BEFORE THE
STATE OF NEW YORK
PUBLIC SERVICE COMMISSION

In the Matter of

Niagara Mohawk Power Corporation d/b/a National Grid

Cases 17-E-0238 and 17-G-0239

August 2017

Prepared Exhibits of:

Staff Advanced Meter
Infrastructure Panel

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Date of Request: June 30, 2017
Due Date: July 10, 2017

Request No. DPS-450 CK-12
NMPC Req. No. NM-1026

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID
Case No. 17-E-0238 and 17-G-0239 –
Niagara Mohawk Power Corporation d/b/a National Grid – Electric and Gas Rates

Request for Information

FROM: DPS Staff, Chelsea Kruger

TO: National Grid, Advanced Metering Infrastructure Panel

SUBJECT: **AMI PILOT PROJECTS – CUSTOMER ENGAGEMENT**

Request:

In these interrogatories, all requests for data, work papers or supporting calculations should be construed as requesting any Word, Excel, or other computer spreadsheet models in original electronic format with all formulae intact.

1. The following questions pertain to National Grid's Worcester, Massachusetts, SmartGrid Pilot Project:
a. Provide the Customer Engagement Plan developed and used for this pilot project.

b. Provide all customer surveys that the Company used before, during, and after AMF meter implementation. Include the results of each survey in your response.

c. For each month since meter deployment, provide the number of residential customers who are enrolled, by heating and non-heating. Include the following information in your response:
i. The number of customers who opted-out of the project before, during, and after deployment, separately for each category.
ii. A breakout of low-income customers who enrolled or opted-out of the project.

d. With regard to customer engagement, provide a detailed list of lessons learned from this project.

e. Provide monthly data for any customer engagement metrics measured during this project.

f. For each month of the pilot, provide customer retention rates for:
i. The AMF meter;
ii. The TOU rate; and
iii. Both the AMF meter and the TOU rate.

2. The following questions pertain to Niagara Mohawk's Clifton Park Demand Response demonstration project:

a. Provide the Customer Engagement Plan used by Niagara Mohawk for this demonstration project.

b. For each month since AMF meter deployment, provide the number of residential customers who are enrolled in Niagara Mohawk's Clifton Park demonstration project by heating and non-heating. Include the following information in your response:
i. The number of customers who opted-out of the project before, during, and after deployment, separately for each category.
ii. A breakout of low-income customers who enrolled or opted-out.

c. With regard to customer engagement, provide a list of lessons learned prior to AMF meter deployment.

d. Provide monthly data for any customer engagement metrics being measured during this project.

e. For each month of the pilot to date, provide customer retention rates for:
i. The AMF meter
ii. The TOU rate
iii. Both the AMF meter and the TOU rate.

<u>Response</u>:

1.

a. The Customer Engagement Plan developed and used for the Worcester Smart Energy Solutions Smart Grid Pilot (the "Pilot") is included as Attachment 1.

b. Customer surveys completed for the Pilot are included in Attachments 2 and 3. Because of size, the surveys are included in zip files. The specific surveys and document reference number for each are listed below:

    i. Meter Decline Survey, November 2013 (Doc. # 0,1)
    ii. Pre-Pilot Survey, February 2014 (Doc. # 2,3,4)
    iii. Post Installation Survey, April 2014-March 2015 (Doc. # 5,6)
    iv. Post Event Surveys; June-July 2015(Doc. # 7,8,9), July-August 2016 (Doc. # 12,13,14)
    v. End of Summer Survey, September 2015 (Doc. # 10,11)

vi. End of Pilot Survey, October 2016 (Doc. # 15, 16)
vii. Opt Out & Drop Out Survey, November 2015 (Doc. # 17, 18)
viii. Opt Out & Drop Out Survey, October 2016 (Doc. # 19, 20)

Summary results for the above surveys can be found in Appendix C, pages 143 – 151 of 158, of the “Smart Energy Solutions Final Evaluation Report” that the Company previously submitted as Attachment 1 to Information Request No. UIU-2 (KOH-89). Attachments 2 and 3 also contain results for the surveys.

c. The Company cannot provide an enrollment break out between heating and non-heating customers because this break out was not tracked as part of the Pilot.

The table below summarizes the total residential customer enrollment in the Pilot, broken out monthly by R1 (non-low-income) and R2 (low-income) residential customers. These monthly counts include residential customers enrolled in either of the Pilot’s two pricing plans (Time of Use with Critical Peak Pricing or Peak Time Rebate). The Company began tracking this information in February 2015, the billing month following the launch of the Pilot’s customer pricing plans.

Month	R1	R2
Feb-15	10625	1399
Mar-15	10462	1378
Apr-15	10279	1345
May-15	10304	1350
Jun-15	10316	1326
Jul-15	10257	1322
Aug-15	10310	1307
Sep-15	10422	1292
Oct-15	10416	1336
Nov-15	10415	1325
Dec-15	10363	1319
Jan-16	10324	1359
Feb-16	10303	1346
Mar-16	10307	1351
Apr-16	10298	1341
May-16	10269	1012
Jun-16	10266	1049
Jul-16	10269	1072
Aug-16	10276	1065
Sep-16	10271	1066
Oct-16	10297	1062
Nov-16	10316	1098
Dec-16	10312	1113

i. & ii.
The table below summarizes the total number of residential customers who declined an AMI meter during the 2012 to 2013 deployment phase of the Pilot broken out by R1 (non-low-income) and R2 (low-income) residential customers. The Company does not have this data broken out by month.

Residential Customer Rate Class	# of AMI Meter Declines
R1	991
R2	100

The table below summarizes the total number of customers who, after having an AMI meter installed, chose to opt out of the Pilot before it officially went live with new customer pricing plans on January 1, 2015. This table is broken out by R1 (non-low-income) and R2 (low-income) residential customers. The Company does not have this data broken out by month**.**

Residential Customer Rate Class	# of Pilot Customer Opt Outs After AMI Meter Install
R1	218
R2	42

The table below summarizes the total number of customers who chose to drop out of the Pilot after it went live (from January 1, 2015 through December 31, 2016). This table is broken out by R1 (non-low-income) and R2 (low-income) residential customers. The Company does not have this data broken out by month.

Residential Customer Rate Class	# of Pilot Customer Drop Outs (1/1/15 - 12/31/16)
R1	252
R2	40

d. The Company provided a list of lessons learned from the Pilot in its response to Information Request No. UIU-2 (KOH-89). In the response, the Company noted the importance of a staged approach to customer engagement, the necessity of tools to support customer engagement, the viability of an opt-out design, and the value of soliciting customer feedback on a recurring basis. Lessons learned are documented in the Pilot evaluation report (pgs. 114 – 117 of 158) that was included as Attachment 1 to Information Request No. UIU-2 (KOH-89). Key customer-focused learnings are also included on page 120 the same report.

e. The customer-engagement metrics that were measured are as follows:

   i. *Total customer traffic of visits to the Pilot's customer web portal* – this data, broken out bimonthly (2x per month), was provided in Attachment 1 to

Information Request No. UIU-2 (KOH-89) (please see Figure D-1 on pg. 152 of 158). Figure D-1 also shows the total count of unique logins for each record, as well as a cumulative count of unique logins.

ii. *Frequency of first time web portal log-ins* – this data, broken out monthly, was provided in Attachment 1 to Information Request No. UIU-2 (KOH-89) (please see Figure 2-8 on pg. 50 of 158).

iii. *Number of new in-home technology installs* – this data, broken out monthly, was provided in Attachment 1 to Information Request No. UIU-2 (KOH-89) (please see Figure 2-9 on pg. 51 of 158).

iv. *Number of Pilot customers with in-home technology* – this data, broken out monthly below, shows the total numbers of participating customers with any combination of the in-home technology options offered by the Pilot (*i.e.*, digital picture frame, programmable communicating thermostat, load control device, and smart plug).

Please note that these figures may not align perfectly with "*Number of new in-home technology installs*" noted above in Part e.iii. due to various customer changes throughout the Pilot (*e.g.* move in, move out, Pilot drop out).

Pilot Program Year	Pilot Program Month	Total Customers with Technology
2015	January	932
2015	February	1007
2015	March	1055
2015	April	1063
2015	May	1072
2015	June	1081
2015	July	1081
2015	August	1091
2015	September	1111
2015	October	1127
2015	November	1127
2015	December	1132
2016	January	1139
2016	February	1145
2016	March	1151
2016	April	1144
2016	May	1145
2016	June	1134
2016	July	1121
2016	August	1122
2016	September	1124
2016	October	1122
2016	November	1127
2016	December	1126

f. The Company did not track a specific monthly retention rate for the AMF meter and/or the TOU rate for the Pilot. Please refer to the Company's response in part c above for the corresponding counts regarding total customer enrollment and/or opt outs during the various phases of the Pilot.

2.

a. Attachment 4 is a copy of the Company's Clifton Park Demand Reduction REV Demonstration Project Implementation Plan. The customer engagement plan is addressed on pages 5 – 8 of the attachment. Customer engagement activities that have occurred to date include:

- Direct mail to 14,464 customers to introduce Smart Energy Solutions and provide an opt-out period;
- Video to educate customers on how Smart Energy Solutions can help Clifton Park residents better manage their energy use;
- Mailed weekly Meter Installation Notifications postcards;
- Presentation focused on the benefits of Smart Energy Solutions for the community outreach meetings;
- Hosted three customer outreach meetings to discuss Smart Energy Solutions and demonstrate the portal:
    - Approximately 170 total attendees;
    - Meeting dates were March 29, April 27, and June 12.
- Continual update of ngrid.com/cliftonpark and the FAQs based on customer feedback into the call centers and as new features were rolled out;
- Mailed welcome letters to those customers whose meters were installed;
- Mailed letter to invite those customers who initially opted out to come and learn more about the program to see if we could get them to opt back in to the program (five people opted back in);
- Social media to begin in July; and
- National Grid Conservation day emails to begin July 3.

b. The Clifton Park Demand Reduction REV Demonstration Project is an opt-out design. Eligible customers are enrolled in the project until they request to opt out. There are 14,456 residential electric premises eligible for the project. Of these, 13,358 have residential natural gas service. Of the eligible population, the distribution of heat/no-heat based on the tariff description in the billing system is as follows:

- 12,328 electric no heat; 2,128 electric heat
- 12,577 natural gas heat; 781 natural gas no heat

In January 2017, letters were sent to the eligible population describing the project along with instructions to opt out. The Company tracks opt outs by calls received in the Contact Center or in the field at the time of meter installation; opt outs are not tracked by heating and non-heating. The table below represents the monthly tracking of opt outs by month.

	Total	Feb 2017	Mar 2017	Apr 2017	May 2017	June 2017
Contact Center	347	202	47	77	17	4
Field	472			12	282	178*
	819					

* 28 of the 178 June filed opt outs were determined after three attempts to install the meters

Of the project eligible premises, 243 are considered low income. Of these, 14 accounts have opted out of the project.

c. National Grid's experience with the Worcester Smart Energy Solutions Smart Grid Pilot project provided insight to the development of the customer engagement tools for the Clifton Park Demand Reduction REV Demonstration Project. Although the project designs have significant differences, the experience of the Worcester project informed the REV demonstration with respect to meter deployment communications.

d. The table below includes the customer engagement metrics that will be tracked throughout the project, including targets.

		Baseline	Goals			
Web Portal Metrics	**Metric Definition**	**Jan - Apr**	**May**	**June**	**July**	**August**
Login Rate	Out of all customers with active utility accounts in that month, what percentage of them have ever logged in	14.75%	16.15%	16.84%	17.53%	18.22%
# Customer has ever logged in	Number of customers who have ever logged in	2,132	2,332	2,432	2,532	2,632
# of new customers logged in	# of new customers logged in	77	200	100	100	100
# of unique customers logged in per month	Number of customers who logged in during a given month	290	315	340	365	390
% of active customers logged in per month	Out of all customers with active utility accounts in a given month, what percentage of them logged during that month	2.00%	2.00%	2.34%	2.52%	2.69%
# login events per month	Total number of login events per month (e.g. a customer logging twice in during one month counts as two logins for that month)	339	339	397	427	456
Top 5 site selections	Ranked by the number of sessions that visited that section	1. My Energy Use - 65%, 2. Ways to Save - 27%, 3. Dashboard - 15%, 4. Home Energy Audit - 15%, 5. Compare My Bills - 12%				
Points & Rewards Metrics	**Metric Definition**	**Jan - Apr**	**May**	**June**	**July**	**August**
Customer Expereince Metrics						
Customers who have enrolled in Points & Rewards	Number of customers who have enrolled in Points & Rewards	404	604	704	804	904
Customers who have earned points	Number of customers who have earned points in Points & Rewards	400	423	493	724	814
Customers who have redeemed points they earned	Number of customers who have redeemed points in Points & Rewards	24	30	35	51	57
Budget Metrics						
Rewards account: Points awarded	As of the end of the month, the total number of points awarded (cumulative)	314,254	434,854	555,454	691,054	841,654
Rewards account: Points & Rewards redemption	As of the end of the month, the total number of points redeemed (cumulative)	29,820	31,425	34,788	38,882	41,463
Rewards account: Points awarded, but not redeemed	As of the end of the month, the total number of awarded points that have not been redeemed (cumulative)	284,434	403,429	520,666	652,172	800,191
Opt-Out Metrics	**Metric Definition**	**Jan - Apr**	**May**	**June**	**July**	**August**
Customers unsubscribed from email channel	Total number of customers who have unsubscribed from specific email types	218	238	258	278	298
Customer Unsubscribe by Email Type -- DRR	Total number of customers who have unsubscribed from DRR emails specifically	0	35	70	105	140
Customer Unsubscribe by Email Type -- WAMI	Total number of customers who have unsubscribed from WAMI emails specifically	0	35	70	105	140
Customer Unsubscribe by Email Type -- HBA	Total number of customers who have unsubscribed from HBA emails specifically	0	35	70	105	140

e.

i. To date, 13,006 electric meters and 11,675 gas ERTs have been installed for the project. Meters will continue to be installed through July. There have been a total of 819 opt outs, as described above.

ii. By design, the Voluntary Time of Use rate ("VTOU") will not be promoted for the project until the fall of 2017. The VTOU rate was approved for Niagara Mohawk customers in November 2016. Modifications to omit the metering charge for Clifton Park customers were approved in the spring of 2017. There are currently no Clifton Park customers on the VTOU rate. There are 45 Clifton Park customers on the SC1C TOU rate. Promotion of the VTOU rate will be coordinated with the Smart Home Rate promotion.

iii. The VTOU rate will not be promoted for the project until the fall of 2017.

Name of Respondent:	Date of Reply:
John Leana Nick Corsetti Melissa Piper	July 10, 2017

nationalgrid

Worcester Smart Grid Pilot

Customer Outreach and Education Plan

December 22, 2011

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Introduction

National Grid's comprehensive Smart Grid modernization and customer interface pilot in Worcester can only succeed if it's rooted in deep customer engagement and starts and ends with the customer. When customers are engaged, they can better understand the benefits of their involvement and ultimately help manage their energy utilization and save costs. The company has reviewed other Smart Grid deployments around the country and has learned how critical effective engagement with customers is to overall success. Utility customers have long been passive buyers of electricity; it is a commodity that is an afterthought amongst larger financial obligations such as a mortgage or rising consumer costs. Historically the sale of electricity has been a one way transaction that has not required our customers to play material role, and customers have not seen a role for themselves. Smart Grid dramatically changes that dynamic with the onset of real time usage data, alternative pricing schemes and the fact that plug in electric vehicles and distributed generation are much more viable. To effectively modify a long established culture, the Company has adapted a thorough and creative approach in the Outreach and Education Plan (O & E). The O & E is a fundamental tool in bridging community, stakeholder and customer experience and their inputs with the Smart Grid technology and grid modernization to achieve, and possibly exceed, the 5% savings target as stated in Section 85 of the Massachusetts Green Communities Act (Chapter 169 of the Acts of 2008). Moreover, engaging customers in a fundamentally new way will enhance both National Grid's and our customer's abilities to impact how and when we use energy, control and reduce costs associated with energy use, as well as convey inherent grid modernization benefits such as increased service reliability, improved outage and emergency restoration response.

Community Customer Worcester

The City of Worcester, centrally located in Massachusetts, is home to a diverse population that represents a microcosm of the Commonwealth, and the 15,000 households and businesses within the Pilot footprint are reflective of that diversity. This varied mix of customers provides the opportunity to test the value proposition of the newly available interactive rates, technology and informed customer actions sought after in deploying the Smart Grid Pilot and will aid in understanding the implications and benefits of Smart Grid technology. In addition, Worcester has a diverse distribution system with both underground and overhead networks within close proximity of a number of existing and potential distribution generation project sites. Worcester's multiple institutions of higher learning are also committed to energy education and technology, renewables, and energy efficiency, and will serve as a critical partner in the Pilot's success.

Listening to Community, Customer, Worcester

Customer engagement will need to be driven and supported by a fluid and ongoing O & E plan that reaches customers effectively and enlists them in a two-way partnership to help them realize their ambitions in managing energy use and achieving savings. Effective customer engagement will maximize the value of the investments being made through the Pilot and can, over time, enhance customer experience and customer satisfaction. The pages ahead will demonstrate that National Grid's O & E strategy was informed by:

- Appreciative Inquiry Community Summit in Worcester (Green2Growth)
- Green Communities Act and Mass Smart Grid Collaborative "Common Evaluation Framework"
- Lessons learned observing other Smart Grid pilots

Community Summit

National Grid has taken major strides in ensuring that our O & E plan is built on the foundations established by the community summit held in September of 2011, which encouraged leveraging customer-centric initiatives and a robust two-way communications approach to enable customers to choose how and when they use energy. This pivotal customer engagement event included approximately 300 stakeholders and is locally known as the **Green Today, Growth Tomorrow Community Summit** (Green2Growth).

