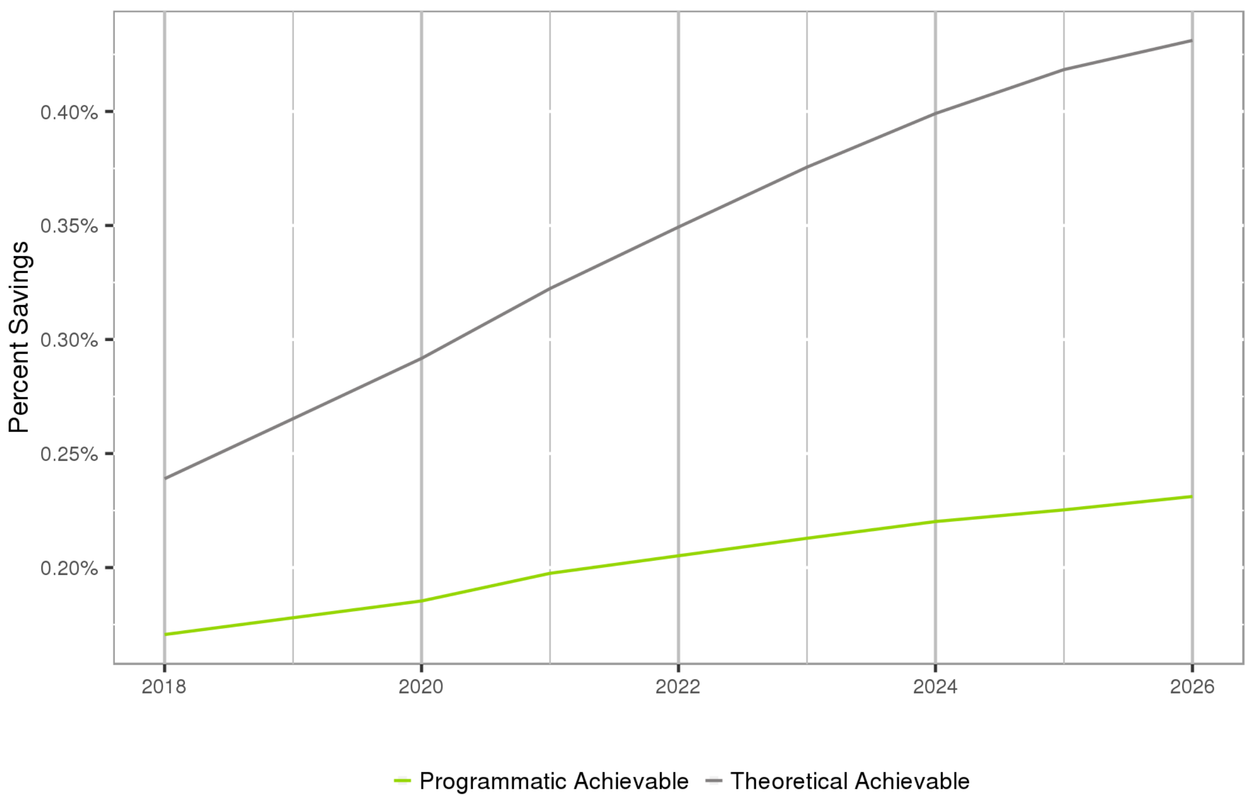

Table 14. Incremental Programmatic and Theoretical Achievable as a Percentage of Peak Day Gas Consumption (%) – Including New Energy Efficiency Measures

Scenario	2018	2019	2020	2021	2022	2023	2024	2025	2026
Programmatic Achievable	0.17%	0.18%	0.19%	0.20%	0.21%	0.21%	0.22%	0.23%	0.23%
Theoretical Achievable	0.24%	0.27%	0.29%	0.32%	0.35%	0.38%	0.40%	0.42%	0.43%

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6.3 Gate Station Analysis

The following set of figures and tables provide the potential savings by gate station for both annual savings and peak day savings.

Figure 8 shows programmatic and theoretical achievable potential annual energy savings by gate station in 2023.

Figure 8. Cumulative Programmatic and Theoretical Achievable Potential in 2023 by Gate Station (DTh/Year)

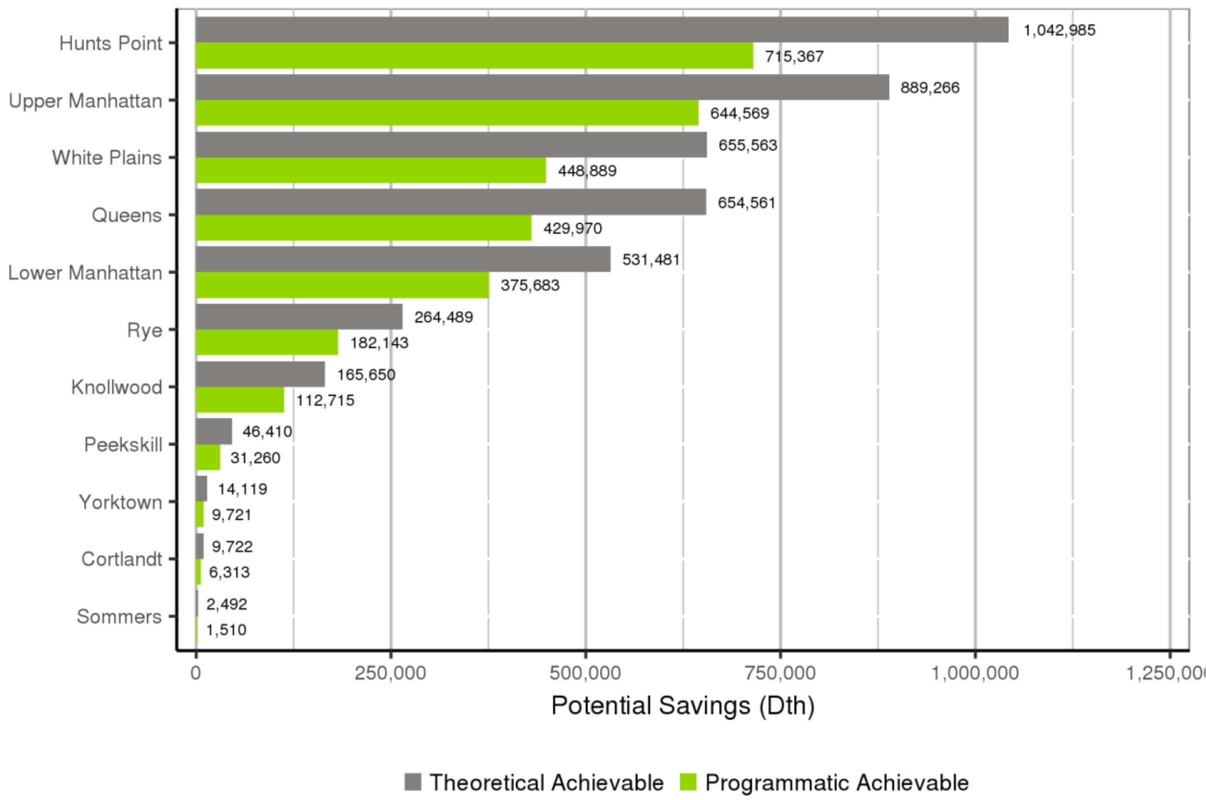

Table 15 15 through Table 18 provide the programmatic and theoretical achievable annual and peak day savings.