Green2Growth Summit Participation

Green2Growth introduced a new 'listen, test and learn[1]' approach to optimize engagement and it opened the door to two-way communications that can enable the Company to better understand what motivates customers to act. The partnership between National Grid and the City of Worcester was an essential factor in the success of the event and provided the Company with its first steps on a journey that will be taken with customers. Additionally, as the Pilot unfolds, the Green2Growth approach and the continuing dialogue it has generated will provide the ability to amplify, modify, or refine tactics based on their effectiveness, building a more interactive and meaningful customer experience. National Grid views Green2Growth and our partnership with the community as a means to be much more of a collaborative partner than an imposer of new technology on an unprepared customer base. When you look at the Smart Grid deployments that have met with consumer backlash, it has been the case that the customers felt as though something dramatically different and unexpected had been foisted upon them. National Grid's partnership with the community of Worcester is designed to avoid those problems and rely on a continuous learning experience and exchange of ideas.

Green Today, Growth Tomorrow Community Summit

Those who participated in Green2Growth in Worcester on September 19 and 20, 2011 had the opportunity to experience something truly groundbreaking. Rather than prescribing Smart Grid as a utility-centric project, the pilot was introduced in the context of broader sustainability initiatives that will serve the passion, vision, and needs of the local community. Civic and business leaders, educators and community groups, university professors, facilities personnel, and students, young people and seniors, low-income and affluent citizens, home owners and renters, enthusiastically embraced the notion that by working together they could each make a difference in their community's environmental and economic future. Understanding Smart Grid and the connection to

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[1] "Listen, test and learn" approach refers to testing and measuring pilot tactics and using the resulting information to improve approaches at several points along the Pilot.

associated impacts on economic vitality, among other benefits, will increase the effectiveness of the pilot investment and bridge community goals to those of the Pilot.

National Grid employees—union members, senior executives, technical and program managers—had an opportunity to listen to their customers first hand. Collaborating with city and state elected officials, regulators, consumer advocates, community-based organizations, thought leaders, and other stakeholders, National Grid learned how their ideas for the Pilot could enable the community's goals. Smart Grid, for its own sake, was not the agenda. Sustainability and technology were discussed as a means to provide feedback from customers on how they could make intelligent choices about reducing and deferring energy usage, how to better manage the distribution system so outage detection and emergency response could be improved and how to enable the integration of more renewable generation, for example.

What a difference TWO days can make...

Green2Growth Summit Customer Participation

What became clear to everyone present—even the skeptics—was the groundswell of support that arose when people were brought together to share ideas and apply their creative energies. Participants recognized that sustainability is a pathway to economic vitality for the community. The fundamental structure of National Grid's Outreach and Education Plan is a direct result of this deep collaboration by National Grid, the Worcester community and engaged stakeholders.

Green2Growth Outreach to recruit and retain participants

Numerous assessments of consumer attitudes have been quantified by leading research organizations[2] and have found certain dominant themes that resonate with people sharing similar perspectives. At the same time, research studies have shown that one person's compelling reason is another person's deterrent and that people tend to project their own perspective onto the broader community. This phenomenon explains why a single tagline or campaign will not successfully reach all audiences.

Green2Growth participants saw these variances in action during the Innovation Panel. The panelists, selected from different professional perspectives, offered a range of value propositions they found to be compelling. One panelist set the stage by describing the importance of forming

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[2] 2011 State of the Consumer Report, Smart Grid Consumer Collaborative, pages 19-25

emotional connections to rational reasons for behavioral changes regarding energy usage. Other panelists spoke about the need for transformative goals to achieve environmental progress, support for providing affordable energy, creating the right educational programs that can help customers cut their bills and teaching children about sustainability. National Grid listened to all of these stakeholders within the community and has incorporated their input into the Outreach and Education approach.

Today, the Company continues to listen and participate in the Green2Growth steering committee supporting the further evolution of the 15 opportunity areas that were identified at the Summit.

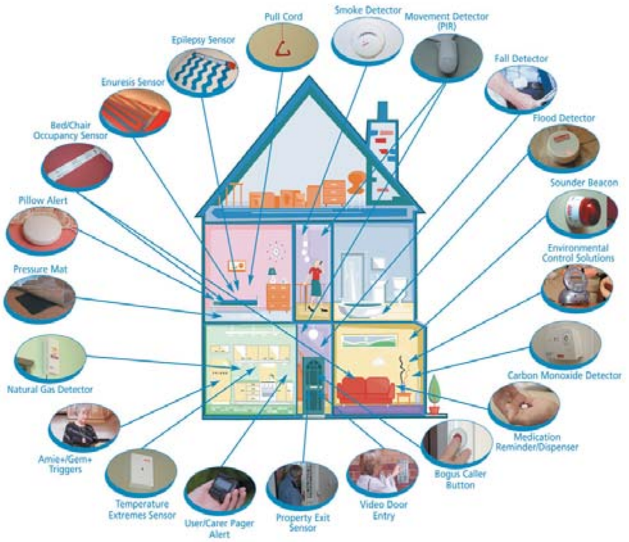
Green2Growth initiatives aligning the community and with the Smart Grid Pilot:

- Asset map showcasing sustainable resources, technologies, opportunities, and leaders
- Viral video project by schools and university students on “Ways our family saves energy”
- “Kids’ eye views of sustainability” video
- Empower low-income consumers as energy leaders
- Advance energy literacy education within the community
- Advance the Sustainability Hub as a World-class smart energy demonstration destination

Participant Illustration

Organization Worcester Community Action Council
Address 484 Main Street Suite 200
City Worcester
State MA
Zip 01608
Website www.wcac.net
Description The Worcester Community Action Council administers federal fuel assistance program and conducts outreach and education to assist recipients in becoming more energy aware/efficient.
Zoom to

Screen shot from Asset Map Draft 1



Sustainability Hub Concept Model

The Sustainability Hub concept is a direct initiative resulting from the Green2Growth Summit. National Grid is leading the development of the Sustainability Hub by partnering with vendors, local institutions and interested stakeholders to create a destination for the community to experience interactive exhibits and have hands-on access to Smart Grid technology & education.

Through this partnership, the Company will continue to further explore, review and communicate Smart Grid initiatives and efforts undertaken in the Pilot. In addition, communication outreach channels incorporated in the O&E Plan such as the Sustainability Hub, online and mobile channels, customer usage benchmarking and data visualization, among others, represent how customer preferences and needs expressed during the Summit are now linked with the Company's approach to the Pilot. National Grid took what we heard in Green2Growth and not only applied it directly to the approach of the Outreach & Education Plan, but is partnering with Green2Growth as a local stakeholder to ensure that we continue to have an open dialogue with stakeholders, continuously advancing the "listen, test & learn" model.

Lessons Learned In Smart Grid

In addition to the Grren2Growth summit, and to gain a better understanding of best practices and build a more meaningful approach, National Grid also collected information, observations and key learnings by:

- Participating in the Statewide Evaluation Collaborative Common Evaluation Framework
- Understanding key insights that can be achieved through the Green Communities Act
- Assessing similar utility pilot efforts across the nation: San Diego Gas & Electric, NSTAR, Unitel, Commonwealth Edison, Duke Energy, Westar Energy, and Oklahoma Gas & Electric
- Obtaining feedback from industry experts: GreenOrder, The Structure Group, To-The-Point
- Consulting with educational institutions and organizations with experience in the Smart Grid arena: Clark University, Worcester Polytechnic Institute, Institute for Energy & Sustainability

Several lessons and best practices can be learned from Smart Grid projects that are already underway. Although Smart Grid remains a relatively new phenomenon in the utility sector, these case studies provide early lessons learned and have helped inform the development of the Company's Outreach and Education strategy. The Company identified a wide range of case studies for in-depth analysis. Two select case studies are attached in the Appendix 4.

Outreach & Education Strategy

The customer voice heard at Green2Growth, along with lessons learned from other Smart Grid pilots helped the Company to craft a highly customer-centric approach that starts long before the Pilot is launched. Engaging customers and stakeholders prior to the launch has proven to be a general best practice in outreach, engagement and communications methodologies. National Grid has developed a strategy that will use current customer touch-points and community-based communication vehicles as an opportunity to deploy the "listen, test & learn" approach and will continuously refine channels of communications, messages developed for education and outreach, and methods of deploying information based on what we hear from our customers. (*Details on Channel and Message delivery are found later in Plan)*.

PRE-LAUNCH Strategy

Gain customer trust first: Customers must clearly understand the "what, when, & why" and see benefits[3]. Installing technology prior to gaining trust and customer buy-in has led to confusion and backlash as evidenced in lessons learned from other Smart Grid deployments. When customers clearly understand how smart energy technology will provide them with more control, choice and understand the benefits of Smart Grid reliability enhancements, it enables them to save energy and costs. All messaging should be informative and in the voice of the customer and should focus on enabling the consumer to make the best choices among the available options. That choice includes the ability to choose the right technology/rate package or the opportunity for the customer to opt-out of the program.

Example:

The Green2Growth website, brand, and activities will continue to develop under the direction of the steering committee, the City of Worcester, and National Grid. The Green2Growth website will be a community-based vehicle for customer outreach, education and communication.

Local community partners can act as ambassadors. Community Based Organizations (CBO), such as school PTO's, conservation groups, faith-based groups, neighborhood associations,

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[3] Note: Timing is critical. To ensure pilot success, consideration of external factors may contribute to customer perception about technology and utility approach: weather, season, trends in price of energy, rate tiers, policy changes, economic conditions, etc.

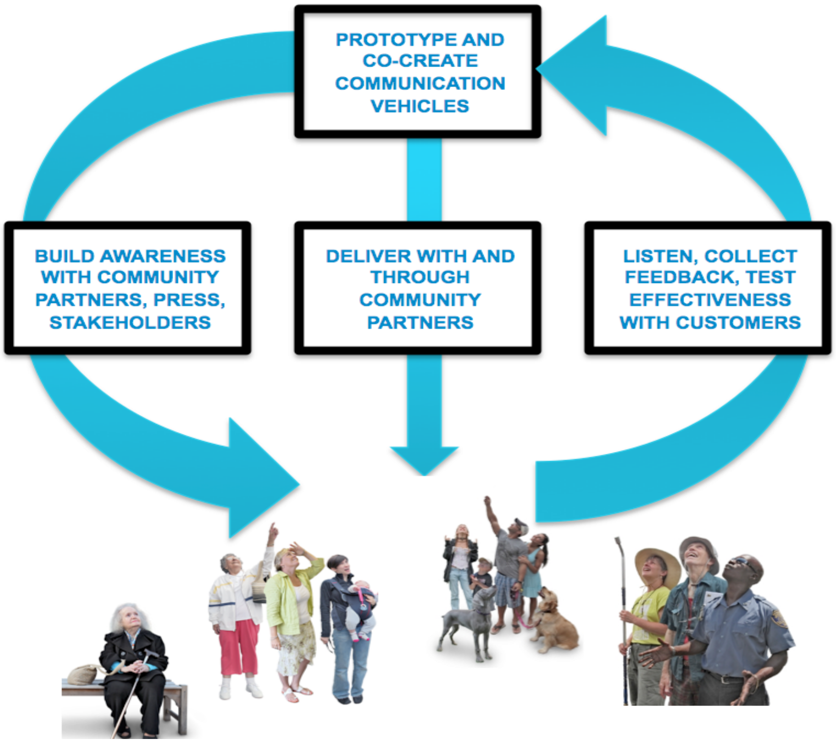
thought leaders, etc. can help convey information/messages to large audience groups. As customers see peers and neighbors participating, it is likely they will be better equipped to participation and engagement.

Develop, deliver & repeat important message(s). Message content and channel deployment will be developed based on community "listen, test & learn" engagement on lessons learned and best practices from other. It is commonly understood that messages need to be repeated multiple times to be internalized, therefore, use of multiple channels to deliver repeated messages will be necessary. Messaging should be informative on the benefits of both grid modernization and customer devices, as well as introduce the technology deployed.

Use multiple channels strategically using segmentation as a guide. Multiple channels should be used to convey and reinforce messages. Channels should be tailored to fit the needs, preferences, and desires of different customer segments as identified in the Statewide Collaborative and results of what the Company learns in the "listen, test, learn" approach.

Equip customer-facing employees, interns, and vendors with knowledge. Customer-facing employees such as those in call centers, customer & business service teams, or field operations, along with employees who reside in the City of Worcester, act as ambassadors of the utility to their family, friends, and neighbors and should be provided with comprehensive training and a robust internal communication plan to deliver to customers to ensure consistency. A process should be established to update messages on a regular and emergency basis. Messaging should include, but not be limited to, information on available resources/expertise, community events and forums, technical information, tips on how to save energy, related utility programs such as rate programs, the benefits of Smart Grid on both sides of the meter, and so on. This internal communications plan should also extend to customer engaging vendors, College Co-op's or other partners working on the Company's behalf.

Instill a sense of positivity and excitement. The Green2Growth Summit echoes a trend that has been repeatedly demonstrated in successful pilots, efficiency programs, and AMI deployments across the country: involving the community and established local organizations to co-create solutions for better pilot success. Residents are more satisfied and Co-operative, local non-profits and advocates feel ownership in the outcome, and employees feel a sense of pride of how their organization is supporting their communities. Green2Growth unveiled many benefits associated with smart meter and Smart Grid technology, including, but not limited to, the potential for greater economic development, integration of renewables and electric vehicles, and more customer choice and control. Taking a positive, proactive approach can engage customers and encourage participation. Building on the momentum generated by Green2Growth, the Company intends to pursue the smart grid related initiatives that came out of the community summit, working collaboratively with community stakeholders to maintain a collective commitment to the success of Smart Grid.



Build on Green2Growth model of collaboration to deliver meaningful & adaptable O & E

LAUNCH & POST LAUNCH

Engage customers as partners in change. When utilities view customers as partners, there is a deeper level of engagement and a sense of an ongoing relationship. For example, championing customers who are successful in developing energy-saving behaviors should be reflected in communications during implementation as a showcase of progress within the community and help motivate customers' interest in smart technologies and drive increased customer engagement.

Continued communications should provide specific value (how-to's, practical tips). During launch, messaging resources should shift toward providing practical tips and additional opportunities that can contribute to greater energy savings, comfort, convenience or other benefits for customers. In addition, broader-based outreach will be deployed to expand awareness on the customer benefits and serve as a touchpoint to those throughout the community who have an interest in the Pilot, but may not be within the Pilot boundaries.

Proactively extend technical support (field demonstrations, in-home visits, local business/technology expos, etc.). Face-to-face interaction with the customer can help create momentum around customer engagement. Customers who have Smart Grid technology installed in their homes should be invited to multiple demonstrations and how-to events to provide an opportunity for them to learn about the broader Pilot goals, understand the basic operation of devices and how they can interact with the energy information newly available to them and become aware of their increased ability to control energy use and potential savings associated with the technology.

Plan, pace and cadence of regular communications events for continuity and momentum. Continued communication creates and maintains trust with the customer which enables deeper customer engagement. The "Listen, test and learn" approach will help customize outreach messages, channel mechanisms, and identify other tactics and timing for disseminating information.

Measure key indicators. Measuring key indicators such as opt-in rates, attendance at events and calls to customer help lines provides valuable information on potential areas of concern as the project progresses. Critical indicators should be reviewed every 2 weeks, especially prior to and during deployment. Measuring indicators also provides the Company with the opportunity to learn what tactics are successful and provides reporting, transparency, sharing best practices, and communicating successes.

Share success stories. Sharing success stories, particularly with Pilot participants, is a way of demonstrating peer engagement, ease of use (for technology, etc.), and tangible results (e.g. cost savings). This can help to increase meaningful participation in the Pilot.

Customer Segmentation

The Company has fully aligned and updated its customer segmentation approach with the Statewide Collaborative Common Evaluation Framework. As such, the segments are incorporated into how the Company communicates with customers and how it evaluates the program in the Company's Evaluation Plan. The Company aims to conduct the Pilot in a manner which allows for the greatest insights into its overall customer base, and in a manner that the learnings can be transferrable across the state to the extent possible.

Pilot participants will be classified across a total of ten participant classifications or segments (described below). In addition to the overarching "All Participants" segment, the Company will define customers at a "sub-segment" level based on characteristics such as income and use levels, age and size of home and a combination of those factors. We will look at participant classifications at the high and low end of the income and use spectrum with all other groups (e.g. participants between low income and $100k per year and homes between 1,000 and 2,500 square feet) captured within in the context of the "All Participants" segment.

1) Low Income – low income participants as defined by rate classification and by the correlation between number of people in the household and annual household income

2) Low Use – participants with average annual energy consumption less than or equal to 50% of the residential class average

3) High Income – participants that answered the pre-pilot survey question on income as more than $100,000 for their household.

4) High Use – participants with average annual energy consumption greater than 150% of the residential class average

5) Participants with Presence of Senior – participants who responded to the pre-pilot survey question indicating presence of an occupant over the age of 65

6) Low Use and Low Income – participants who are both low use (as described above) and low income (as described above)

7) High Use and Low Income – participants who are both high use (as described above) and low income (as described above)

8) Small Homes – homes that are less than 1,000 square feet

9) Large Homes – homes that are greater than 2,500 square feet

10) All Participants

There will also be a control group which will not receive any of the communication, education and outreach of the Pilot participants. The comparison between the control and customer segments will help the Company to determine the impact of the Outreach & Education Plan. See the Evaluation Plan section for more detail.

In addition to the 10 residential segments described above, the Company's Pilot will include commercial participants from a cross section of industries. We will use rate classes to classify them by size of business, including Small C&I (G1) and Medium C&I (G2). Small C&I will include businesses with average usage of less than 10,000 kWh per month or 200 kW of demand while Medium C&I will include businesses with an average use exceeding 10,000 kWh per month and demand not exceeding 200 kW. Commercial customers will not be subdivided into demographic segments.

Though the Company will segment its customers consistent with the Common Evaluation Framework, the Company will engage its customers based on the benefits of Smart Grid. Additionally, the look and feel of the educational materials will be developed in a manner that resonates with the customer. Specifically, the Company can leverage, at least but not limited to information such as demographic and ethnic data that will help to inform the development of more relevant materials. This will enable the Company to undertake a multi-cultural outreach and education approach to target and reach members of the community with in-language communication.

Given the different energy use of the various segments and what will likely be a varying degree of new technology adoption, the Company will enable its customers to determine what Technology Package and Rate Plan (discussed below) they prefer based on their needs and desire to reduce energy consumption.

Technology Packages and Rate Plans

As indicated within the Smart Grid filing, the Company will offer two different rates in the pilot, critical peak pricing (CPP) and peak time rebate (PTR). CPP will have off peak (cheaper) and on peak (more expensive) times to reflect the higher costs of electricity for a portion of the year and PTR offers customers a rebate when they shift their load away from critical time periods. Both of these rates seek to provide a benefit to customers for shifting their load around times of stress on the grid. In addition to choosing a rate, every residential participant will be offered[4] the opportunity to receive one of four technology packages for their home. They are:

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[4] Participants must have broadband internet in their home for technology levels 3 & 4. While every participant will have the opportunity to participate in technology levels 2, 3, & 4, the goal for total numbers at each level are limited and will be filled on a first come basis according to customer segment (discussed above).

- **Level 1 (or the Platform)** – The base technology level. Participants will have access to a personal web site which will provide them advanced energy information customized to their energy consumption. Participants will also receive enhanced consumption information on their monthly utility bills[5]. Features are made available by the installation of the new smart meter, which will contain one of two new rates.
- **Level 2 (or Energy Window)** – Participants will receive the same technology as Level 1 participants as well as a home display unit (HDU). Using customer input in conjunction with internal testing, the Company will select a more engaging/enhanced home display unit.
- **Level 3 (or Automated HVAC Control)** – Participants will receive the same technology as the Level 1 participants, as well as the opportunity to receive a thermostat or Automated HVAC Control capable of receiving load control signals through the Smart Grid and automate load reductions during critical events. The system can analyze the customer's usage patterns and/or the thermal performance of a residential unit and enable optimization opportunities.
- **Level 4 (or Advanced Controls)** – Participants will receive the same technology as the Level 1 participants, plus:

    - Home Display Unit (HDU)
    - HVAC controls
    - Load control devices which are enabled by the use of a home gateway device which facilitates advanced web and/or mobile control.

Small commercial and industrial customers will be offered technology consisting of everything included in Level 2 along with circuit-level monitoring technology, details of which are discussed within the Smart Grid filing.

Customer Technology & Rate Selection Process

Customers will be supplied with education material about the different rates and technology options available. They will learn about the different rates available and strategies to take advantage of the rates, such as load shifting, and the enabling technologies National Grid will offer to customers. Additionally, customers will also learn about the bill protection safeguards the Company has put in place. National Grid intends to utilize the Customer selection process illustrated below in Figure 1 during the Pre-pilot phase. Customers will then be contacted to provide them with the opportunity to choose the available package that best meets their needs.

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[5] This group will include some customers that do not have internet access in their home. However, they may still be able to access information about their energy usage on the internet potentially from work, the public library or web enabled mobile device.

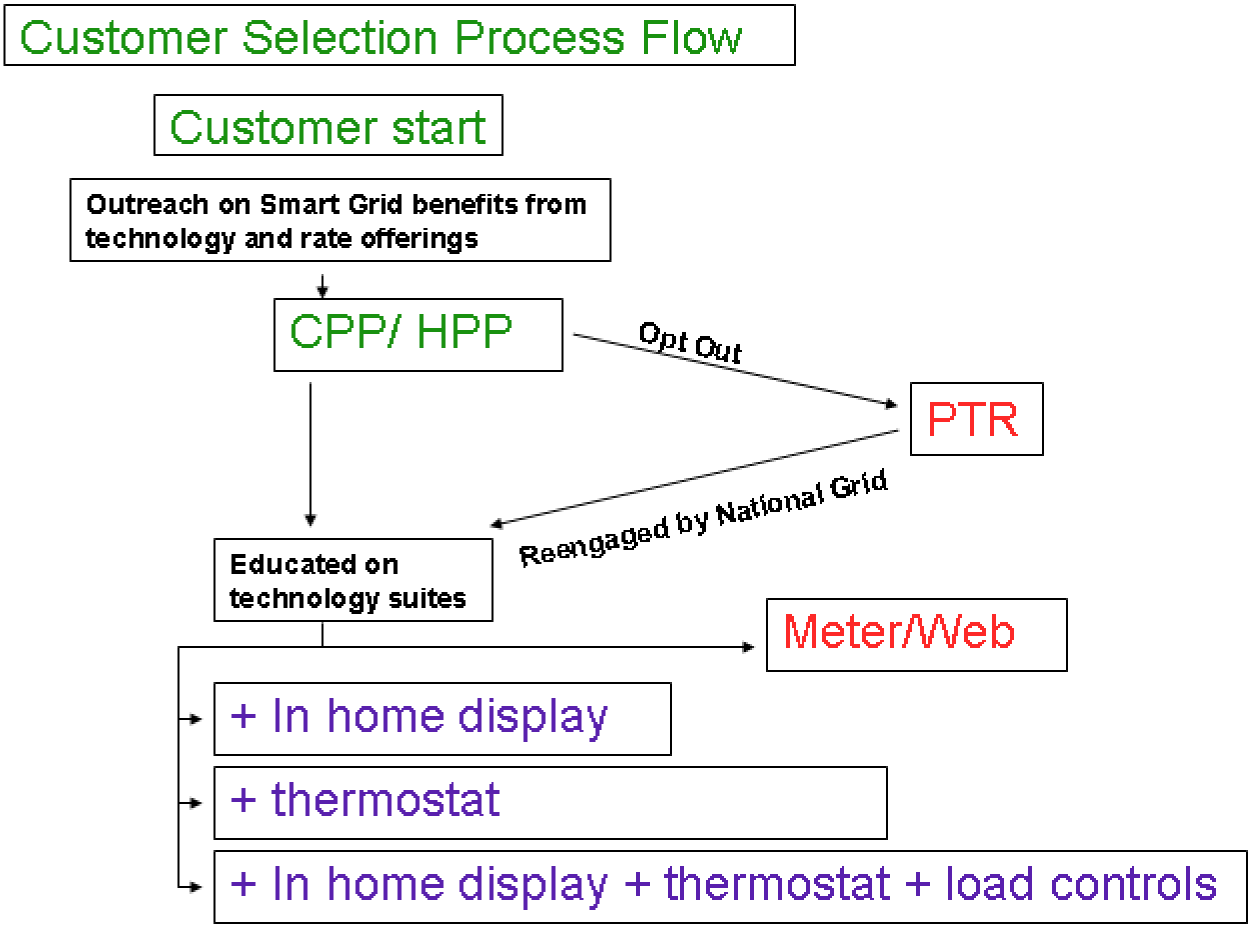

Figure 1. Customer Selection Process Flow.

Opt Out Process

Approximately 6 to 9 months before the pilot implementation, the Company will begin to reach out and educate customers about the benefits of Smart Grid and the opportunities Smart Grid can provide to the customer. Two months before the pilot commences, customers will receive a form to opt out of CPP pricing. Customers will then have 30 days to return the completed form. Those customers who opt-out of CPP will receive Standard Basic Service but will be eligible for the Peak Time Rebate (“PTR”) described in Exhibit PTZ-2 for any load reductions during a Critical Peak Period. One week before the pilot commences the Company will notify customers of their rate plan during the Pilot.

Customer Engagement Tactics

A strong customer engagement strategy has proven to be critical in the success of Smart Grid pilot projects, and is also a cornerstone of the Company’s overall approach to serving its customers. In order to engage customers, the Company needs to deliver information and messages that will resonate with customers. To do this, the Company will target customers using multiple, interactive channels and tactics that reach and engage customers in different ways. In addition, engagement should be directed towards the community at large, rather than solely Pilot participants. The sections below describe the Company's approach to developing the messaging, channels and tactics that will most effectively create customer engagement.

Messaging

The Company's first goal in educating the customers on Smart Grid is to eliminate potential adoption barriers. The Company believes that informed customers are best prepared and empowered to make the right decision that best meets their needs

In accordance with the Common Evaluation Framework and its intent, the Company will conduct a pre-pilot survey and messaging research[6]. The pre-pilot survey will help provide a better understanding of each customer. Messaging research will help to determine the customer's key motivation in technology adoption in addition to providing insights on how to best communicate with them. The survey and research will be the first communications with customers.

The findings of both the pre-pilot survey and messaging research will enable the Company to be better informed on how to communicate with customers. Additionally, in order to ensure a consistent customer experience throughout the Pilot timeframe, the same messaging will also be spread across all channels and within each tactic to ensure a holistic and integrated communications approach, regardless of how the customer chooses to engage with the information.

The Company believes the messages to customers will be critical to develop the functional and emotional connections needed affect behavioral change necessary for energy consumption reduction. In addition, the channels by which the Company communicates the messages are also important to ensure the customer can be reached with the messages intended. The Channels and Tactics section below describes how the Company will be reaching out to customers to engage them.

Channels and Tactics

National Grid has identified five major channels through which to engage individual customers in a meaningful and impactful manner. These are as follows:

1. College Co-op
2. Home (Residential) & Business (Commercial & Industrial/C&I)
3. Community Partners & Leaders
4. Retailers & Contractors
5. Local and Social Media

Within these channels, the Company has also developed customer engagement tactics tailored specifically to the context, reach, and capabilities of each channel. These channels and tactics

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[6] Company approach to pre-pilot survey and Messaging research found in Evaluation section of the Smart Grid filing.

comprise the Company's customer engagement strategy for the Pilot. All communications associated with the Pilot will aim to drive individual customer engagement, not just build general awareness.

College Co-op Program

The College Co-op Program is designed to be a high quality, cost effective college internship program that will align local student talent with the education and outreach needs of the pilot. The Co-op will be a group of trained and qualified students dedicated to supporting the Smart Grid customer experience by complementing Company resources and responding to customer questions and concerns on:

- pilot choice (rates/technology options)
- in home technology devices
- customer troubleshooting
- provide additional information on Smart Grid
- connect to employee expertise as necessary
- implement local education and outreach tactics on the benefits of Smart Grid.

In addition, the College Coop Program should create momentum to further identify local champions of the program and provide opportunities for increased engagement, to teach customers to use new technology effectively, and to encourage participants to give feedback and support each other in technology applications.

Benefit: Provides customers with knowledgeable personnel they can interact with to help educate, train, resolve questions and drive engagement. More opportunities and sources for education was a key item identified by participants at the Green2Growth Summit and the Company is using this information to build the College Co-op as an important component of the O & E Plan.

Customer Education & Training Venues: The College Co-op, in conjunction with National Grid account managers for C&I customers, will provide select education and training venues for participants such as local seminars, webinars, speakers/community leader forums, and in-home trainings.

Benefit: In-person trainings and community events will drive deeper participation, creating higher participant and customer comfort and satisfaction as well as higher contributions toward the Pilot's 5% energy savings goal.

Programs with Local Schools: The College Co-op participants and additional employee resources will coordinate speaking engagements, assemblies, internship and shadowing programs with local schools from K-12 as well as local colleges in the area. This initiative will enable students to become advocates and potentially volunteers as well as provide them with an opportunity to make a difference in their community.

Benefit: Programs with local schools will help engage students in energy savings, helping to achieve the 5% savings goal. National Grid can also leverage its existing experience with internship and school engagement programs such as the *Engineering Our Future* and *Smart Grid Workforce* programs.

Call Center Support: The Company will train appropriate and dedicated call center staff to be fluent regarding the needs of the Smart Grid Pilot and its customers. A script will be developed which will align with the materials provided to the College Co-op members explaining the technology in simple terms and the ways in which customers will be able to engage and use the technology they have chosen. A dedicated Smart Grid toll free number will be provided and distributed on all print material for customers to call with questions and concerns to the Call Center.

The Company will develop a process to analyze data and common questions/themes from these calls as part of its “listen, test and learn” approach in order to adjust its tactics and messaging throughout the Pilot.

> **Benefit:** A call center is required to address customer questions about the functioning and use of Smart Grid technology. Call centers are particularly important to engage with customers who may not attend events or have access to the internet and desire a person they can immediately contact.

Commercial & Industrial Relationships: For commercial and industrial customers, National Grid relationship managers will work closely with College Co-op members and other Company employees as subject matter experts. The Company will focus on providing face-to-face interaction with C&I customers, collaborating to achieve aggressive energy savings and build multi-customer, multi-industry partnerships where possible to promote the efficient sharing of resources. To pursue key partnerships, the Company can partner with other companies, current sustainability providers, contractors, and consultants, if applicable.

> **Benefit**: C&I customers are often able to save much more on a percentage basis versus residential customers, helping to meet the 5% savings goal put forth in the Green Communities Act. Direct interactions with National Grid will enable these customers to achieve savings.

College Co-op Blog: Members of the Co-op will maintain a community blog with short articles, how-to's, recognition of community members, progress toward goals, and photos from events on the Pilot microsite.

> **Benefit**: Showcasing members of the Co-op as the face of National Grid to the community will help to bring a more personal feeling to the Pilot, with the intent of creating higher customer satisfaction and participation.

Home (Residential) and Business (C&I)

Reaching customers where they live and work is critical to help drive adoption. Various outreach and educational tactics have been developed that enable customers to get more directly involved with energy management at the places where they spend most of their time.

Direct Mail: Direct mail will be used to provide information during the Pre-Pilot and Pilot phase. It will be targeted with unique messaging for each customer segment, as appropriate.

> **Benefit:** Direct mail ensures a very targeted communication to a specific customer or target audience to generate awareness and education as well as elicit a response based on a specific call to action. Direct mail is especially important during the Pre-Pilot phase to help introduce the Technology Packages and Rate Plans to customers. Benchmarking has shown that many customers prefer the mail channel versus other channels for communications with their utility.

Technology of Choice Call: Customers will be called toward the end of the pre-pilot phase to help explain the technology options and obtain their choice for which technology best meets their needs. If a customer wants a demonstration of the technologies, a meeting with a College Co-op program participant will be established.

> **Benefit:** Customers will be empowered with information that better enables them to make the appropriate technology decisions thereby helping to ensure they utilize it to reduce their energy consumption.

Welcome Kit: A welcome kit is a package of information relating to Smart Grid sent to Pilot participants. The welcome kit will include a set of introductory materials distributed to all Pilot participants in conjunction with meter installation. This kit will provide customers with all of the following: a print brochure/booklet detailing Pilot programs, goals in energy reduction for the campaign and motivational materials (how we can all do our part to help out), a to-do checklist for home energy savings (pre-populated notebook + checklist with energy efficiency information) and an engaging, energy related give-away that will provide a constant reminder about reducing energy. The timing of the delivery of welcome kits to customers will align with media and press efforts to generate momentum and engagement at the individual level.

Benefit: In providing a specialized, targeted welcome experience, the Company will build on the initial notification, while providing a simple, intuitive, and directed way to jumpstart both engagement and adoption within the program.

Installation Notification (Call & Door Hanger): An outbound phone call will be made prior to the start of the Pilot to Pilot participants, providing them with smart meter installation information date and advance notification of a welcome kit. A door hanger with the same information will also be left at the residence or business to supplement the phone call.

Benefit: Smart meter installation notifications will provide an opportunity to generate up-front awareness of the Pilot, offering a sense of a personalized level of customer service and help address customers concerns.

Education and Engagement Website/Microsite: A necessary element of the customer experience is a Pilot microsite, which serves as an integrated way to share profile, usage, community and educational information and an events calendar. The website will also be an integral component of the social media strategy, linking the blog, Facebook, and Twitter communities (see below) and providing a platform for how-to-videos, energy use and live chat. A website acts as a critical amplifier for messaging in other channels.

- **How-to Videos**: short, demonstrative videos hosted on the site will provide “how-to” information on how to optimize use of the site and use of in-home technologies to support the Pilot.

Benefit: As a critical aggregator of multiple customer engagement channels, the website provides a central point of destination for customers to provide customer information and engagement opportunities. These opportunities can help customers save money, improve their comfort and convenience, and better access information, support their distinct needs and augment their participation in reaching the 5% reduction goals.

Email: This channel would likely be the main distribution channel for customers who have email as their preferred communication channel.

Benefit: Email communications can be targeted to specific segments or distributed to all participants and is an extremely cost-effective way to reach customers to engage and educate on energy savings.