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Table 15. Gas Energy Efficiency Cumulative Programmatic Potential Annual Savings Forecast by Gate Station (DTh/Year)

Gate Station	2018	2019	2020	2021	2022	2023	2024	2025	2026
Cortlandt	909	1,875	2,899	3,980	5,118	6,313	7,561	8,859	10,204
Hunts Point	104,735	215,082	331,333	453,520	581,578	715,367	854,657	999,402	1,148,909
Knollwood	16,120	33,090	50,984	70,605	91,215	112,715	135,062	157,525	180,625
Lower Manhattan	56,777	116,000	177,605	241,502	307,574	375,683	445,664	517,336	590,498
Peekskill	4,546	9,357	14,436	19,782	25,392	31,260	37,374	43,718	50,272
Queens	61,558	126,035	194,417	268,775	347,370	429,970	516,444	604,968	696,685
Rye	26,212	53,908	83,097	114,610	147,666	182,143	217,972	254,355	291,799
Sommers	211	437	680	939	1,216	1,510	1,821	2,147	2,489
Upper Manhattan	95,265	194,791	298,492	409,836	525,380	644,569	767,115	889,668	1,014,556
White Plain	65,590	134,253	206,491	283,694	364,572	448,889	536,479	626,135	718,440
Yorktown	1,388	2,851	4,391	6,089	7,869	9,721	11,641	13,554	15,515

Table 16. Gas Energy Efficiency Cumulative Theoretical Potential Annual Savings Forecast by Gate Station (DTh/Year)

Gate Station	2018	2019	2020	2021	2022	2023	2024	2025	2026
Cortlandt	1,242	2,631	4,174	5,872	7,723	9,722	11,854	14,096	16,417
Hunts Point	134,076	283,604	449,179	631,108	829,275	1,042,985	1,270,783	1,510,294	1,758,200
Knollwood	21,377	45,198	71,539	100,431	131,843	165,650	201,616	239,362	278,377
Lower Manhattan	70,800	148,754	233,941	326,309	425,636	531,481	643,126	759,513	879,269
Peekskill	5,984	12,655	20,033	28,128	36,932	46,410	56,496	67,083	78,026
Queens	82,801	175,726	279,241	393,626	518,870	654,561	799,758	952,880	1,111,696
Rye	34,227	72,325	114,411	160,529	210,620	264,489	321,756	381,823	443,876
Sommers	306	652	1,043	1,480	1,963	2,492	3,063	3,669	4,300
Upper Manhattan	118,086	248,251	390,662	545,263	711,706	889,266	1,076,736	1,272,319	1,473,648
White Plain	85,038	179,602	283,971	398,245	522,272	655,563	797,185	945,677	1,099,024
Yorktown	1,833	3,870	6,118	8,579	11,250	14,119	17,166	20,360	23,659

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Table 17. Gas Energy Efficiency Cumulative Programmatic Potential Peak Day Savings Forecast by Gate Station (DTh/Peak Day)

Gate Station	2018	2019	2020	2021	2022	2023	2024	2025	2026
Cortlandt	5	10	15	21	27	33	39	46	53
Hunts Point	459	947	1,466	2,017	2,598	3,212	3,855	4,530	5,233
Knollwood	77	158	245	339	439	544	653	765	881
Lower Manhattan	249	511	788	1,078	1,383	1,701	2,032	2,376	2,732
Peekskill	22	45	70	96	124	153	184	216	249
Queens	291	600	929	1,286	1,665	2,065	2,487	2,923	3,377
Rye	125	258	400	552	713	882	1,059	1,241	1,430
Sommers	1	2	3	3	5	6	7	8	9
Upper Manhattan	416	856	1,319	1,819	2,344	2,892	3,463	4,046	4,648
White Plain	309	636	984	1,356	1,748	2,161	2,593	3,041	3,505
Yorktown	6	13	20	28	36	44	53	62	71

Table 12. Gas Energy Efficiency Cumulative Theoretical Potential Peak Day Savings Forecast by Gate Station (DTh/Peak Day)

Gate Station	2018	2019	2020	2021	2022	2023	2024	2025	2026
Cortlandt	7	14	23	32	43	54	66	79	92
Hunts Point	641	1,365	2,179	3,087	4,089	5,183	6,363	7,616	8,925
Knollwood	110	234	373	526	694	876	1,072	1,278	1,493
Lower Manhattan	344	731	1,164	1,643	2,169	2,741	3,356	4,008	4,687
Peekskill	31	66	105	148	195	247	302	360	420
Queens	423	901	1,439	2,038	2,698	3,419	4,195	5,018	5,876
Rye	176	374	595	840	1,109	1,400	1,713	2,043	2,386
Sommers	1	3	4	6	8	11	13	16	18
Upper Manhattan	569	1,208	1,923	2,715	3,585	4,531	5,547	6,625	7,749
White Plain	434	923	1,469	2,074	2,738	3,459	4,233	5,052	5,904
Yorktown	9	19	30	42	56	70	86	103	120

7 Demand Response Results

This section provides the results of the gas DR potential study. The scenario is similar to the achievable potential scenario selected as the program portfolio model for energy efficiency in the core DER potential study. Below we present results for potential and cost-effectiveness on both a portfolio-level and measure-level. We also report potential on a gate station-level.

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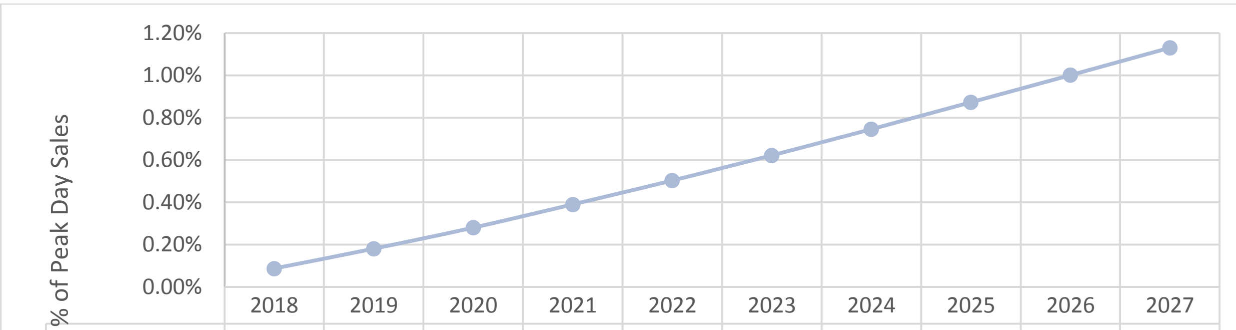
Results are either provided for the full 10-year potential study period or for 2023, a critical year for Con Edison gas forecast planning. Con Edison forecasts a shortfall in existing pipeline capacity by 2023 due to the population growth and encouraging customers to switch from fuel oil to natural gas heating.[20]

7.1 Portfolio Results

Figure 9 shows the technical, economic, and achievable gas DR potential summed over all measures and customer segments as a percentage of sales[21]. In the first year, gas DR can account for 1% of peak day consumption in ten years.

Figure 9. Portfolio-Level Potential Results As % of Peak Day Sales



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Achievable	0.09%	0.18%	0.28%	0.39%	0.50%	0.62%	0.75%	0.87%	1.00%	1.13%

Figure 10 shows the technical, economic, and achievable gas DR potential in dekatherms (DTh) summed over all measures and customer segments.