Print Newsletter: The newsletter will be a print report directly mailed to a targeted set of customers. Additionally, a quarterly newsletter will also be sent to local community leaders. Newsletters will provide customers and community leaders with aggregate participation details and engagement results, featured articles, energy tips and tricks, educational info, event information, and ways to get involved.

Benefit: Print newsletters provide an ongoing way to serve customers who may not have web access, or miss out on other channels of communication, offering a useful connection to both engaged and ‘under-engaged’ customers. Also, in providing local community leaders with information and updates on the Pilot, the newsletter serves a supplementary function in meeting their needs for awareness and information on the Smart Grid effort.

Bill Inserts: The bill insert collateral will be included in every month's bill. Pilot customers will receive 1-2 key messages each month, such as data on technology benefits, energy saving tips, local events, or how to get involved.

Benefit: Bill inserts are an effective way to reach customers that receive hard copies of bills. Since customers must open their bill, they will be exposed to the bill stuffer automatically. Bill inserts will contain messages on choice and control participants have with their smart technology

Face-to-Face Customer Outreach: Proactive and reactive face-to-face customer outreach will be conducted by the College Co-op program participants, as well as Company employees, vendors, and community partners.

Benefit: Face-to-face interaction is a necessary component of gaining and maintaining customer trust and engagement. Some customers may not have access to other communications channels such as online or mobile or may not be interested in them. In addition, face-to-face interaction is needed for home visits, demonstrations, and communicating the benefits and function of new meter technology and the Technology of Choice Call mentioned see above). This channel gives the Company the opportunity to engage in a two-way dialogue with participants and customers and augments the "listen, test & learn" approach.

Peer Comparisons, Data Visualizations and Competitions - Data visualization interfaces are a key component of the Pilot because they enable a greater degree of energy savings. Data visualization was also one of the most important items identified by the community at the Green2Growth Summit. The Company, in partnership with a technology vendor, will provide information to customers on energy use and show how customers compare to their peers or neighbors. This behavioral approach has delivered proven energy savings and has been documented by companies like OPower and Efficiency 2.0. Data visualization, manifested on display monitors and customer web portal, provide participants with real-time behavioral cues. For instance, during peak periods, participants may receive a message to power down or hibernate unused computers, delay use of washers and dryers, or adjust thermostats by one or two degrees for a short period. These customer communications would be focused on cost savings to accrue to the customer. To provide customers with one central resource for their information, the Company would intend to have this functionality within the Pilot Microsite.

Benefit: This system provides tangible and emotional incentives for participants to save energy. Energy challenges and social comparisons have proven effective in influencing behavior, not only in the energy savings realm but across multiple sectors and stakeholder groups. Some outside examples include the DARPA Network Challenge[7] and Quest to Learn[8] educational model.

Mobile – Applications (Apps) & Text: Mobile channels like apps and texting are an effective way to engage customers in community-based energy savings. Program information and participation/adoption-driving communications sent via print, web, and other channels will be replicated via mobile and text reinforcing messaging to promote action. For example, customers can receive texts via mobile phones regarding peak pricing events, providing tips on how to save energy and money. Customers will also be able to view and interact with a mobile version of their

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[7] DARPA Network Challenge website: http://archive.darpa.mil/networkchallenge/

[8] Quest to Learn website: http://q2l.org/

own customer web portal and will still be able to interact with their in-home devices along with viewing their energy consumption on-the-go.

> **Benefit**: Mobile channels help reach a broad set of customers due to the prevalence of mobile phones across income groups. Mobile phones represent the most prevalent source of communication as 83% of Americans have a cell phone – more than those who have home internet.[9] By supporting mobile, we ensure that customers are able to view relevant campaign materials through cross-channel communications, thereby further driving engagement and awareness needs.

E-Newsletter: Circulated via multiple channels (e-mail, mobile, Pilot website, Twitter, Facebook, etc.), the E-Newsletter will be distributed every quarter. Content will include Pilot information, tips, local event info, call-outs of the most engaged customers, and more.

> **Benefit**: The E-Newsletter provides a key outlet for providing customers with targeted campaign communications on an ongoing basis. This integrative communications channel provides a way to increase customer engagement and participation, thereby driving actions resulting in energy savings (such as adjusting thermostats, use of visualization technology, etc.) in a targeted, low-cost fashion.

Social Media: As described in the Common Evaluation Framework, social media are media for social interaction, using highly accessible and scalable publishing techniques. Social media use web-based technologies to transform and broadcast media monologues into social media dialogues. A common thread running through all definitions of social media is a blending of technology and social interaction for the co-creation of value.[10]

Social media platforms such as Facebook and Twitter are an effective way to communicate with customers. These channels provide real-time opportunities to communicate with the customer and also engage in two-way communication. Facebook and Twitter also support games, apps, and photos, making customer engagement a dynamic and rich experience for those in the Pilot. These platforms also provide geospatial networking such as the "Places" app in Facebook mobile. This can be used to promote customer engagement events. The Company will create a Facebook Group for the Pilot and Twitter account and hash tags for relevant terms. Other social media platforms may be considered as Facebook and Twitter campaigns are effective.

> **Benefit**: Conveying messages through Facebook and Twitter reinforces messaging in other channels, providing a valuable, additional customer touch point. Also, these channels connect customers together, creating a network effect of momentum around the Pilot. Additionally it is easy to provide frequent, low-cost, and timely messages through social media channels.

Community Partners & Leaders

The Company believes that community partners and leaders are a key channel by which to influence customers to adopt Smart Grid. The community, whether defined as a neighborhood, local organization, or schools & colleges, can help to educate and inform customers regarding the benefits of Smart Grid. The partnerships resulting in the Green2Growth summit will enhance the Company's capacity to leverage customer outreach in a unique way.

As an example, through the Green2Growth website, National Grid will have the ability to provide support and links on the benefits of Smart Grid technology, as well as other Green2Growth

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[9] Pew Internet and American Life Project website: http://www.pewinternet.org/Trend-Data/Device-Ownership.aspx

[10] Massachusetts Smart Grid Collaborative Common Evaluation Framework, 5.2.4, #6

initiatives including, energy efficiency, renewable energy sources, net metering, etc. Green2Growth activities will involve local community groups, schools, universities, associations, consortiums, and other non-profits throughout the state, as well as DOER, DOE, and other agencies; with the site providing annotated links to relevant sites and events.

In addition, the Company will leverage many of the tactics listed in the Residential and C&I section above including:

- Website/microsite
- E-Newsletter
- Mobile – apps & text
- Blog
- Social media
- Face-to-face and community-based outreach

The Company will develop tactics that are specific to ensuring this broader audience is also educated on the benefits of Smart Grid:

Welcome Kit: Community leaders/influencers will also receive a specialized welcome kit, with details on efforts for the Pilot, the consumer experience, program goals and objectives, events, and how they can get involved.

> **Benefit**: Targeting messages will help to engage community leaders to help make the Pilot successful. This will result in further customer engagement and the potential for more energy savings.

Sustainability Hub: National Grid can provide hands-on education and experience through a model energy display located in the community. The Company will work with community leaders, vendors, and educational partners and leverage current company assets to create a rich experience driving residential and commercial participation, as well as building awareness throughout the whole community.

> **Benefit:** Such an approach can provide an enriching experience for visitors, showcasing the extent of innovation possible, along with the necessary information for applying each innovation in their own home. This will also drive program participation rates if the programs are showcased in the Home. By working with vendors and leveraging current both Company and partnership assets, the Company believes the cost for this tactic to be minimal.

Home Smart Demos: At a customer hosted home, participants can share best practices and tips with each other. The College Co-op program can assist by demonstrating other smart technologies such as rooftop solar, energy use displays, programmable thermostats, electric vehicles, etc. The emphasis for the demonstration program is to use the same technology installed at customer residences to increase engagement and use with the technology package they selected.

> **Benefit**: As community members learn how to implement energy savings in their own homes, they will be able to help contribute at a greater rate to the 5% energy savings goal. In addition, it is more likely that participants will understand how to implement changes after an in-person demonstration versus only receiving written instructions and participants may become community champions, helping others to better understand and adopt the technologies.

Local Advocates Program: Such a program would include a continuous series of events in the community to talk about and demonstrate aspects of the Pilot. Events could include: hosted breakfast presentations to demonstrate and hand-out information, hosting a standing community event (rotary meeting, business expo, chamber event, etc), educating and training employees in schools, sponsoring town hall meetings, etc. These events would run regularly and continuously throughout the Pilot. Each event will be tailored for a particular audience (e.g. teachers, business owners, neighborhood residents, not-for-profits, etc.)

> **Benefit:** In bringing the community together to talk about the Pilot, National Grid can hear directly from the community, supporting the Company's 'listen, test and learn' approach to the outreach strategy. Additionally, this forum provides an opportunity for cross-collaboration, increasing engagement and creating more efficiency and effectiveness for energy saving initiatives.

Retailers & Contractors

Retailers and Contractors are typically a trusted resource for customers to get educated on products or services. Therefore, this will be another channel by which the Company indirectly communicates with customers about the benefits of Smart Grid. The Company will use the tactics listed in the Residential and C&I section above including:

- Website/microsite
- E-Newsletter
- Mobile – apps & text
- Blog
- Social media
- Face-to-face and community-based outreach

In addition, the following tactics will be deployed:

Training Program: National Grid's College Co-op program will present and demonstrate Smart Grid infrastructure capabilities including communications architecture and metering technology. The team will be equipped with educational collateral and Q&A materials to help retail employees and contractors to address customer questions. This effort can leverage National Grid's existing platforms for its current retail training programs.

> **Benefit**: Retailers and contractors can become important ambassadors for the Pilot. Because they are viewed as technical experts within the community, they will inevitably interact with participants. Their effective interaction with participants can promote energy savings to help reach the 5% energy savings goal.

In-Store Demonstrations: This customer engagement forum will provide the local community the opportunity to interact with and learn more about the technology packages. These seminars will be informal and collaborative and held at a location that is typically a local shopping destination. The customer seminar will provide customers another venue to hear about and have demonstrated the benefits around the technology packages in addition to providing other energy savings tips. These events will be organized and managed by the company and College Co-op program.

> **Benefit:** In-store seminars provide an opportunity for continued education and training for the local community in venue they are familiar with. These events also reinforce the Pilot program's focus on community involvement. Most importantly, this venue provides opportunities for cross-community collaboration on energy-saving initiatives.

Local Media

Another channel that helps to inform and educate customers is their Local Media. This channel will be used to help ensure customers are seeing, reading and hearing about the benefits of Smart Grid from their local community resources. Tactics the Company will deploy are as follows:

Media -'Smart' Forums: Media events, potentially held in the Sustainability Hub venue, will provide program updates on successes and learning from the Pilot. Community members and community leaders would be invited.

> **Benefit**: The Company believes that transparency is the key to building and maintaining customer trust. In addition, this venue provides an opportunity for media coverage of community efforts and perspectives.

Media "Kit": To supplement more localized customer needs, the Pilot will entail the creation of a press kit and use of PR partners across the campaign to involve and inform local media. This method will provide media partners with information on the Pilot, including tracking to program adoption and energy reduction goals, local customer engagement, and opportunities for media placement and support to reach the broadest participant customer and community base.

> **Benefit**: A clear, comprehensive press kit and ongoing follow-up through local media will be crucial to jumpstarting up-front community awareness at the start of the Pilot, ensuring that the effort starts off with a good degree of customer engagement and awareness.

Ongoing Outreach Efforts to Local Media Outlets: The Pilot will proactively connect with PR and media partners to involve and inform the community on an ongoing basis. As a supplementary effort, the media/PR effort will identify and target local community leaders, who agree to voluntarily track their usage and report back on progress via media outlets. During the Pilot, ongoing media stories and support will drive customer understanding of the Pilot.

> **Benefit**: Ongoing media coverage maintains momentum around participant engagement and community unification around energy savings goals. As a 'listen, test and learn' component, PR may be a clear leverage point to avoid launch issues and begin a successful pilot.

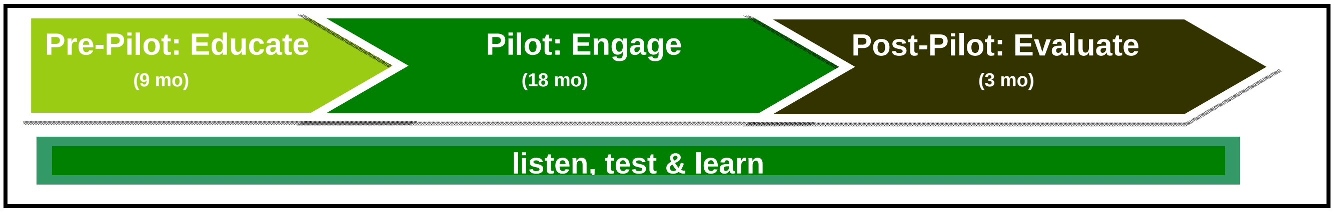
Customer Engagement Timeline

Timing around customer engagement has proved to be a critical aspect of Smart Grid project success. National Grid has developed a plan to allow for more pre-deployment engagement to ensure that customers and other stakeholders are aware of the Pilot and how the technology and findings will benefit their households and businesses. The pre-pilot phase was increased from six months in the previous plan to nine months in the current plan. The company has also extended the length of the Pilot deployment stage to 18 months from 6 to 12 months. The overall Pilot timeline however remains the same at thirty (30) months.

The overall timeline for the Outreach and Education to all 15,000 customers is as follows:

- **Pre-Pilot (~9months):**
    - Conduct pre-pilot and messaging research
    - Communicate the functional and emotional benefits of upgrading the infrastructure and overcome objections, concerns, or fears
    - Communicate functional and emotional benefits of each Technology Package and Rate Plan to enable a choice that best meets customer needs
    - Secure Technology Package and Rate Plan selection

- **Pilot Deployment (~18months):**
  - Launch O&E integrated communications plan by segment, prior to installation, to drive adoption and engagement
  - Monitor communication effectiveness and modify tactics as required to increase utilization
- **Post-Pilot (~3months):**
  In-depth evaluation based on Common Evaluation Framework and additional National Grid measures as deemed necessary
  - Continued implementation of successful tactics and engagement strategies



See Appendix for visual representation of engagement timeline and tactics.

Seasonal timing: Because of the highly seasonal nature of energy use, the Company plans to deploy educational communications on energy efficiency programs and how-to's for summer cooling and for winter heating. This will be an important strategy to meet the 5% energy savings goal. Examples of this could be weatherization, time of day use, adjusting thermostats, etc. Seasonal messaging will go through all communication channels.

Evaluation Plan

The Company has also updated its full Evaluation Plan to align with the Statewide Evaluation Collaborative's Common Evaluation Framework. See the Company's Evaluation Plan document for complete detail on methodologies.

The below section summarizes the aspects of the Evaluation Plan related only to the measurement of the engagement strategy effectiveness, and are as follows:

1) Common Evaluation Framework Alignment
2) Customer Satisfaction Survey
3) Observational Design

Common Evaluation Framework Alignment

As noted earlier, National Grid supports the Statewide Evaluation Collaborative's Common Evaluation Framework and is committed to complying with the direction established by the Technical Subcommittee. The Evaluation Plan provides for a detailed evaluation approach and standards based on the Framework.

In accordance with and the intent of the Common Evaluation Framework, the Company will conduct a pre-pilot survey, details of which can be found in the Company's Evaluation Plan. In addition to what the Company is indicating in the Evaluation Plan, the Company will also conduct messaging research through survey instruments to understand how best to communicate the Smart Grid offerings to customers in a manner that helps to drive adoption. As noted in the Common Evaluation Framework, some key questions to be understood are: what are the different motivations for choosing to participate; what do customers see as benefits; and what are the participant's awareness of benefits?

The findings of the Messaging research will then directly inform the communications developed to educate and motivate customers to adopt and ultimately reduce their energy consumption.

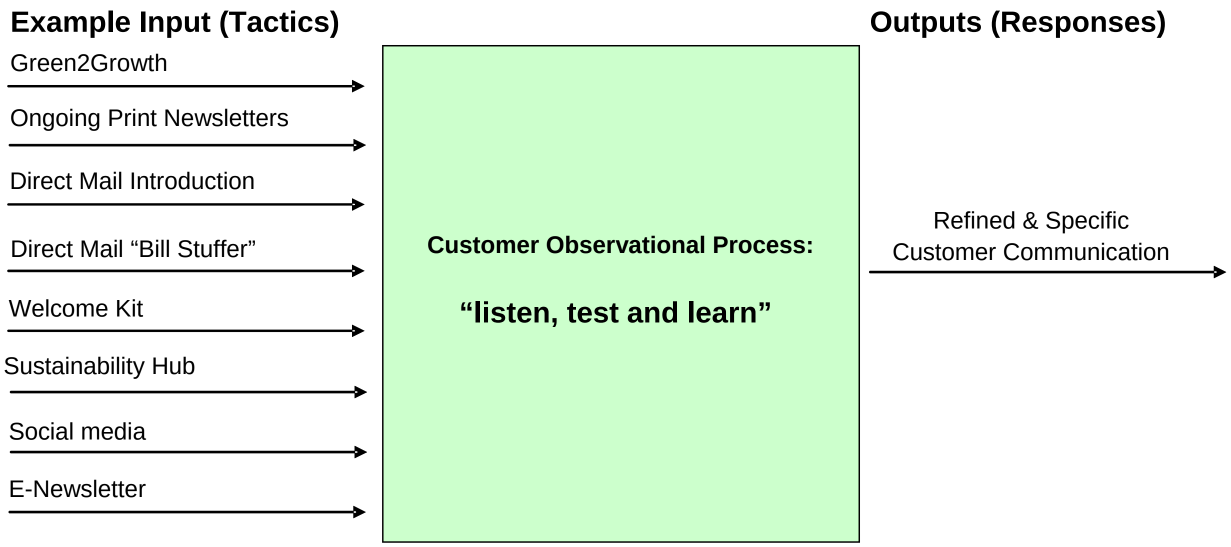
Customer Satisfaction Surveys

In addition to Common Evaluation Framework efforts, the Company will also conduct a Customer Satisfaction survey during the pre-pilot and Pilot phase to obtain insights into customer's likelihood to adopt and use the technology package. This survey will allow the Company to listen to our customers, aligning it with the "listen, test, learn" approach mentioned throughout the Outreach and Education Plan. The survey results will be used to understand customer sentiment and therefore allow the Company to adjust communication and delivery strategies for the various education and outreach efforts over the course of the Pilot.

Observational Design

The Company will test its engagement efforts throughout the Pilot using observational design methods. An observational design will allow the Company to listen to all customers equally by observing and reporting results before tactics are changed to more effective means.

Table 1: Observational Design Method



Through the use of the observational design approach, the Company will strive to determine what communication channels have the largest impact on smart grid adoption, and will be able to shift Pilot resources from less effective channels to the more effective ones over the course of the program.

Summary

In response to community and stakeholder input from the Green2Growthth Summit, a collaborative statewide approach, and technology advances within the energy industry, the Company has updated its outreach and education approach. This new Outreach and Education Plan is now focused on customer engagement rather than general awareness. Given this shift in approach, the new Plan will be implemented with various partners in the community to help customer engage with the new technology packages and ultimately reduce their energy consumption.

Based on the customer engagement tactics indicated above, the below table is a summary of detailed Outreach & Education budget, further detail can be found in, *Appendix 1 – Customer Engagement Budget.*

Description		Duration	Budget
Pre-Pilot (9 months)	Educate	9 months	$ 1,817,780
Pilot: (18 months)	Engage	18 months	$ 510,460
Post-Pilot: (3 months)	Evaluate	3 months	$ 90,000
		Total	**$ 2,418,240**

Appendix

1. Customer Engagement Budget
2. Green2Growth: Customer & Stakeholder Listening Session
3. Sustainability Hub
4. Select Case Studies

Customer Engagement Budget

Based on the customer engagement tactics indicated above, an estimated budget for the Outreach and Education Plan is as follows:

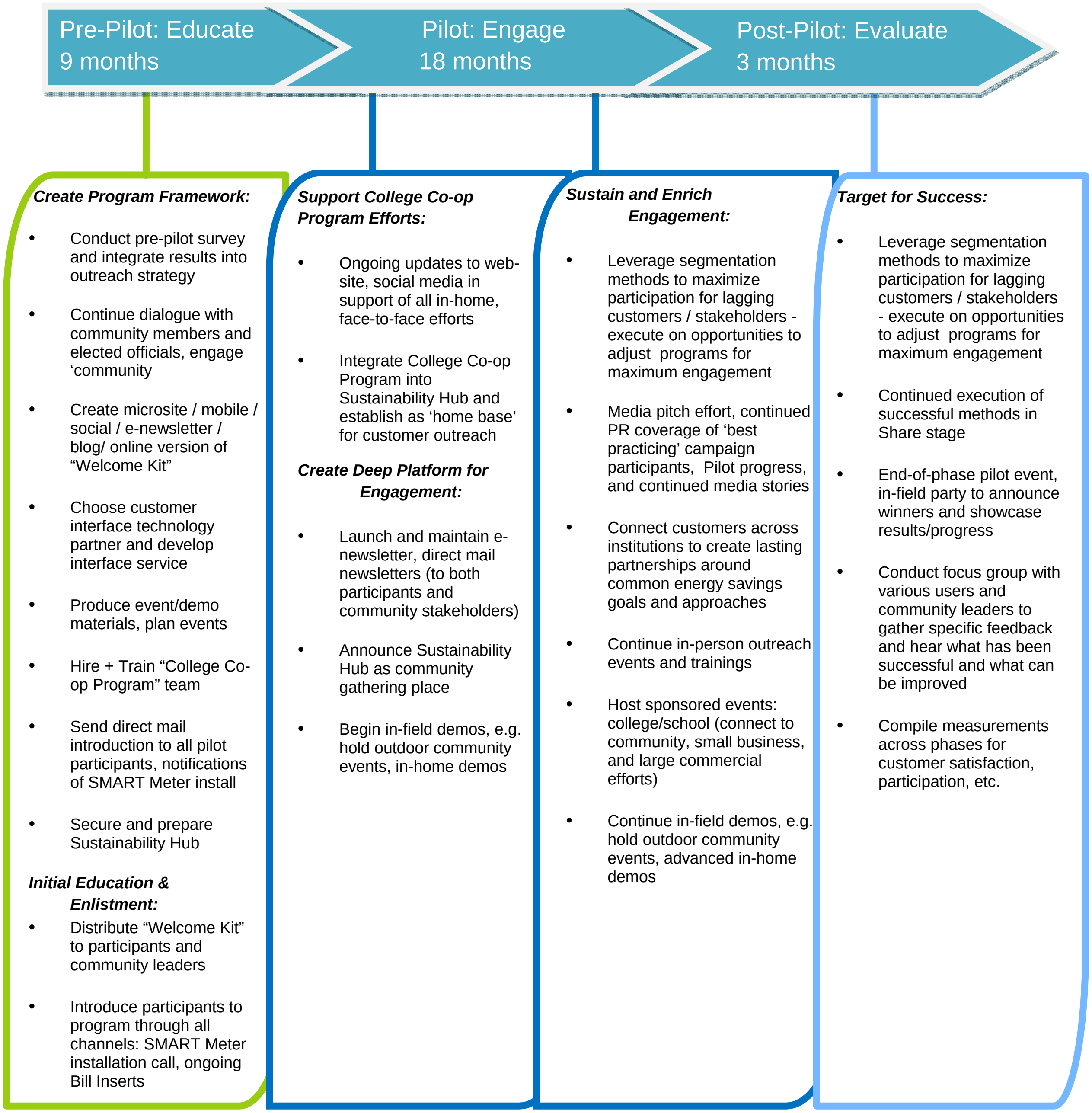
	Engagement Tactic	Description	Budget
Pre-Pilot: Educate (9 months)	**Message Research**	Quantitative research to define and develop communications that will increase likelihood of adoption and usage	$50,000
Throughout Program (30 months)	**College Co-op program**	6 FTEs + 1 Manager (2 FTEs)	$665,600
		Seven computers @ $1200	$8,400
		Training (4 sessions)	$10,000
		NG Facility	$0
Throughout Program (30 months)	**Customer Education & Training Venues**	12 breakfast venues in NG facility with 30 participants @$8pp	$2,880
		8 lunch & learns with 30 participants @$15pp	$3,600
		invitations 9000 @0.36 pp, 6000 @ $0.04	$3,480
		18 webinars – 50 people each, $0.14/min/pp; 60 mins	$7,560
Pilot: Engage (18 months)	**Programs with Local Schools**	Presentations developed to target K-4, 5-8, 9-12, College	$15,000
Pre & Pilot: Engage (27 months)	**Call Center & Training Sessions**	Call Center Support: 18 months	$36,000
		Training (4 sessions)	$10,000
Pilot: Engage (18 months)	**Commercial and Industrial Relationships**	1-1 education and training sessions with Commercial customers at their facility; Existing National Grid Resources & College Co-op Cost	$0
		Collateral material	$3,200
Pre-Pilot: Educate (9 months)	**Direct Mail**	Design, print, & mail color postcard to 9000 customers, 30 months @0.36pp	$97,200
Pre-Pilot: Educate (9 months)	**Technology of Choice Call**	Customer calls to help explain options and arrange a meeting with a co-op person, if needed to help the customer make decision	$60,000
Pre-Pilot: Educate (9 months)	**Installation Notification Call**	1 time @ 0.03/call	$450
Pre-Pilot: Educate (9 months)	**Installation Notification Door Hanger**	Design, print, place 15,000	$32,000
Pre-Pilot: Educate (9 months)	**Welcome Kit (Residential - 15,000 & Community Leaders - 500)**	Design & develop welcome kit including: package, letter, DVD, brochure, engagement item, and mailing.	$200,000

Pre-Pilot: Educate - Pilot: Engage (27 months)	**Education and Engagement Website/Microsite**	Design, develop, test, maintain	$225,000
Pre-Pilot: Educate - Pilot: Engage (27 months)	**"How to" Videos**	Five videos: Design, develop and integrate into the website	$12,500
Pre-Pilot: Educate - Pilot: Engage (27 months)	**Email**	6000 customers, 1/month, 30 months @$0.04pp	$7,200
Pre-Pilot: Educate - Pilot: Engage (27 months)	**Print Newsletter**	1/quarter (10 total) for 9000 customers plus 500 community/retailer leaders	$63,650
Pre-Pilot: Educate - Pilot: Engage (27 months)	**Bill Inserts**	2 sided, 4 color, 1/month for 15,000 customers, 30 months	$15,750
Pilot: Engage (18 months)	**Face-to-Face Customer Outreach**	College Coop 1-1 education and training at customer homes, Included in College Co-op Cost	$0
		collateral material	$9,600
Pre-Pilot: Educate (9 months)	**One time system & production setup fee**	Initial paper report setup / output integration for *Energize Home Energy Reporting*	$75,000
Pre-Pilot: Educate (9 months)	**Messaging campaign execution upload/ integration**	Includes web texting and mobile apps. Service fee for campaign upload / integration into reports. Excludes creative and segmentation work.	$75,000
Pre-Pilot: Educate (9 months)	**One time National Grid Report Branding**	One time standard Home Energy Report Template setup and delivered with National Grid Branding	$18,000
Pilot: Engage (18 months)	**Print Production & Mailing, 12 reports per year**	Includes cost for migration to Portal only use (customers will not be able to receive paper and use portal. Includes Mobile App for online user.)	$409,860
Pre-Pilot: Educate - Pilot: Engage (27 months)	**E-Newsletter**	10 newsletters, 1/quarter, 6000 customers & 500 community/retailer leaders	$38,350
Pre-Pilot: Educate - Pilot: Engage (27 months)	**Social Media**	Facebook, Twitter, YouTube: Existing National Grid Resources	$0
Pilot: Engage (18 months)	**Sustainability Hub**	Demonstration area of smart grid and its benefits	$50,000
Pilot: Engage (18 months)	**Home Smart Demos**	30 demos with hostessing costs of 20 people @ $15pp and invitations	$9,000

Pre-Pilot: Educate - Pilot: Engage (27 months)	**Local Advocates Program**	8 breakfast venues in NG facility with 20 participants in academia or municipality @$8pp	$1,280
Pre-Pilot: Educate - Pilot: Engage (27 months)	**Training Program (Retailers & Contractors)**	8 lunch and learns at retailers store, 20 people @$15pp, invitations and give-away; collateral material development and printing	$2,400
		Collateral material	$3,480
Pilot: Engage (18 months)	**In-Store Demonstrations**	6 held in-store; partnerships to pay for set-up and demo items, and Company hostessing costs of 20 people @ $15pp and invitations	$1,800
Pilot: Engage (18 months)	**Translation Services**	Translate education materials throughout the Pilot into one language	$12,000
Throughout Program (30 months)	**Media-‘Smart’ Forums**	4 (1 pre, 2 during, 1 post) lunch forums with 50 people @ $15 pp; National Grid or other free facility	$3,000
Throughout Program (30 months)	**Media Kit**	Smart Grid information provided to over a dozen media outlets to keep them abreast: Existing National Grid Resources	$0
Throughout Program (30 months)	**Ongoing Outreach Efforts to Local Media Outlets**	Proactive and reactive outreach to media outlets for 30 months	$90,000
Post-Pilot: Evaluation (3 months)	**Customer Satisfaction Surveys**	Quantitative research to understand customer’s barriers to adopt and use the technology. Enables message modifications.	$90,000
Post-Pilot: Evaluation (3 months)	**Observational Design**	Determines communication channel effectiveness	$0
		Total Budget	$2,418,240

Timeline and Associated Outreach

The below is a depiction of how the Pilot is planned to proceed This is a visual representation only and is not intended to be a rigid framework, given the 'listen, test and learn' approach may lead to moving educational elements forward or upward in the timeline. Additionally, many educational methods may be spread over more than one phase.



Pre-Pilot: Educate
9 months

Pilot: Engage
18 months

Post-Pilot: Evaluate
3 months

Create Program Framework:

- Conduct pre-pilot survey and integrate results into outreach strategy
- Continue dialogue with community members and elected officials, engage 'community
- Create microsite / mobile / social / e-newsletter / blog/ online version of "Welcome Kit"
- Choose customer interface technology partner and develop interface service
- Produce event/demo materials, plan events
- Hire + Train "College Co-op Program" team
- Send direct mail introduction to all pilot participants, notifications of SMART Meter install
- Secure and prepare Sustainability Hub

Initial Education & Enlistment:

- Distribute "Welcome Kit" to participants and community leaders
- Introduce participants to program through all channels: SMART Meter installation call, ongoing Bill Inserts

Support College Co-op Program Efforts:

- Ongoing updates to web-site, social media in support of all in-home, face-to-face efforts
- Integrate College Co-op Program into Sustainability Hub and establish as 'home base' for customer outreach

Create Deep Platform for Engagement:

- Launch and maintain e-newsletter, direct mail newsletters (to both participants and community stakeholders)
- Announce Sustainability Hub as community gathering place
- Begin in-field demos, e.g. hold outdoor community events, in-home demos

Sustain and Enrich Engagement:

- Leverage segmentation methods to maximize participation for lagging customers / stakeholders - execute on opportunities to adjust programs for maximum engagement
- Media pitch effort, continued PR coverage of 'best practicing' campaign participants, Pilot progress, and continued media stories
- Connect customers across institutions to create lasting partnerships around common energy savings goals and approaches
- Continue in-person outreach events and trainings
- Host sponsored events: college/school (connect to community, small business, and large commercial efforts)
- Continue in-field demos, e.g. hold outdoor community events, advanced in-home demos

Target for Success:

- Leverage segmentation methods to maximize participation for lagging customers / stakeholders - execute on opportunities to adjust programs for maximum engagement
- Continued execution of successful methods in Share stage
- End-of-phase pilot event, in-field party to announce winners and showcase results/progress
- Conduct focus group with various users and community leaders to gather specific feedback and hear what has been successful and what can be improved
- Compile measurements across phases for customer satisfaction, participation, etc.

Customer and Stakeholder Listening Sessions- Green2Growth Summit

Overview

On September 19-20, 2011, National Grid hosted a Green2Growth community summit in Worcester to hear directly from 300 stakeholders, including residential and commercial customers, as well as representatives of government, the DPU, technology providers and vendors, community organizations, academic institutions, students, and the media. The event allowed Worcester residents and community members to contribute their own ideas to a vision, process, and desired outcome for a positive transformation of Worcester's economic base. The event explored how to build upon the unique qualities, assets and history of Worcester while taking advantage of new investment in sustainable development and smart energy technology. The stated purpose of the event was to "design a road map to transform Worcester into the innovative energy leader of a smarter Commonwealth."[1]

The Company used this summit to gather customer and community input and cultivate a rich, partnership-based mode of interaction and engagement. The community event was a cross-functional collaboration between several groups representing virtually all of the Pilot scope and planned area. The summit steering committee, with National Grid, consisted of members from:

The City of Worcester	Worcester Business Development Corporation
YWCA Central Massachusetts	Worcester Community Action Council
Worcester Polytechnic Institute	Massachusetts Low-income Energy Affordability Network
The Learning Circle	The Institute for Energy & Sustainability
To the Point	American Red Cross of Central Massachusetts
Clark University	Case Western Reserve University (moderator)

The summit was led by David Cooperrider, creator of the "Appreciate Inquiry" approach to stakeholder engagement and ideation. An Appreciative Inquiry summit is a large group planning, designing, or implementation meeting that brings a whole system of internal and external strengths together in a concentrated way to work on a task of strategic importance. Moreover, it is a meeting where everyone is engaged as a designer, across all relevant and resource-rich boundaries, to share leadership and take ownership for making the future of a significant effort and opportunity successful. As a self defined "asset-based approach" it starts with the belief that every organization, and every person in that organization, has positive aspects that can be built upon.[2] The Appreciative Inquiry process resulted in significant stakeholder input across the two day session, and concluded with the identification of points of contact for further refinement of ideas.