[20] http://globenewswire.com/news-release/2017/10/03/1140234/0/en/Con-Edison-Offers-New-Ways-to-Meet-Growing-Natural-Gas-Customer-Needs.html
[21] Navigant determined the forecast peak day gas sales based on the system throughput on weekdays in January in 2014-2016. We then forecasted this value into the future using growth factors from CECONY's firm volume gas forecast dated 2017.

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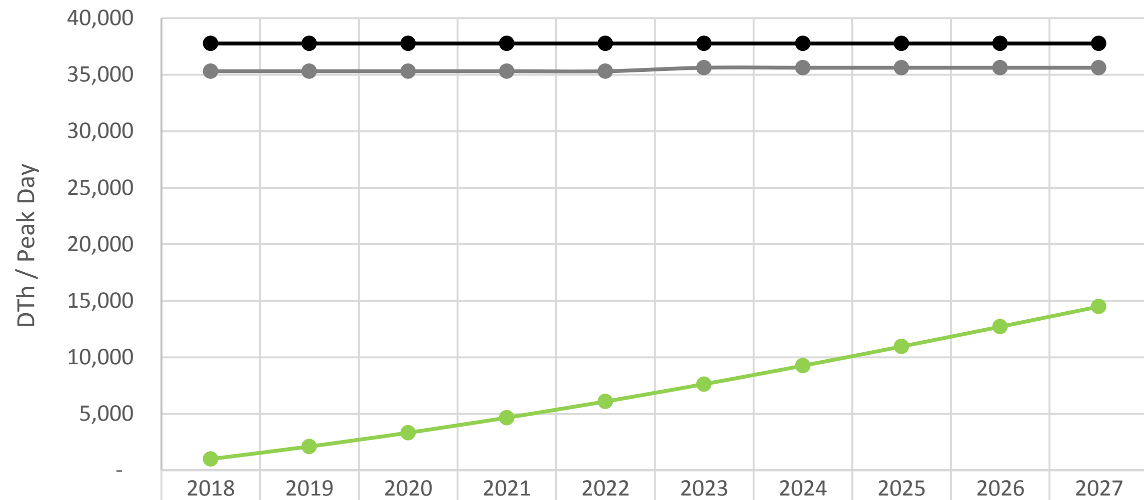
Figure 10. Portfolio-Level Potential Results in DTh per Peak Day



	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Technical	37,765	37,765	37,765	37,765	37,765	37,765	37,765	37,765	37,765	37,765
Economic	35,313	35,313	35,313	35,313	35,313	35,623	35,623	35,623	35,623	35,623
Achievable	998	2,106	3,324	4,654	6,091	7,628	9,254	10,953	12,704	14,486

The following table provides the estimated program costs per year. Con Edison provided to us the $3.3 million administrative budget was provided to us based on Con Edison analysis program participation levels.

Table 19. DR Program Costs per Year

Year	Administrative Costs	Incentives	Program Costs
2018	$3,300,000	$1,194,494	$4,494,494
2019	$3,366,000	$1,329,307	$4,695,307
2020	$3,433,320	$1,468,466	$4,901,786
2021	$3,501,986	$1,608,878	$5,110,865
2022	$3,572,026	$1,746,722	$5,318,749
2023	$3,643,467	$1,877,542	$5,521,008
2024	$3,716,336	$1,996,197	$5,712,533
2025	$3,790,663	$2,097,724	$5,888,386
2026	$3,866,476	$2,177,122	$6,043,598
2027	$3,943,805	$2,230,025	$6,173,830

Table 20 summarizes the benefit-cost ratios by cost test of the gas DR portfolio based on all achievable measures installed in 2018. The DR programs can be cost-effective with appropriate allocation of avoided costs. In 2020, the programs become cost-effective when considering the avoided reservation charge.

Table 20. Portfolio-Level Benefit-Cost Ratios in 2018

Cost Test	Portfolio B/C Ratio
Societal Cost Test	0.86
Total Resource Cost Test	0.55
Utility Cost Test	0.52
Participant Cost Test	3.81
Rate Impact Measure Test	0.32

7.2 Measure Results

Table 21 is the cost-effectiveness ratio using the Societal Cost Test for all measures by building segment in 2018. The C&I Thermostat/EMS measure is cost effective in all building segments except for the C&I Thermostat measure in Restaurant, Small Office and Miscellaneous. In 2023, small office becomes cost effective. The cold climate heat pump is not cost-effective. Additionally, the water heater controls in small and large multi-family are not cost-effective since the controller is assumed to be for one water heater per tenant unit.

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Table 21. Measure Level Societal Cost Test, Benefit-Cost Ratios in 2018

Customer Segment	Measure Name	SCT Benefit/Cost Ratio
Education	Com | Gas DR - C&I Thermostat / EMS	1.11
Grocery	Com | Gas DR - C&I Thermostat / EMS	5.94
Hospital	Com | Gas DR - C&I Thermostat / EMS	1.87
Large Office	Com | Gas DR - C&I Thermostat / EMS	1.56
Large Retail	Com | Gas DR - C&I Thermostat / EMS	1.02
Miscellaneous/Entertainment	Com | Gas DR - C&I Thermostat / EMS	0.58
Multi-Family - Common Area	Com | Gas DR - C&I Thermostat / EMS	4.43
Nursing Home/Lodging	Com | Gas DR - C&I Thermostat / EMS	7.27
Restaurant	Com | Gas DR - C&I Thermostat / EMS	0.70
Small Office	Com | Gas DR - C&I Thermostat / EMS	0.91
Small Retail	Com | Gas DR - C&I Thermostat / EMS	2.02
Warehouse/Industrial	Com | Gas DR - C&I Thermostat / EMS	2.41
Warehouse/Industrial	Com | Gas DR - Industrial Process Load Control	1.38
Warehouse/Industrial	Com | Gas DR - Wastewater Treatment Scheduling	1.38
Large Multi-Family - Res	Res |Gas DR - Smart Thermostat Setback	16.69
Single Family - Res	Res |Gas DR - Smart Thermostat Setback	14.30
Small Multi-Family - Res	Res |Gas DR - Smart Thermostat Setback	15.40
Large Multi-Family - Res	Res | Gas DR - Water Heater DR Control	0.34
Multi-Family - Common Area	Com | Gas DR - Water Heater DR Control	3.01
Small Multi-Family - Res	Res| Gas DR - Water Heater DR Control	0.34
Single Family - Res	Res |Gas DR - SF Cold-Climate Ductless Heat Pump	0.84

The following figure summarize the gas DR measure level results. The C&I Thermostat/EMS has the highest savings potential with 4,967 Dth per peak day.