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[1] Green2Growth website: http://www.green2growth.com/EventDetails/
[2] Green2Growth website: http://green2growth.com/AboutTheProcess/

As part of the Summit, participants identified 15 opportunity areas for the community and Pilot. After identifying these opportunity areas, participants self-selected into small groups to help flesh them out, summarized their findings, and identified a point of contact for further communication and refinement of the idea in partnership with stakeholders both present at the Summit as well as additional stakeholders. The following is a summary of the opportunity areas explored at the Summit:

Opportunity Areas

Opportunity Area	Description/Ideas
Sustainability Center	Venue for green job training, demonstration center
Asset Roadmap / Green Monster Scoreboard / Awards	Visual representation of green assets around Worcester, "Green Monster" and Green "Academy Awards" for innovation
Keep the $ flowing into Worcester	Link energy investments to economic development
Video Challenge	Student-produced videos presenting energy challenge(s)
Green2Growth business network	Local businesses commit to match energy and percent dollar savings based on residential savings
Job shadowing and training	Students receive training from National Grid employees on energy saving initiatives to be applied in the community
Renewable project development forum	Central website including: zoning laws, financial subsidies, discussion page, information, clearinghouse, link-up page, and land rental listing
Achieving net zero	Setting aggressive energy savings goals for the community, including having some homes and buildings achieve the "net zero" status
Greening the heart of Worcester	Urban farming, community gardening, and edible landscapes, potentially powered by solar technologies
"Worcester, come near to our heart"	Student led video around deep cultural change in the community
Low-income leadership	Initiatives to lower the energy burden on low-income families and create ways to engage this group in energy savings and innovation
Greening the transportation of Worcester	Make public transportation more user-friendly through highly-visible, color-coded public stops, and transit-oriented development
Green declaration of independence	This opportunity area group worked on identifying an overall vision statement[3] and set of principles for the "Green2Growth" initiatives.
Worcester's Sustainable Portfolio	Create an economic base around innovation that will lead to a sustainable investment cycle
Keep the Momentum Going	Establish community ownership of *Green2Growth* and form an

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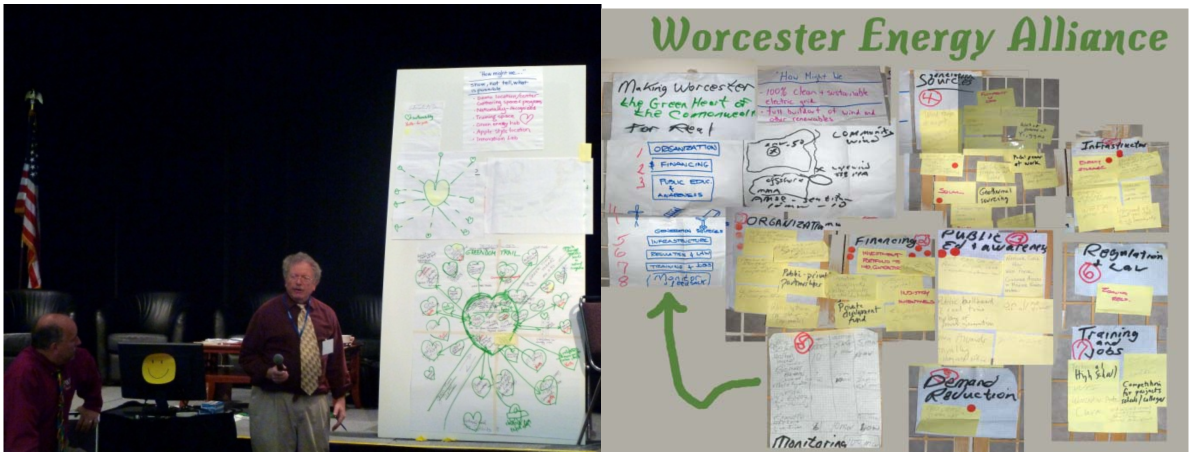
[3] *"We the people of the Green2Growth Summit commit ourselves to building a sustainable community which will thrive within the limits of our natural land base. We commit to improve the quality of life for our generation and future generations. We demand freedom from the tyranny of fossil fuels and other limited approaches of the past. To that end, we pledge to these universal principles: Respect our history; be inclusive and build on our community heritage; innovate with optimism; take a measurable approach; balance all the inputs and outputs; create choices; achieve progress through doing; and integrate our approaches."*

‘Rapid Prototyping’ Exercise



‘Rapid Prototyping’ Exercise – How the working groups captured their thinking and ideas during the summit.

In addition to feedback in their workbooks and through the Opportunity Area Small Groups, the facilitators gathered additional stakeholder input during the session including:

- Feedback on a survey about the vendors with demonstrations in the Exhibit Area of the conference
- Informal feedback from Summit participants
- Summit website blog[4] and email contact[5] for summit comments:
- Expert comments from the keynote speakers and panelists including:

Mayor of Worcester	Chairwoman, Massachusetts Department of Public Utilities
Manager, City of Worcester	Cisco, Senior Vice President and General Manager of Smart Grid
President, To the Point	BestBuy, Senior Director of Home and Energy Management
Principle Engineer, South Mountain	Fairmount Minerals Professor, Weatherhead School of Management, Case
Senior Policy Advisor at Green For All	MIT Lecturer, Author, Founder, Society for Organizational Learning
Program Manager, Energy and Conservation, City of Worcester	Assistant Attorney General, Bureau Chief, Business and Labor Bureau

How the Summit influenced the revision of the Pilot Proposal

The Summit influenced the revision of the Pilot Proposal in several key ways:

- Updates to Outreach and Education plan reflect community-based interests and preferences on communication and engagement
- Updates to technology plan take into account inputs from Summit stakeholder

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[4] Summit Blog: http://www.green2growth.com/Blog/
[5] Summit email contact: feedback@green2growth.com

Email and Survey Stakeholder Feedback

Theme	Quote	Organization
Community Engagement	I have a great interest in energy conservation and being "green." On top of using efficient lights I try my best to keep my electricity use as low as possible by powering off my electronics at night and not leaving the lights on.	Resident
Community Engagement	Our city has to be smarter, cleaner and greener if we're going to grow and thrive	City of Worcester, Mayor
Community Engagement	Green Jobs like installing wiring, solar panels, construction for commercial, industrial and residential building is necessary.	TurnItAround Consulting Group
Environmental Responsibility	It would be a moral tragedy for the people who were hurt first and worst in the pollution based economy, benefit last and least from a the green economy.	Senior Policy Advisor at Green For All
Environmental Responsibility	Currently, building a super-energy efficient underground house within city limits. I am looking for any help I can get and would be willing to offer what I have learned thus far.	Resident – Local Environmentalist
Environmental Responsibility	As a School Committee Member and a former principal in Worcester I believe that it is essential that we look for ways of educating our students about ways to go "green," save our resources through conservation.	School Committee Member
Technology & Progress	I like the idea of using the latest technology to monitor my electric usage.	MA Dept of Energy Resources
Technology & Progress	My research and company both relate to the present grid and the development and operation of the future grid. I would like to learn about the plans for the future and hopefully be involved with developing the technologies that will enable the smart grid.	Clark University and Machflow Energy
Summit/multi-stakeholder experience	I am a master's student in Environmental Science and Policy at Clark University. For a long time, I have been very interested in climate change, sustainability, energy, etc. I am now beginning an internship with Absolute Green Energy of Worcester.	Clark University Graduate Student
Summit/multi-stakeholder experience	It's heartening to see a utility company working to change business as usual, and Worcester is an ideal locale, with top-down and bottom-up support for greening our economy. I would like to be part of the process.	Worcester Green Jobs Coalition; Worcester Energy Barn-Raisers

Worcester Sustainability Hub

Customer Learning the Technology

The Sustainability Hub concept is a direct initiative resulting from the Green2Growth Summit. Coincidently, this idea has been successfully demonstrated at Duke Energy's Envision Center. The Sustainability Hub will be an area destination for the community to experience interactive exhibits and education on energy technology, local sustainability efforts and provide hands-on access to the Smart Grid technology & rates offered by the Pilot. National Grid is leading the development of the Sustainability Hub by partnering with vendors, local institutions and community stakeholders to create an easily accessed, fully integrated showcase and learning center. The Sustainability Hub concept is modeled after the Apple Store concept[1] to leverage best practice in the customer experience.

When a customer enters the Sustainability Hub, they will be welcomed by National Grid employees, partner vendors, community partners and College Co-op participants providing guidance on what the Sustainability Hub can offer and act as an ambassador to direct visitor inquiries and interests. Customers and visitors interested in energy and sustainability technology can get information and first hand access to the technologies of the future and today, from energy efficiency appliances to smart grid devices to Renewables. Pilot customers can bring their devices for in-person repair, assistance, and education. In addition, internet access terminals will be made available for participants that may not have access in their homes.

The Hub will feature museum-style electronic learning exhibits that introduce customers to partnering consumer products and direct access to the Pilot's smart grid devices. These exhibits will demonstrate customer actions that can impact reductions in energy use and costs. In addition, the Sustainability Hub will conduct and illustrate a multi-media dashboard that shows how customer's consumption amount, consumption time, time of use, and rate plan affects their smart grid pilot outputs, including monthly consumption and bill impacts.

To maximize participation and visitation, the space will be in a highly accessible location, such as ground floor retail space with ample parking available. The Sustainability Hub will also be promoted throughout the Pilot within the Outreach & Education plan, raising visibility of the Sustainability Hub and encouraging customers to visit to address concerns. It will also be promoted via the Green2Growth website, all local and regional media contact and other communication channels available from National Grid and its partners. The intent is to the generate interest in the Sustainability Hub within the Pilot boundaries and beyond.

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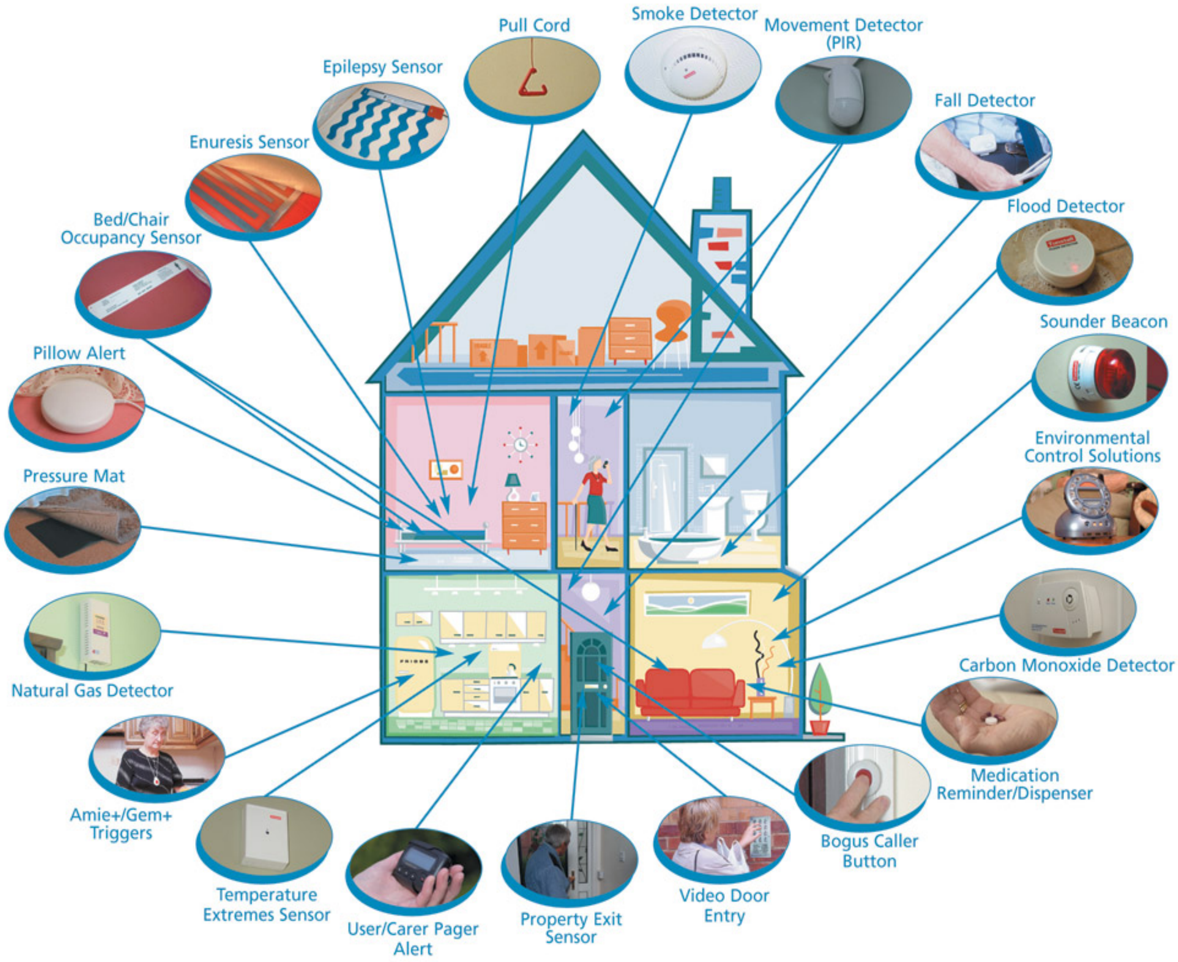
[1] Modeled after the Apple Store. Source: WATHI EU, LUC , "Apple Stores"; 9-502-063; Harvard Business School. R E V : MAY 2 0 , 2 0 1 0, page 4

The demonstration would cover the following technology:

- Energy efficiency treatments (i.e.: windows, spray in insulation, tankless water heater)
- Controllable & programmable appliances
- Controllable & programmable in-home management technologies
- Advanced meters
- Access to customer interactive energy portal
- Display illustrating smart grid distribution grid devices
- Local demonstrations on sustainability/renewables



The Sustainability Hub will offer interactive exhibits and off-the-shelf energy lifestyle improvement tools and appliances along with smart in-home controllable devices which are all part of smart grids two-way communications connecting the customer with the utility.

Collaboration

In addition to museum-style learning exhibits, the Sustainability Hub would be designed to foster two-way dialogue between Company employees, engineers, partnering vendors, community stakeholders, and College Co-op participants. This interaction would allow customers to provide real-time feedback on the smart grid pilot and technology to National Grid, participating smart grid manufacturers and the Massachusetts' Department of Public Utilities. National Grid believes that this will enhance the qualitative measurement and verification of the Outreach and Education efforts and provide additional feedback mechanisms for the "listen, test & learn" approach. The space will also include a Choice Desk, where customers could learn about, try on, and adopt smart grid devices for their participation in the pilot.

Office without Borders

To attract the highest density of Worcester customers, the Sustainability Hub can offer an open Community Office space, equipped with full conference capabilities for the community to host community based meetings, education and academic tours. Through this center of exchange, National Grid hopes to become more invested and integrated in communities and with customers to best address their concerns, questions and needs as it relates to their Pilot experience.

Location

To make an opportunity like this effective, National Grid would need approximately 1,000 square feet of ground level retail with access to major highways and with ample parking for customer visits and bus tours. National Grid has had initial meetings with stakeholders who have offered to partner with us in providing appropriate, cost effective space.

Cost Model

The Sustainability Hub is being developed with a partnership model approach with the expectation that space, equipment, most services and overhead will be donated in part by community, stakeholder and vendor partners. Estimated cost totaling $50,000 has been assembled through field visits and discussions with potential partners.

Select Case Studies

PG&E

Pacific Gas and Electric Company Smart Meter roll out was piloted in Bakersfield, California and was met with challenges due to weather-related timing and coinciding rate changes.

PG&E was a pioneer in the AMI field, being one of the first utilities to invest $2.2 billion prior to ARRA funding. Moreover, it has been proven that the metering technology used in PG&E's pilot was sound.[1] It is commonly believed that PG&E's smart meter pilot would have been more successful if it had included a robust O & E component, particularly before deployment to convey the benefits of smart meter to the customer base.

Implications of lack of outreach and education efforts prior to deployment:

- Law suits[2]
- Opt out requirement[3]
- Substantial resources devoted to fixing problem
- Ultimate loss of customer trust
    - Increased scrutiny led to more questions about usefulness, higher rates, privacy issues, and health concerns.
    - Negative perceptions of the company led to political friction and regulatory criticism.

Duke Energy

Duke Energy Envision Charlotte: a collaborative partnership among major employers, building owners and managers along with municipal and technology leaders. The aim of the pilot was to become a global model for environmental sustainability with measureable community results. In specific, they aimed to achieve a 20% reduction of energy use and 10% peak demand reduction in five years for 70 commercial buildings in a highly concentrated, urban area. By achieving its vision and goals, Envision Charlotte aims to "demonstrate Charlotte's national leadership as a sustainable, progressive, cost-efficient place to do business" and promote economic growth. On behalf of the Clinton Global Initiative, former president, Bill Clinton, said "The initiative will combine Smart Grid technology, energy education, and automation technology to create a sustainable, and a replicable model of energy efficiency."[4]

To engage customers, Duke utilized partnerships as a foundational component of an integrated customer communications model. They have also founded a Steering Committee, received buy-in from NGOs, city, business leaders, and policymakers. Duke's *Envision Centers* in

---

[1] Structure Group report commissioned by CPUC: http://www.cpuc.ca.gov/NR/rdonlyres/2B0BA24E-E601-4739-AC8D-DA9216591913/0/StructureExecutiveSummary.pdf
[2] San Francisco Chronicle/SF Gate website: http://articles.sfgate.com/2009-11-10/business/17179299_1_usage-data-pg-e-new-meters
[3] CPUC Ruling: http://docs.cpuc.ca.gov/efile/RULINGS/143742.pdf
[4] *Enhancing Access to Modern Technology* Plenary of the 2010 Clinton Global Initiative

Erlanger, Kentucky and North Carolina State University also provide customers with interactive exhibits of Duke’s thinking on the Smart Grid. Some of Envision Charlotte’s communication platforms include:

- Direct discussions with commercial partners
- Envision Centers (featuring interactive exhibits to demonstrate Smart Grid, renewable and energy efficient technologies; promoting the importance of renewable power to meet the clean energy needs of tomorrow and helps outline how customers can play an important role in helping reducing greenhouse gas emissions.)
- Other: Screen display in building lobbies, Intra-customer competitions, DVD, etc

nationalgrid

Karla M. Corpus
Senior Counsel
NY Regulatory

January 17, 2017

VIA ELECTRONIC DELIVERY

Honorable Kathleen H. Burgess
Secretary
New York State Public Service Commission
Three Empire State Plaza, 19th Floor
Albany, New York 12223-1350

RE: Case 14-M-0101 – Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision (REV)

NATIONAL GRID: CLIFTON PARK DEMAND REDUCTION REV DEMONSTRATION PROJECT-IMPLEMENTATION PLAN

Dear Secretary Burgess:

Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid") hereby submits for filing the Clifton Park Demand Reduction REV Demonstration Project Implementation Plan as required by the REV Demonstration Project Assessment Report ("Assessment Report") filed by the New York State Department of Public Service Staff ("Staff") with the Commission on December 1, 2016 in Case 14-M-0101.[1]

Please direct any questions regarding this filing to:

Philip Austen
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Tel.: 516-545-4753
Mobile: 631-599-0285
Email: pausten@nationalgrid.com

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[1] The Assessment Report was re-issued on December 28, 2016, removing references to a trademarked term and a trademarked acronym.