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Figure 11. 2023 Achievable Potential Savings (DekaTherms/peak day) Measure Histogram

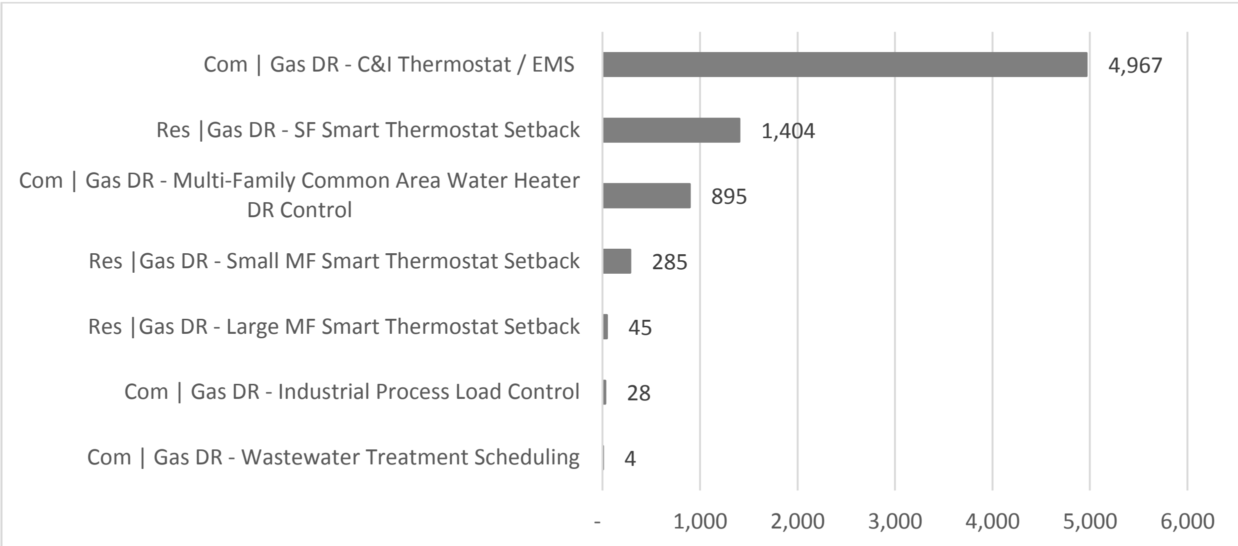

Table 22 provides the DR program participant count per customer or dwelling unit.

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Table 22. Measure Participant Count (per customer or per dwelling unit)[22]

Measure Name	Customer Segment	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027
Industrial Process Load Control	Warehouse/Industrial	2	4	7	9	12	15	17	20	23	26
Wastewater Treatment Scheduling	Warehouse/Industrial	0	1	1	1	2	2	2	3	3	4
Smart Thermostat Setback	Large Multi-Family - Res	34	73	115	161	211	265	322	381	442	504
Smart Thermostat Setback	Single Family - Res	3,434	7,265	11,502	16,143	21,173	26,560	32,257	38,199	44,305	50,484
Smart Thermostat Setback	Small Multi-Family - Res	330	699	1,106	1,552	2,036	2,554	3,102	3,673	4,260	4,854
Water Heater Controller	Multi-Family Common Area	1,560	3,277	5,152	7,187	9,378	11,716	14,188	16,777	19,460	22,210
Cold Climate Heat Pump	Single Family-Res	0	0	0	0	0	0	0	0	0	0
C&I Thermostat / EMS	Education	10	20	30	41	53	65	77	89	102	114
C&I Thermostat / EMS	Grocery	22	47	74	103	135	169	205	243	282	322
C&I Thermostat / EMS	Hospital	1	2	3	4	5	7	8	10	11	13
C&I Thermostat / EMS	Large Office	405	847	1,328	1,846	2,399	2,984	3,596	4,230	4,880	5,541
C&I Thermostat / EMS	Large Retail	1	2	3	4	5	6	8	9	10	11
C&I Thermostat / EMS	Multi-Family - Common Area	54	114	179	251	329	412	500	591	686	783
C&I Thermostat / EMS	Nursing Home/Lodging	145	305	482	675	884	1,107	1,343	1,590	1,845	2,105
C&I Thermostat / EMS	Small Office	-	-	-	-	-	0	0	1	1	1
C&I Thermostat / EMS	Small Retail	7	15	24	33	43	54	66	78	90	102
C&I Thermostat / EMS	Warehouse/Industrial	71	150	236	331	433	543	659	780	905	1,032

The following set of graphics are the achievable potential by measure and segment. Figure 12 are the results for C&I Thermostat/EMS setback temperature adjustment. The highest potential for savings for this measure are for multi-family common-area.

Figure 12. Achievable Potential Results for C&I Thermostat / EMS (DTh/peak day)

[22] Multi-family common area participation units is per building, not per dwelling unit.

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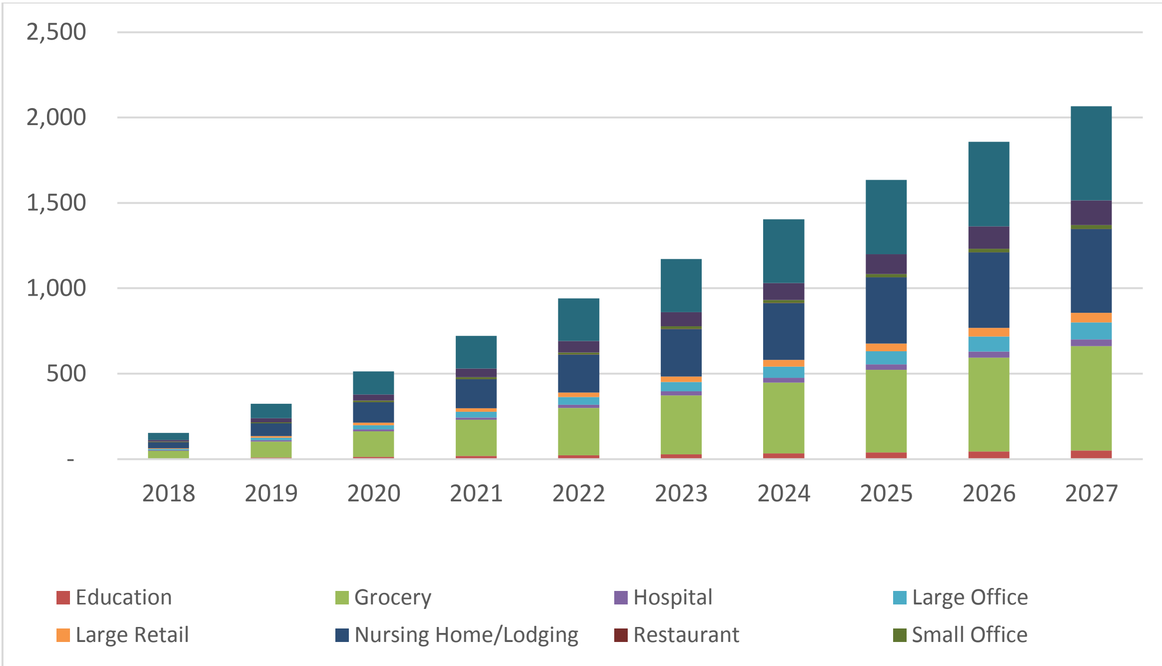

Figure 13 is the achievable potential for wastewater treatment scheduling and industrial process load control.