National Grid looks forward to continuing to work collaboratively with Staff as it proceeds with the implementation of the Clifton Park Demand Reduction REV Demonstration Project.

Respectfully submitted,

/s/ Karla M. Corpus

Karla M. Corpus
Senior Counsel

Enc.

cc: Marco Padula, DPS Staff, w/enclosure (via electronic mail)
Christian Bonvin, DPS Staff, w/enclosure (via electronic mail)
Denise Gerbsch, DPS Staff, w/enclosure (via electronic mail)
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Kara Fedors, w/enclosure (via electronic mail)
Pamela Dise, w/enclosure (via electronic mail)
Carol Teixeira, w/enclosure (via electronic mail)

Demand Reduction REV Demonstration Project

in

Clifton Park, New York

Implementation Plan

Case 14-M-0101

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Appendix A – REV Alignment

Appendix B – Outreach and Engagement

EXECUTIVE SUMMARY

On July 1, 2016 Niagara Mohawk Power Corporation d/b/a National Grid ("National Grid" or the "Company") filed a proposal for the Demand Reduction REV Demonstration Project (the "Project")[1] designed to provide residential customers in the Town of Clifton Park ("Clifton Park" or the "Town") with price signals, tools and information, enabled by infrastructure investments and distributed energy resources ("DER"),[2] to reduce electric demand during peak times and inform the Reforming the Energy Vision ("REV") proceeding. The purpose of this implementation plan (the "Implementation Plan") is to describe National Grid's detailed execution plans for the Project.

The Project aligns with the New York Public Service Commission's ("Commission") Order Adopting a Ratemaking and Utility Revenue Model Policy Framework ("REV Track Two Order") wherein the Commission asserts "[o]ne of the most important objectives of REV is improving overall system efficiency including the efficiency of capital investment to create value for customers. Toward that objective, electric peak reduction is among the most immediate priorities for REV implementation."[3]

National Grid believes that it is possible to create more responsive relationships with customers by leveraging critical infrastructure, customer outreach and engagement, deep energy insights and actionable information, as well as price signals and DER products and services, which incentivize customers to reduce peak electric load and overall electric and gas energy use. Toward that end, the following elements are included in the Project:

- Infrastructure
  - Advanced Metering Functionality ("AMF")
  - Volt/VAR Optimization (includes Conservation Voltage Reduction) ("VVO")
- Customer Outreach & Engagement
- Deep Energy Insights & Actionable Information
- Price Signals
  - Peak Time Rewards ("PTR")
  - Voluntary Time-of-Use ("VTOU") Rate
- DER Services
- Community Choice Aggregation ("CCA") Support

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[1] National Grid's July 1, 2016 submittal was an errata filing to replace the proposed Customer Convenience Demonstration Project for Clifton Park, contained within the Company's July 1, 2015 submittal of a suite of REV demonstration projects, with a renamed project entitled "Demand Reduction Demonstration Project" to reflect the substantial revisions in scope from the original July 1, 2015 filing.

[2] For the Clifton Park REV Demonstration Project, "DER" is defined as including energy efficiency, demand response, and renewable distributed generation offerings, consistent with the Commission's definition in Case 14 -M-0101, *Proceeding on Motion of the Commission in Regard to Reforming the Energy Vision* ("REV Proceeding"), Order Instituting Proceeding (issued April 25, 2014), p. 25.

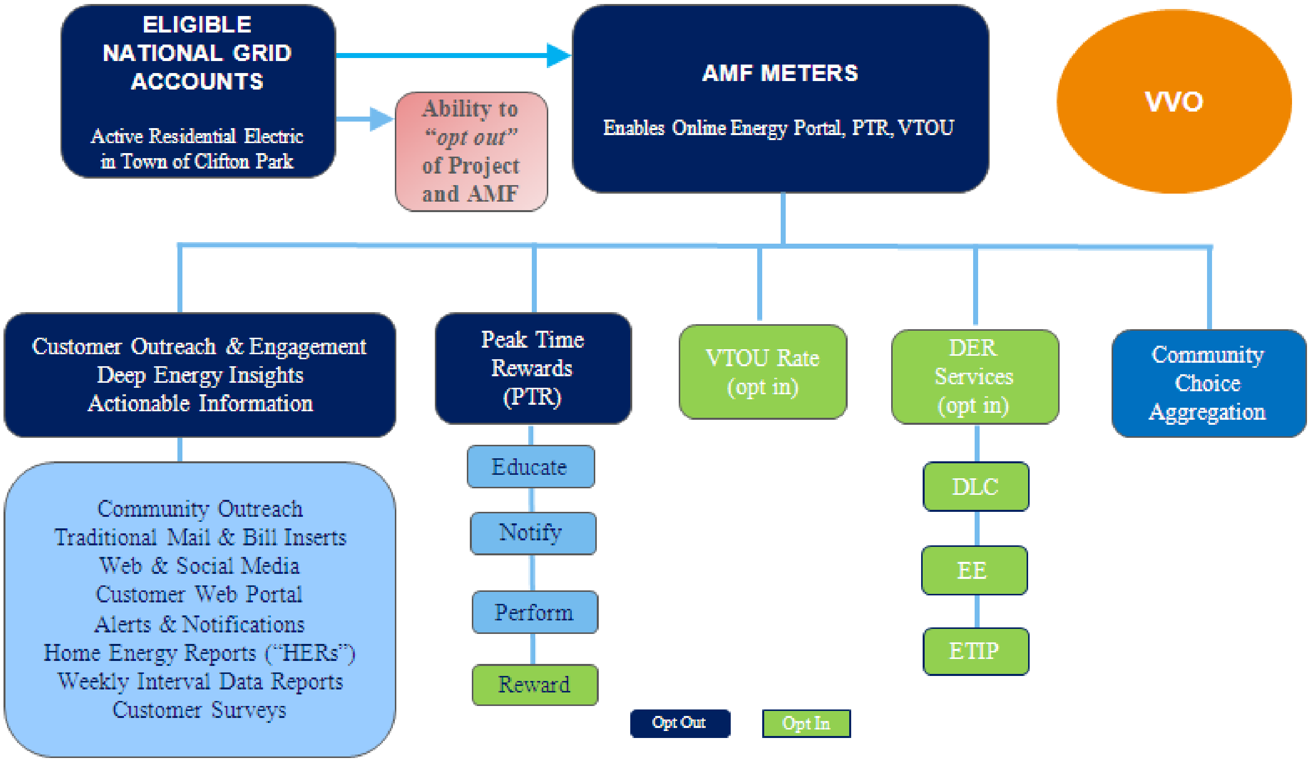
[3] REV Proceeding, Order Adopting a Ratemaking and Utility Revenue Model Policy Framework ("Track Two Order") (issued May 19, 2016), p. 72.

PROJECT DESIGN

Project Components Details

A summary of the Project's key services and offerings are provided below in Figure 1 (Project Overview Diagram). With the exception of VVO, customers can opt-in or opt-out of each Project element. A description of each Project element follows.

Figure 1: Project Overview Diagram[4]



Infrastructure

National Grid will install infrastructure intended to provide benefits to the Company's Clifton Park customers and enable other key Project elements. These infrastructure enhancements include:

- AMF; and
- VVO.

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[4] Note: A customer who opts out from the AMF meter installation will still have access to monthly consumption and other data on the web portal. Although PTR is an opt-out Project element, a customer will need to accept the terms and conditions on the vendor's website (*i.e.*, opt in) in order to earn points and rewards.

AMF

National Grid, working with its partners in the Project, will replace the existing electric meters installed at residential premises in Clifton Park with Commission-approved meters that have the capability of communicating, through cellular technology, near real-time electric interval data to these customers.[5]

Existing gas meters will also be upgraded to communicate gas usage through the electric meters. These enhanced metering capabilities are designed to:

- Provide customers with access to near real-time data about their electrical and gas usage;
- Provide greater knowledge of residential customers' load shapes;
- Enable timely messaging to customers about their energy consumption allowing for proactive energy consumption decisions;
- Allow valuation of electric demand response (*e.g.*, rewards to customers) based on projected and actual demand;
- Support the assessment and possible monetization of the impact PTR events may have on installed capacity ("ICAP") tags for electric mass-market customers, and
- Facilitate the offering of new services and functions.

AMF deployment in Clifton Park will replace existing National Grid meter reading and billing processes. AMF meters will be read and data transferred over the cellular network to National Grid for utility billing. Data will also be transferred to Project partners over secure networks in order to enable Project elements including the customer web portal. Interval data will also be used for Project deployment of PTR, billing of the VTOU rate, and to support authorized Project evaluation activities.

AMF deployment is anticipated to commence the end of the first quarter of 2017. Customer letters introducing the Project and the AMF installation process will be distributed at least one month meter installations begin. This allows for a period during which customers can opt out of the AMF metering technology as well as certain other aspects of the Project.

Customers choosing not to have AMF installed will be directed to a specialized team at the National Grid contact center. The contact center will direct Customer Meter Services ("CMS") to not install an AMF meter for those customers who choose to opt out. These customers will retain their existing automatic meter reading ("AMR") meter, or if they had previously elected the "AMR Opt-Out Option,"[6] retain a non-AMR meter. Additionally, during the Project term, customers will have the option to have their AMF meter removed and replaced with an AMR meter at no cost to the customer.

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[5] Case 16-E-0023, *Petition of Itron Inc. for Approval of the OpenWay Centron 4G LTE Commercial Meter Line,* Order Approving Itron OpenWay Centron 4G LTE Commercial Meter (issued November 23, 2016). The meter vendor, Itron, is assessing whether future changes to the cellular communication network used for the AMF rollout (*e.g.*, "4G" to "5G") would require upgrades to meter hardware and/or software. For the three years of the Project, the vendor anticipates no changes to the cellular network requiring hardware or software upgrades. National Grid, in collaboration with the vendor, will continue to assess the impacts of cellular communications network changes when assessing scalability of the Project.

[6] *See* P.S.C. No. 220 Electricity, Niagara Mohawk Power Corporation d/b/a National Grid, Schedule for Electric Service ("National Grid Electricity Tariff"), Rule 25.6, *et seq*.

National Grid will track the number of targeted customers that choose to opt out of AMF during the initial opt-out period, as well as those choosing to have AMF meters removed during the Project term.

Existing AMR meters that will be replaced by AMF technology will be cataloged and reviewed for depreciation status. National Grid will work with New York State Department of Public Service Staff ("Staff") to ensure proper accounting for meters that are depreciated and retired.

The steps for AMF deployment:

First Article Meters[7] delivered to National Grid	January 6, 2017
User Acceptance Testing Complete	February 2017
Go Live Declared	March 2017
Field Deployment of Meters	Through May 31, 2017

VVO

National Grid will enhance the efficiency of the electric distribution system through the installation of software and devices that better regulate the voltage of the distribution system. These system enhancements will benefit all customers connected to the substations being upgraded. Working with the Project's VVO partner, National Grid will install devices on the distribution system that monitor voltage along with advanced controllers for voltage regulators and reactive capacitors.

National Grid will evaluate the extent to which optimized regulation of the voltage and power factor of the electric distribution system benefits customers, ultimately reflected by improved feeder power factor, flatter voltage profiles, reduced feeder losses, reduced peak demand, and reduced energy consumption by customers.

VVO will include:

- Three Substation Transformer Load Tap Changers;
- Eleven Feeders, including:
    - 11 Line Voltage Monitors,
    - 39 Advanced Switching Capacitors, and
    - 8 Pole Top Regulators;
- Central controller and data concentrator installed at the National Grid Control Center in Liverpool, New York;
- Supervisory control through supervisory control and data acquisition ("SCADA") and Energy Management System ("EMS"), and
- Cellular connectivity between all field, substation devices, and the data concentrator.

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[7] First article meters are initial production runs made to validate specifications and built before manufacturing the entire meter population.

The schedule for VVO deployment is as follows:

Elnora circuit devices installed	May 2017
Grooms Road circuit devices installed	September 2017
Elnora Substation make-ready work	May 2017
Grooms Road Substation make-ready work	June 2017
VVO system commissioning	November 2017
VVO fully deployed	December 2017

Customer Outreach and Engagement

National Grid will engage residents of the Clifton Park community to educate energy consumers about the Project and solicit input. The strategies to be used include:

- Community outreach;
- Mail and bill inserts; and
- Web and social media.

Community Outreach

To effectively engage the Town, National Grid will work to engage community leaders through coordination with the Town leadership, small group meetings with targeted organizations, and open community-wide meetings.

Coordination with Town leadership

National Grid will work with the Town leadership, particularly the Government Re-Thinking Energy & Environment Now ("G.R.E.E.N") Committee, to refine many of the important Project details.

National Grid anticipates meeting with Town leadership on a monthly basis to provide key Project updates and receive Town feedback on Project progress. If meetings are not necessary or impractical in a given month, National Grid may provide written progress updates and solicit feedback where appropriate. The below Table 3 summarizes engagement with the Town to date.

Table 3: National Grid Town Engagement to Date

Meeting Date	**Agenda**
August 26, 2016	Met with Town leaders to discuss a CCA-like energy procurement model
September 12, 2016	Discussion of Project status and discussion of Town leaders' interest in CCA
October 14, 2016	Follow-up meeting on Project status and interest in CCA with those Town leaders that requested additional information

Small group meetings with targeted organizations

National Grid will reach out to key community organizations to understand their concerns and expectations for the Project. National Grid's goal is to create ongoing outreach and communication opportunities with groups from a wide range of social networks within the community. These groups can include faith-based communities, neighborhood associations, schools, sports and recreation groups, book clubs, civic organization, and employers. National Grid believes that engaging these groups throughout the Project will build a steady stream of participation.

Specifically, National Grid will engage these community organizations in the following manner:

- Identify and engage local contractors, retailers, and others in the business community that can market, sell, and install DER products and services;
- Reach Clifton Park customers to educate them about Project opportunities (*e.g.*, PTR, DER products and services, VTOU pricing, etc.), and
- Solicit feedback on key aspects of the Project.

Open community-wide meetings

National Grid will also engage Town leadership at meetings open to the entire community through a series of Town meetings. The goals of these meetings are to:

- Gauge community buy-in to the Project from engaged community members, collecting contact information for future engagement;
- Solicit ideas for additional energy services important to the community for inclusion in the Project, and
- Educate Town leaders on key aspects of the Project (*e.g.*, VTOU pricing) that they can promote through their personal networks.

Each outreach approach is intended to reinforce others to build awareness, interest, and participation in the Project. By providing multiple opportunities to interact, SC-1 customers will receive more information to make educated decisions about energy use while National Grid will remain apprised of additional community education opportunities.

Prospective Tactics	February				March				April				May				
	6	13	20	27	6	13	20	27	3	10	17	24	1	8	15	22	29
Tabling: Clifton Park Shopping Center	X				X				X				X				
Classroom Prep: Shenendehowa Central Schools (1 HS, 3 MS, 8 ES)			X				X				X				X		
Tabling: Clifton-Park Halfmoon Public Library		X				X				X				X			
Tabling: Clifton Park Town Justice (Clifton Commons)				X				X				X					X
Tabling: YMCA Clifton Park		X				X				X				X			
Cap Region Spring Home Show										X							
Science and Health Discovery Night (Shen H.S.)												X					
Van: Clifton Park Winterfest	X																
Van: Clifton Park Farmers Market (Date TBA: Summer 2017)																	
Van: Clifton Park Farm Fest (25th Annual) - (Date TBA: Fall 2017)																	

Mail and Bill Inserts

Prior to the installation of AMF, National Grid will deliver a set of communications to introduce Clifton Park customers to the new interval meter benefits and key Project elements available immediately and in the future. These communications will be sent in the form of reports delivered by direct mail, bill stuffers, and email (see attached Appendix B - Sample Smart Energy Introduction Letter to Customers, and Sample Bill Insert from National Grid affiliate's Worcester Smart Grid Pilot, for examples from other smart energy pilots). National Grid will send a welcome packet prior to the installation of AMF focused on education. Following the installation of AMF, customers will receive educational materials focused on the various Project elements. Table 4 below summarizes the outgoing communications to customers by type, volume, and date.