Figure 13. Achievable Potential Results for Industrial Processes (DTh/peak day)

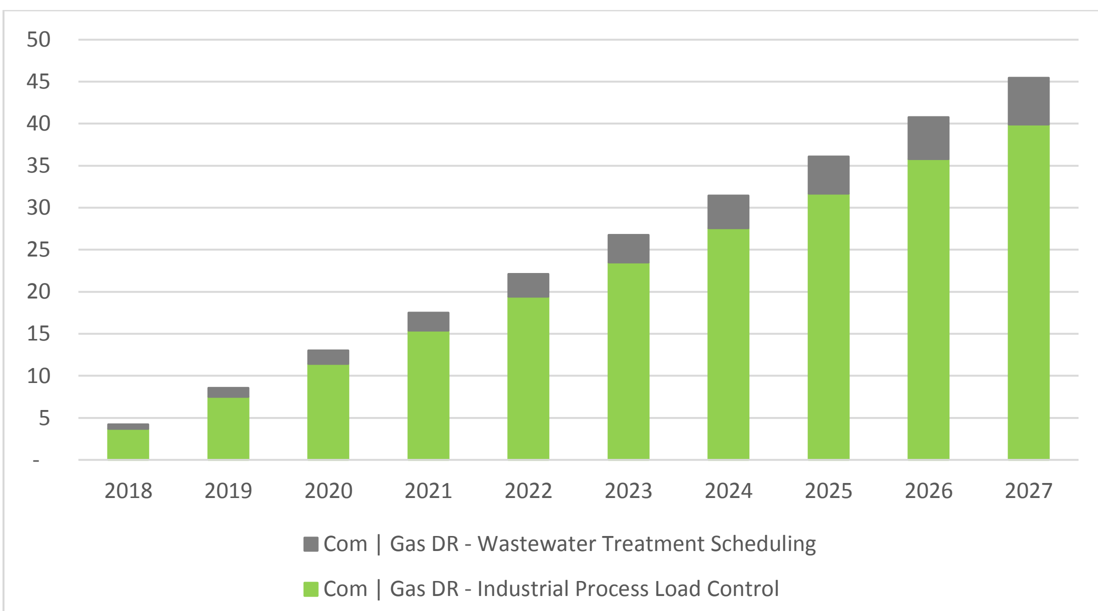

Figure 14 is the achievable potential for water heater control.

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Figure 14. Achievable Potential Results for Multi-Family Common Area Water Heater DR Control (DTh/Peakday)

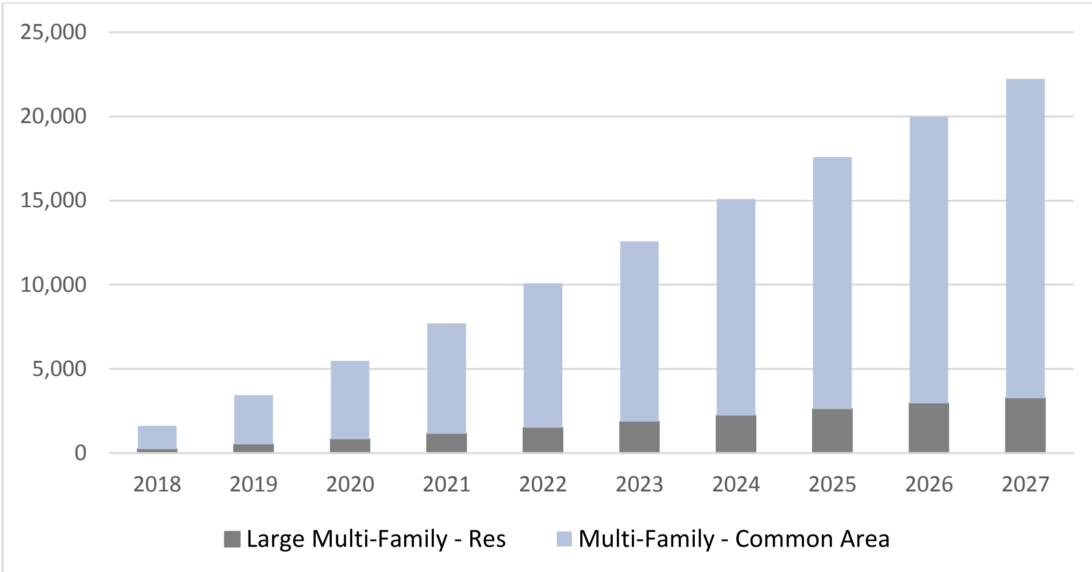

Figure 15 shows the results for the smart thermostat setback measures applicable in residential buildings.

Figure 15. Achievable Potential Results for Smart Thermostat Setback (DTh/peak day)

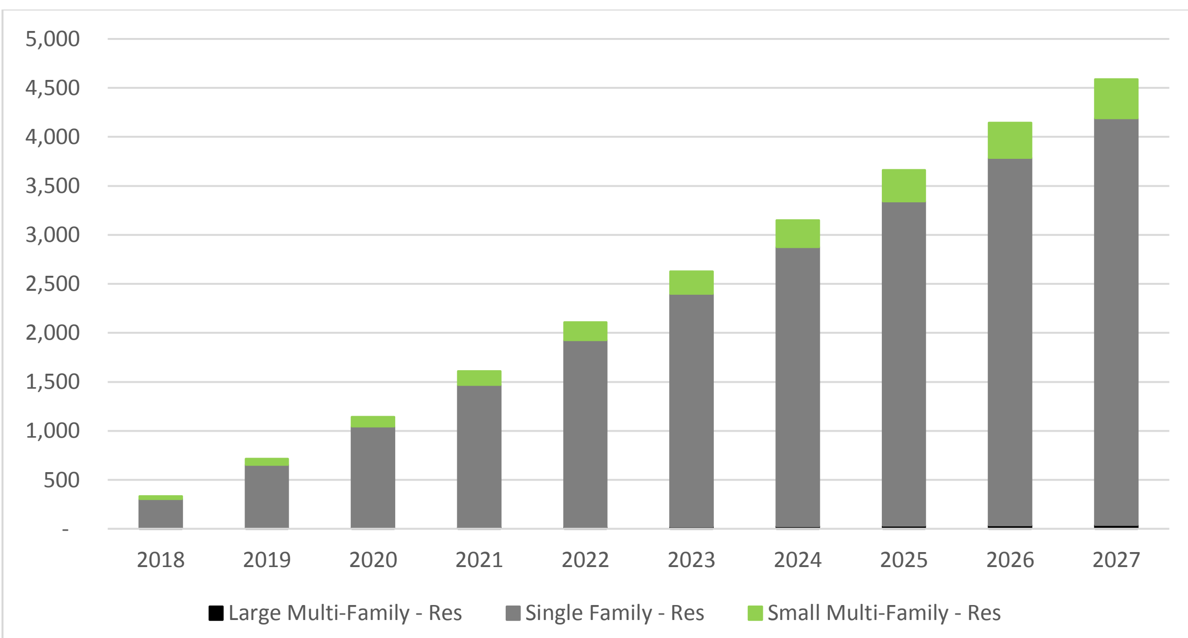

Figure shows the results for the cold temperature ductless heat pump measure.

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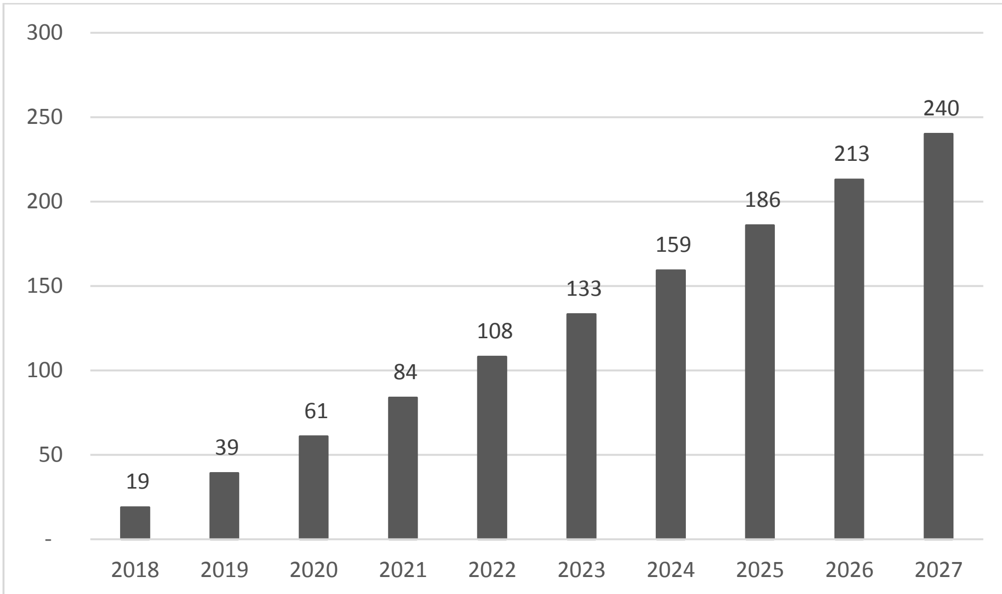
Figure 16. Achievable Potential Results for Cold Climate Ductless Heat Pump (DTh/peak day)



7.3 Gate Station Results

The following figures provides the savings at 2018 and 2023 respectively by gate station.

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Figure 17. Achievable Potential Results by Gate Station in 2018 (DTh/peak day)

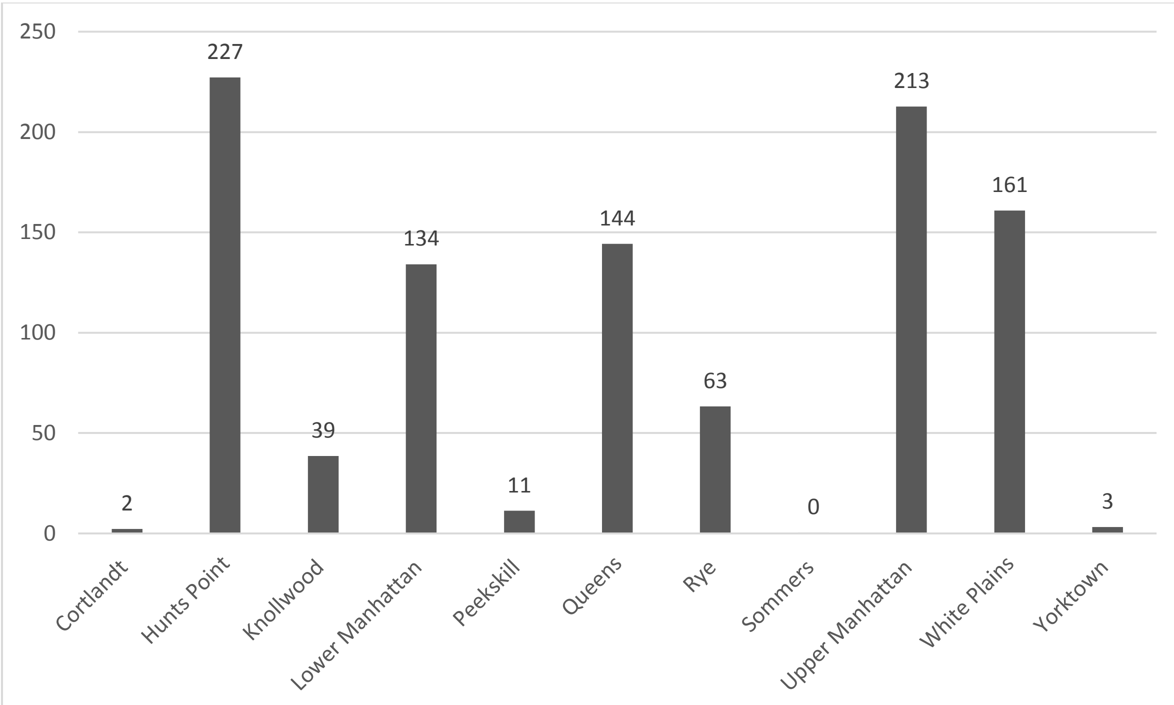
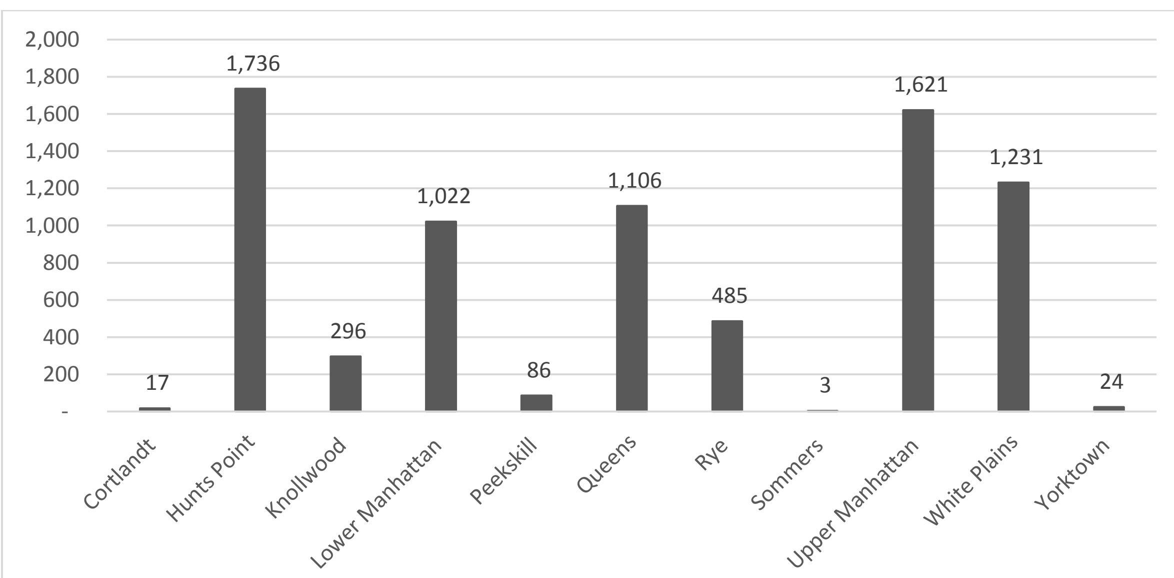


Figure 18. Achievable Potential Results by Gate Station in 2023 (Dth/peak day)



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Appendix A - Potential Gas DR Opportunities for Future Analysis

The table below provides a brief description for each gas DR opportunity and how Navigant could hypothetically model their impact in the DSMSim model. Navigant selected six of these measures through collaboration with Con Edison.

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Table A. Summary of Potential Gas DR Opportunities for Analysis (highlighted items selected for analysis)

#	Sector	Opportunity	Existing Utility DR Programs	Description / Notes	Modeling Plan & Challenges
1	Res Single-Family	Thermostat	• Gas: SoCalGas • Electric: Many	• Smart thermostats or energy management systems (EMS) make slight adjustments in temperature setpoints to reduce overall space heating demand during peak hours	• Model the potential savings of temperature adjustments to preheat space before event and/or adjusting thermostat setpoints during event • Select a DR event timeframe and estimate the impact of reduced heating system runtime
2	Res Multi-Family	Thermostat / EMS	• Gas: None • Electric: Many		
3	C&I	Thermostat / EMS	• Gas: None • Electric: Many		
4	Res Single-Family	Cold-Climate ASHP	• Gas: None • Electric: Many	• Cold-climate air-source heat pumps (ASHPs) can provide space heating with COPs >1.75 at 5°F. • For homes with both ASHPs and gas heating systems, the ASHP could become the primary heating system during peak hours	• Model the potential savings of switching from gas heating to ASHP operation during peak events. • Select a DR event timeframe and estimate the impact of decreased gas use and increased electricity use • ASHP heating performance and efficiency varies with outside temperature • Creates a potential fuel switching issue if increased ASHP runtime creates increased gas demand for power production
5	Res Multi-Family	Cold-Climate ASHP	• Gas: None • Electric: Many		
6	C&I	Cold-Climate ASHP	• Gas: None • Electric: Many		

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<table>
<tr><th>#</th><th>Sector</th><th>Opportunity</th><th>Existing Utility DR Programs</th><th>Description / Notes</th><th>Modeling Plan & Challenges</th></tr>
<tr><td>7</td><td>Res Single-Family</td><td>Appliances</td><td>• Gas: None
• Electric: None</td><td>• Delaying start times or reducing heating input for kitchen and laundry appliances (e.g., dishwasher, clothes washer, clothes dryer)
• ENERGY STAR offers credits for DR capable products and several major appliance manufacturers currently have models</td><td>• Model the potential savings of delaying start time until after event, or in the case of clothes dryers, using a longer, lower heat input setting during event
• Select a DR event timeframe and estimate the impact of reduced appliance usage</td></tr>
<tr><td>8</td><td>Res Single-Family</td><td>Water Heater Controls</td><td>• Gas: None
• Electric: Many</td><td rowspan="2">• Controls that adjust water heater temperature setpoints during periods of low expected usage (e.g., midday, vacation)
• Offered by SoCalGas for multifamily EE, under study by MNCEE / GTI for single-family EE</td><td rowspan="2">• Model the potential savings of temperature adjustments to heat additional water before event and/or adjusting thermostat setpoints during event
• Select a DR event timeframe and estimate the impact of reduced water heater runtime</td></tr>
<tr><td>9</td><td>Res Multi-Family</td><td>Water Heater Controls</td><td>• Gas: None
• Electric: Many</td></tr>
</table>

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#	Sector	Opportunity	Existing Utility DR Programs	Description / Notes	Modeling Plan & Challenges
10	C&I	Process Load Controls	• Gas: None • Electric: Many	• Controls that automatically reduce or delay certain process loads in C&I buildings during peak events. • Similar to traditional fuel switching / interruptible rates, but would be potentially automatic and quicker notice	• Model the potential savings of load curtailments for major gas-fired process loads at C&I facilities • Select a DR event timeframe and estimate the impact of reduced process heating demand • Will need to review both electric process DR programs and traditional fuel switching / interruptible rates to identify measure opportunities and potential reductions
11	C&I	Wastewater Treatment Schedule	• Gas: None • Electric: Several pilots (BPA, LBNL)	• Automatic or manual controls that reduce wastewater treatment gas consumption during peak events by adjusting processing schedules (mostly for boilers) • Installing anaerobic digesters at wastewater treatment plants to offset grid-supplied gas and electricity consumption	• Model the potential savings of load curtailments at wastewater treatment facilities by adjusting schedules • Will need to review electric DR pilots at wastewater treatment facilities to identify measure opportunities and potential reductions • Model the potential grid-supplied gas savings from anaerobic digester

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#	Sector	Opportunity	Existing Utility DR Programs	Description / Notes	Modeling Plan & Challenges
12	C&I	Traditional Fuel Switching / Interruptible Rates (Duel Fuel customers)	• Gas: National Grid, Many others • Electric: None	• Switch applicable natural gas loads to other fuels and/or reduce overall gas consumption	• Model the potential savings of fuel switching opportunities during peak events • Will need to review existing gas fuel switching / interruptible rate programs to identify measure opportunities and potential reductions

Appendix B - Estimation Methodology for Gas DR Measures

Navigant characterized the potential natural gas savings and costs for six natural gas demand response (DR) measures. Through discussions with Con Edison, Navigant analyzed full-day DR impacts for peak days, rather than DR events that would last one or several hours. Con Edison expected the gas DR events to be called during winter days with an average daily temperature below 22°F, estimated at 15 days total for most measures, and 30 days total for multi-family water heater controller.

This section summarizes Navigant's methodology for characterizing each gas DR measure.

Residential Measures

1. **Res MF Water Heater Controls**
    a. **Technology Description**: Retrofit controller for gas storage water heaters that adjusts the temperature set point from ≥130°F to 120°F during peak events, which reduces energy consumption to heat water to supply temperature, and avoids standby losses in the storage tank.
    b. **Technology Cost**: Estimated at $300 installed cost based on Con Edison electric DR program costs (~$300) and Aquanta water heater controller product ($149 uninstalled)
        i. Aquanta Website (link)
    c. **Energy Savings Methodology**: Calculate daily energy savings from turning down the water heater thermostat from ≥130°F to 120°F using NY TRM calculation methodology for domestic hot water tank blanket (pg. 55 of NY TRM) and indirect water heater (pg. 63 of NY TRM) for standby losses and large MF storage tank water heater (pg. 184 of NY TRM) for supply temperature reduction.
        i. 130°F baseline setpoint for Small and Large Multi-Family segments, 140°F baseline setpoint for Multi-Family Common Area per NY TRM.
        ii. Estimated 30 days per year for gas DR event, with additional energy efficiency savings during the rest of the year (335 days per year).
    d. **Key Questions / Issues**:
        i. Navigant assumed a 5% annual savings from supply temperature reduction based on the latest field test information.[23] This is a conservative estimate relative to the 10-20% simulated savings if supply temperature was reduced for the entire year. We use 5% since customer behavior could dampen energy saving since bathroom hot water end-uses use a thermostatic mixing valve to reach a given temperature. Lower hot water temperature from water heater leads to more hot water use (less cold water) at the tap to reach a given mixed

[23] Summary of current field tests by MNCEE and GTI: Summary Page (link), Presentation (link).

water temperature. The exact tradeoff is unknown, but current field studies suggest a 5-10% annual energy savings once including this tradeoff.

2. Res SF & MF Smart Thermostat

a. **Technology Description**: Smart thermostats make slight adjustments to temperature settings (e.g., 3°F) to reduce overall space heating demand during peak hours. Measure assumes smart thermostat is already installed and only requires activation for gas DR capabilities.

b. **Technology Cost**: Estimated at $12 per thermostat to activate the gas DR capabilities for an existing smart thermostat.

i. Review of implementation costs for direct-load control programs (2015 Navigant report for NPCC), $20/kW x 0.6 kW/home = $12/home

ii. 2015 Navigant report for Northwest Power and Conservation Council (link)

iii. **Cost Share of DR Technology for Gas DR vs. Electricity DR Programs** – assumes 75% cost share for gas DR program and 25% for electric DR program based on assumption that site would also participate in electric DR programs, program has net costs of $9.

c. **Energy Savings Methodology**: Peak day gas furnace consumption calculated using NY TRM entry for gas furnaces, and assume peak day impact of TRM programmable thermostat measure (pg. 120 of 2016 NY TRM for Programmable Thermostats). Note - does not include impacts of increased electricity consumption for heat pump.

i. Estimated 15 days per year for gas DR event.

3. Res SF Cold-Climate Ductless Heat Pump

a. **Technology Description**: Many single-family homes have installed ductless mini-split air conditioners and heat pumps to supplement the centralized HVAC system. For homes with both gas furnace and small ductless heat pump, this strategy adjusts the thermostat set points to decrease gas furnace operation, and increase ductless heat pump operation during peak days.

i. **Density**: Assume 5% potential market for gas heating customers with ductless minisplit providing auxiliary heating. 2015 NYSERDA study found ductless mini-splits account for roughly 5% of CAC installs.

1. 2015 NYSERDA Residential Statewide Baseline Study (link)

b. **Technology Cost**: Estimated at $300 installed cost based on Con Edison smart thermostat programs and similar direct load control (DLC) programs. Costs would cover any adapter needed to communicate with the ductless heat pump, since those products traditionally do not communicate with central thermostats. Net cost of $225 after 25% cost share from electric DR program.

a. **Cost Share of DR Technology for Gas DR vs. Electricity DR Programs** – assumes 75% cost share for gas DR program and 25% for electric DR program based on assumption that site would also participate in electric DR programs, program has net costs of $225.

c. **Energy Savings Methodology**: Based on two case studies for ductless heat pumps in cold climates, we estimate a 1-ton ductless heat pump could offset 10% of a home's heating load during peak day events. Peak day gas furnace consumption calculated using NY TRM entry for gas furnaces (pg. 120 of 2016 NY TRM for Programmable Thermostats). Note - does not include impacts of increased electricity consumption for heat pump.

   i. Cadmus Paper at 2016 ACEEE Summer Study (link)

   ii. Mitsubishi Electric Study for DOE Webinar (link)

   iii. Estimated DR events on 15 days per year.

d. **Key Questions / Issues**: Feasibility of communicating with ductless mini-splits, since most products use in-room remote controls rather than a thermostat. Mitsubishi and others sell adapters that would allow to connect with other whole-home thermostats.

Commercial & Industrial Measures

4. C&I Thermostat / EMS

a. **Technology Description**: Thermostat or EMS system reduces temperature set points during peak events.

b. **Technology Cost**: Costs calculated on a per sq.ft. basis based on assumed costs for adding DR capabilities to thermostats serving RTUs or EMS serving a centralized HVAC system.Assumes 75% cost share for Gas DR program and 25% for electric DR program.

   i. Estimate of $300 per RTU thermostat from Con Edison smart thermostat and other utility DR programs. Use NY TRM assumptions for sq.ft. per ton to estimate the number of RTUs per prototype building. Net cost of $225 after 25% cost share from electric DR program.

   ii. Estimated Whole Building/EMS costs of $5,000 from 2015 Navigant Northwest Power and Conservation Council study (link) and 2015 LBNL study (link) Net cost of $3,750 after 25% cost share from electric DR program.

   iii. **Cost Share of DR Technology for Gas DR vs. Electricity DR Programs** – assumes 75% cost share for gas DR program and 25% for electric DR program based on assumption that site would also participate in electric DR programs, program has net costs of $225 or $3,750 as noted above.

c. **Energy Savings Methodology**: Estimate space heating consumption (Therm per 1,000 sq.ft.) during peak days based on annual full-load operating hours and daily occupancy for prototype buildings. Savings percentage based on NY TRM entry for thermostat / EMS savings (pg. 212 of 2016 NY TRM for Programmable Thermostats).

i. Estimated DR events on 15 days per year.

It is important to note for this measure that there are differences in cost-effectiveness between building types, and specifically why the Nursing Home/Lodging segment shows greater cost-effectiveness than the Hospital segment. The following example shows how the savings are calculated and explain the causes for the comparison between Hospital and Nursing Home/Lodging segments.

The gas DR savings for each building type depends on the baseline gas consumption, the assumed annual Equivalent Full Load Hours (EFLH), and daily operating hours. Navigant used Con Edison customer data to determine baseline heating consumption (Therms/1000 SF) and then assumptions from the NY TRM about the prototypical building characteristics and operations. We also assume that operating hours on the peak day would be full load hours. The Figure below summarizes the data and methodology for determining the baseline gas consumption during each peak day with examples for Hospital, Nursing Home / Lodging, and Education segments.

Both Hospital and Nursing Home / Lodging segments have relatively high heating consumption (Row 1, Therms/1000 SF), but differences in the EFLH spread the gas consumption over a larger number of hours (Row 2), so the actual consumption on any peak day is lower (Row 3). The Nursing Home / Lodging segment has higher baseline consumption and is more concentrated to peak days (lower EFLH), so it shows higher peak day savings potential. With similar costs and higher savings, the Nursing Home / Lodging shows higher cost-effectiveness than the Hospital scenario.

Table B. EMS measure inputs and calculations

Row	Building Type	Data Source	Education	Hospital	Nursing Home/Lodging
1	Heating Consumption (Therms/1000 SF)	Consumption from Con Edison Customer Data	169.67	240.50	373.28
2	Annual EFLH (Equivalent Full Load Hours)	NY TRM (pg 444) provides EFLH for each building type	901	3366	1077
3	Therms / 1000 SF per EFLH	Row 1 / Row 2	0.19	0.07	0.35
4	Assumed EFLH on Peak Day	NY TRM (Appendix A) provides occupancy schedule; assume full load operation during peak days	9	24	24
5	Baseline Consumption Therms / 1000 SF on Peak Day	Row 3 x Row 4	1.69	1.71	8.32

5. **Wastewater Treatment Scheduling**
    a. **Technology Description**: Water and wastewater treatment plants use a combination of natural gas and biogas for digester boiler, on-site generation, space heating, and other processes. This measure would delay or decrease certain processes, or increase the use of biogas to decrease grid-supplied natural gas during peak days.
        i. **Density**: Navigant reviewed Con Edison customer data by NAICS code to segment annual natural gas consumption for water/wastewater treatment facilities from the rest of the Warehouse/Industrial building segment. From this analysis, water/wastewater treatment systems make-up roughly 7% of the Warehouse/Industrial annual natural gas consumption. Note - one interruptible customer site makes up the majority of consumption, and if removed, the density would go to 0.4%.
    b. **Technology Cost**: Costs of $10,000 per site ($5k equipment, $5k design and installation) estimated from a CEC-funded electric DR pilot. Net cost of $5,000 after 50% cost share from electric DR program.
        i. 2015 CEC AutoDR Pilot Report (link)

ii. **Cost Share of DR Technology for Gas DR vs. Electricity DR Programs** – assumes 50% cost share for gas DR program and 50% for electric DR program based on assumption that site would also participate in electric DR programs, program has net costs of $5,000.

c. **Energy Savings Methodology**: The CEC pilot found 10% demand reduction opportunities without affecting major plant operations. We estimate a similar result for total site natural gas consumption based on this study, and a 2005 NYSERDA study on natural gas vs. biogas at an Ithaca wastewater treatment plant.

i. 2015 CEC AutoDR Pilot Report (link)

ii. 2005 NYSERDA Ithaca Report (link)

iii. Estimated DR events on 15 days per year.

6. C&I Process Load Controls

a. **Technology Description**: This measure would delay or decrease certain gas-intensive processes at industrial sites during peak days.

b. **Technology Cost**: Costs of $10,000 per site ($5k equipment, $5k design and installation) estimated from a CEC-funded electric DR pilot. Net cost of $5,000 after 50% cost share from electric DR program.

i. 2015 CEC AutoDR Pilot Report (link)

ii. **Cost Share of DR Technology for Gas DR vs. Electricity DR Programs** – assumes 50% cost share for gas DR program and 50% for electric DR program based on assumption that site would also participate in electric DR programs, program has net costs of $5,000.

c. **Energy Savings Methodology**: Estimate 10% demand reduction opportunity for total site natural gas consumption (Therms per 1,000 sq.ft.) based on review of industrial electric DR programs. 2013 ORNL DR potential study estimated approximately 10% electric DR potential for the average industrial site. Actual savings will vary by site, industry, etc. and most electric DR programs use a site audit to identify electric DR potential.

i. 2013 ORNL Industrial Electric DR Report (link)

ii. Estimated DR events on 15 days per year.