Table 4: High-Level Project Rollout Schedule

Project Element	Mail Volume	Mail Dates
Meter Letter	14,409	February 2017
Welcome Letter	13,689	Rolling basis
Points and Rewards Enrollment	11,609[8]	Rolling basis
VTOU Rates	14,409	March –April 2017
DER Opportunities	14,409	November 2017

In all communications to customers, National Grid will provide a dedicated phone number and trained team of representatives who will be prepared to answer questions on Project specifics.

Web and Social Media

National Grid continues to expand the existing Clifton Park micro-site, a component of the Company's current nationalgrid.com website, to include information on the Project for all Clifton Park residents. The Project website will include the following information:

- AMF details including technology specifics, rollout schedule, and opportunity to opt out;
- Information about PTR and the VTOU rate;
- Energy services information and sign-up options for DER products and services immediately available and services that will be available once AMF is installed (*e.g.*, PTR); National Grid will include bi-weekly or monthly geo-targeted content to the Clifton Park area in the Facebook and Twitter editorial calendars. Content will include Project updates and customer stories gathered in the field. National Grid will create the post(s), set-up targeting, monitor and reply to

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[8] Assumes 20% of targeted Clifton Park customers are already participating in the existing National Grid electric and gas energy efficiency programs, the Electric Residential Engagement Program and the Gas Residential Engagement Program (formerly known as the Residential Building Practices and Demonstration Programs), and are already receiving HERs and enrolled in the associated Points and Rewards offerings. Analysis to confirm Point and Rewards enrollment of the Clifton Park population is in progress.

customer inquiries, and provide metrics. Web and social media avenues will include frequent content updates as outlined below. Ngrid.com/cliftonpark will be updated throughout the year to announce the rollout of new products and services and will include Project-specific information;

- Bill inserts will be incorporated four times per year as new Project elements are rolled out, and
- Social media updates will be on-going throughout the year.

See Appendix B, Sample National Grid Affiliate's Social Media Messages, for examples of National Grid Facebook posts.

Customer Research

National Grid will deploy customer surveys to support analysis and tracking of progress on hypothesis test questions and to support the Project deployment. Surveys will gather information on customer attitudes and experiences on various Project elements. The information gathered will identify outreach and engagement approaches that may need to be modified to further enhance customer participation.

An initial baseline survey of Clifton Park residents was deployed in October 2016. This research indicated that customer age ranges have different needs to support their energy decisions. Given these research findings, National Grid will segment the Clifton Park customer population by age as well as their current level of HERs participation (via the Company's existing Electric Residential Engagement Program and Gas Residential Engagement Program), to allow for tailored messaging to better support customer segments throughout the Project. The identified segments are:

- HERs[9] participants who currently log in and use the portal to view their monthly energy usage;
- HERs Participants who have never logged into the portal; Young (18-54);
- HERs Participants who have never logged into the portal: Older (55+);
- HERs Non-Participants; Young (18-54), and
- HERs Non-Participants; Older (55+) SC-1 eligible non-residential accounts (*e.g.*, religious-based organizations).[10]

Future Project surveys will be rolled out strategically with the deployment of different aspects of the Project. For example, a survey may be deployed after meter installations are complete and initial AMF education materials are distributed to provide feedback on customer experiences with meter exchanges and the effectiveness of AMF education.

Deep Energy Insights and Actionable Information

National Grid will work with the Company's engagement partner to increase customer engagement by providing interactive energy insights and actionable information. Customers will be presented with actionable energy information and will be provided with messaging about the benefits of energy

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[9] *Id.*

[10] Non-residential SC-1 eligible accounts provide an opportunity for community-based engagement within this Project.

efficiency, demand reduction, and pricing programs that encourage shifting energy usage to lower price, off-peak times of the day.

Customers will be engaged in energy insights and actionable information via a variety of channels and strategies, including digital communications, traditional mail, a customer web portal, alerts and notifications, HERs, customer education reports, and weekly reports.

Customers who do not wish to receive specific communications can choose to opt out by notifying National Grid. Customers will be engaged via the channels outlined in the below Table 5 (Customer Communication Channels).

Table 5: Customer Communication Channels

Communication Channel	**Description**
Web Portal	National Grid web experience will be customized for Clifton Park customers and will present electricity and gas usage, and behavioral messaging. (Visit at ngrid.com/cliftonpark)
High Bill Alerts	High bill alerts delivered via email. Alerts will utilize AMF data to identify customers trending towards a high bill and inform them of a potential high bill.
Home Energy Reports (“HERs”)	The existing HER channel will be leveraged to promote tailored energy-saving products and services.
Emailed Home Energy Reports (“eHERs”)	The existing eHERs messaging channel will be leveraged to promote energy-saving products and services.
Weekly Interval Data Reports	Customers with AMF will be sent an opt-in weekly interval data report via an email giving them insights on how they are using energy on a weekly basis.

Web Portal

Customers will be engaged through the National Grid website, which will have customized data presentment specific to Clifton Park customers. Prior to AMF rollout, the digital experience will include monthly electric and gas usage information, and promotional messaging about National Grid energy-saving products and services. The digital experience will be significantly enhanced after AMF meters are installed. Specifically, customers will have access to the following features:

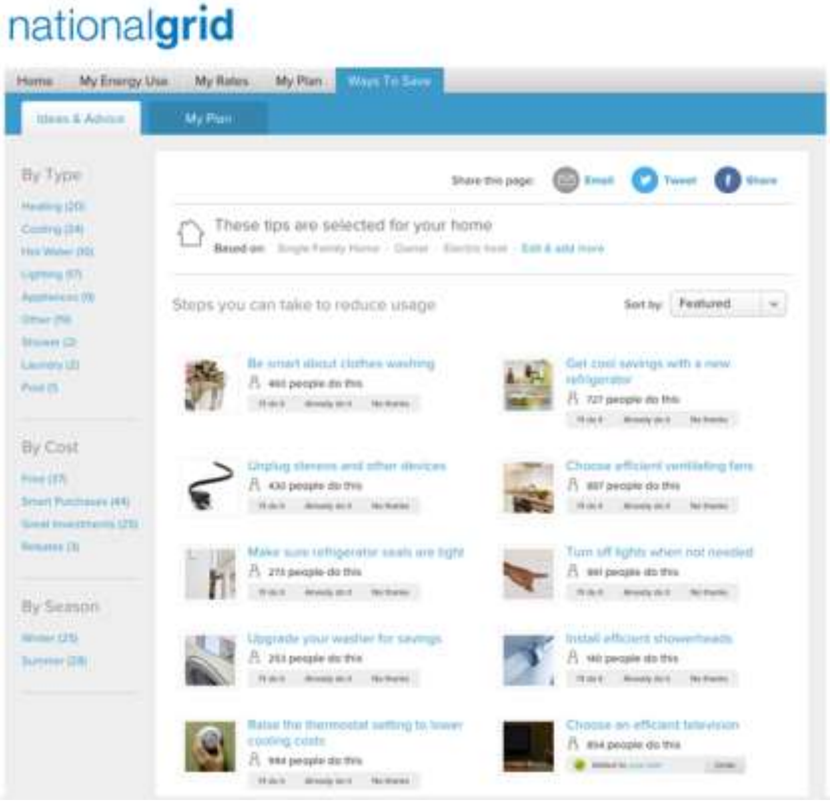
- Interval energy usage tracking (See Figure 4);
- Energy savings recommendations (See Figure 5), and
- Energy usage alerts (See Figure 6).

Figure 4: Energy Usage Tracking

You could save more by managing your critical peak usage

Critical peaks are the highest demand times for electricity. Watch for mobile and email alerts for critical peak days. You'll get alerts a day in advance.

Figure 5: Energy Savings Recommendations



High Bill Alerts

In addition to displaying alerts on the web portal, high bill alerts will be sent by email (see Figure 6 below) when customers are on track to exceed their typical energy usage each month. This usage threshold and notification date will be set by National Grid with input from the Company's engagement partner. These alerts will also include links ("calls to action") on how customers can save energy.

National Grid will aim for limited frequency of alert messages to any individual customer.

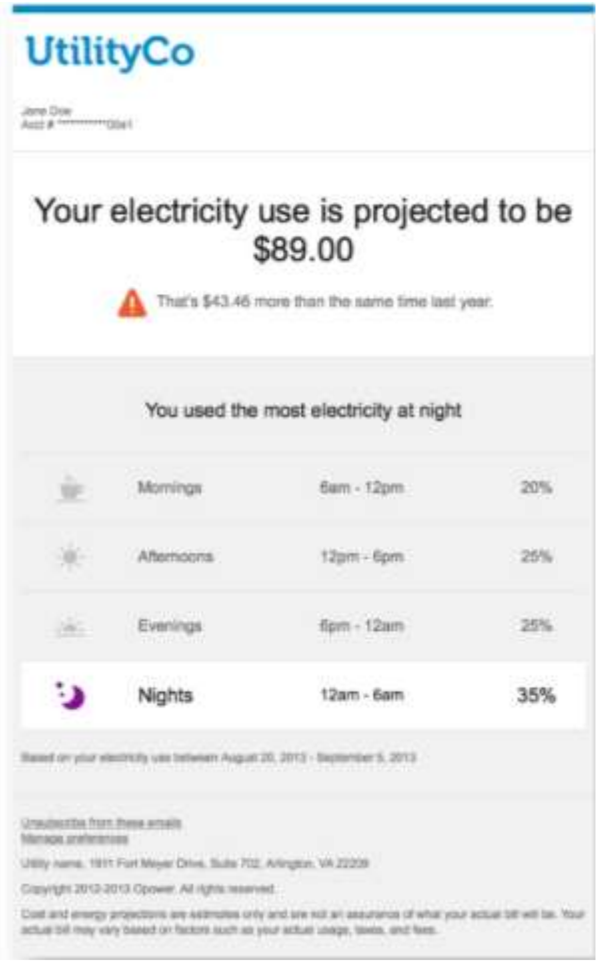
Home Energy Reports

National Grid currently delivers HERs to approximately 8,000 customers in Clifton Park through ongoing National Grid energy efficiency programs, the Electric Residential Engagement Program and the Gas Residential Engagement Program, as detailed in the Company's Energy Efficiency Transition Implementation Plans (ETIPs).

Weekly Interval Data Reports

National Grid will send weekly interval data report emails to customers that have AMF meters installed. These reports will give customers additional insights into the daily electricity usage and provide behavioral nudges and targeted tips to promote energy conservation.

Figure 6: Email Message Usage Alerts



UtilityCo

Jane Doe

Your electricity use is projected to be $89.00

That's $43.46 more than the same time last year.

You used the most electricity at night

	Mornings	6am - 12pm	20%
	Afternoons	12pm - 6pm	25%
	Evenings	6pm - 12am	25%
	Nights	**12am - 6am**	**35%**

Based on your electricity use between August 20, 2013 - September 5, 2013

Unsubscribe from these emails
Manage preferences

Utility name, 1911 Fort Meyer Drive, Suite 702, Arlington, VA 22209

Copyright 2012-2013 Opower. All rights reserved.

Cost and energy projections are estimates only and are not an assurance of what your actual bill will be. Your actual bill may vary based on factors such as your actual usage, taxes, and fees.

Price Signals

National Grid's goal is to design electric energy price signals that achieve the greatest possible impact in the form of reduced peak energy usage in order to better align usage patterns with the realities of the electric grid, recognizing the location, time, and attributes of energy reductions.

Ultimately, reducing peak electric energy usage will benefit customers by lowering the amount of expensive peak energy procured, minimizing the cost to operate the electric grid, and decreasing the need for additional infrastructure investment.

To reach this goal, National Grid will balance the following factors:

- Peak reduction per customer;
- Number of customers participating, and
- Customer satisfaction.

The Project seeks to test if residents are presented with energy price signals whether they will act to reduce local and system peak loads. The Project is designed to offer two forms of price signals: PTR and the VTOU rate. PTR provides rewards for taking action at specific times, while the VTOU rate design provides pricing that encourages off-peak energy use.

PTR

Through a single marketing message, “Reduce Your Energy Usage and Earn a Gift Card Reward,” National Grid will seek to incentivize Clifton Park customers to reduce electric use during specified peak times. Participating customers will be rewarded for curtailing electric load through behavioral actions such as turning off lights and adjusting their thermostats.

Key elements of PTR include:

- Event performance analytics performed on all customers with AMF;
- No penalties for failure to reduce load during PTR events;
- Pre-event and post-event notifications;
- Rewards earned by those enrolled in “Points and Rewards”; and
- Rewards awarded based on participation in up to 20 PTR events per year.

Event performance analytics

All electric customers that receive an AMF meter will be targeted for PTR. This will provide insight on community-level load curtailment. Event analytics will be performed comparing modeled expected consumption to actual consumption based on AMF interval data during the event period. Determinations will be made whether Project participants curtailed electric load or not.

Customers that choose to opt out of PTR will not receive PTR notifications. Customers can opt out of PTR even if they have an AMF meter.

No penalties

PTR is a rewards program based on positive motivation. There are no penalties for failure to curtail load during events.

Pre-event and post-event notifications

Pre-event notifications will inform customers of the time frame and date of event with recommendations on how to reduce usage during the event.

Post-event notifications will inform customers if their data reflected they curtailed load during the event, and whether they earned points that can be redeemed for rewards.

“Points and Rewards” enrollment

In order for individual customers to earn rewards they must enroll in “Points and Rewards” and accept the vendor’s terms and conditions.

Awarding and distributing rewards

There may be up to 20 PTR events per year during the summer electric capability periods of June through September. Rewards will be awarded based on whether or not individual customer data reflects electric load curtailment during specified events compared to modeled expected load. Customers are able to earn points for each event and can redeem points for rewards at any time

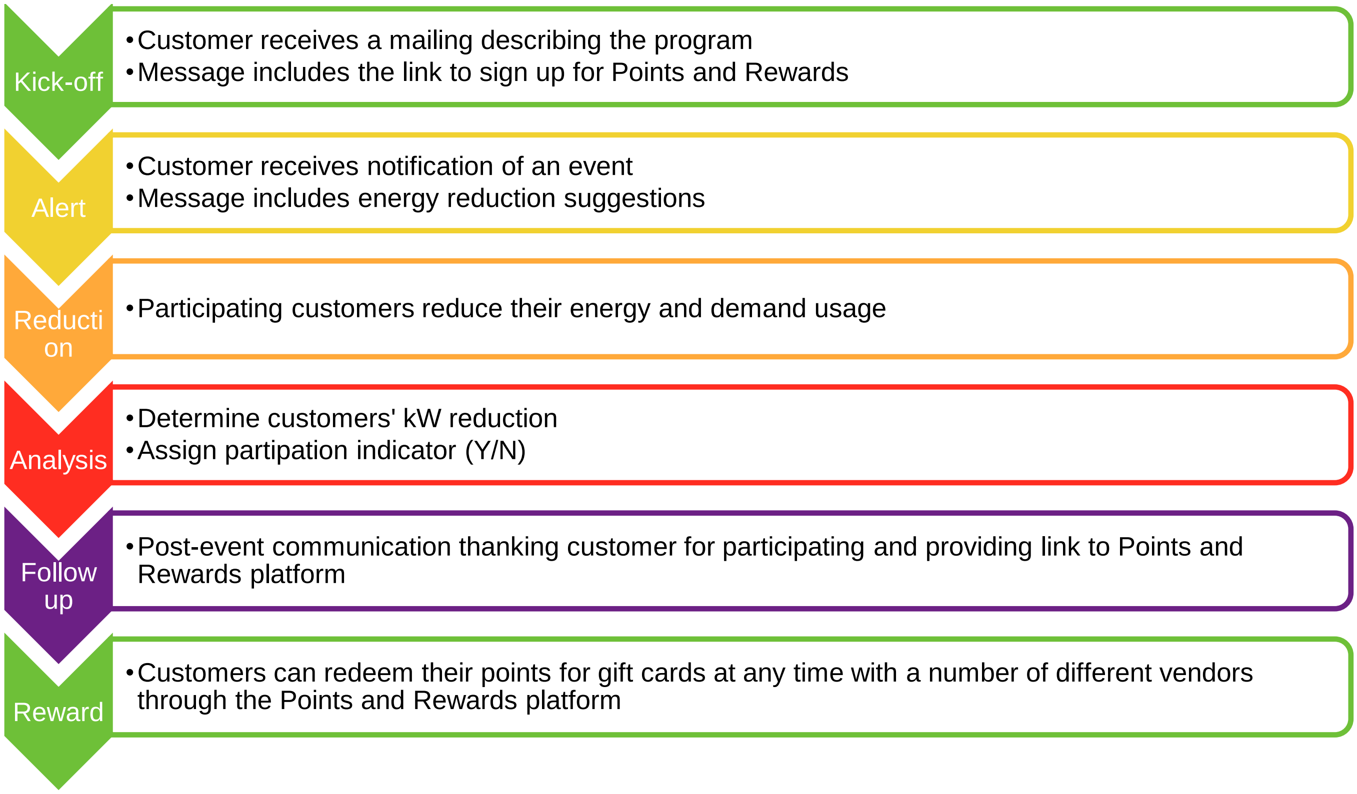
PTR events will be called by National Grid, and may be triggered by a number of indicators that will be further defined. Some examples of peak event triggers include:

- High Day Ahead Locational Marginal Price (“LMP”);
- High temperature;
- High humidity; and
- Various electric transmission restrictions that may arise (*e.g.*, feeder specific).

.

Figure 7 below provides an overview of the PTR program.

Figure 7: PTR Customer Experience



Kick-off
- Customer receives a mailing describing the program
- Message includes the link to sign up for Points and Rewards

Alert
- Customer receives notification of an event
- Message includes energy reduction suggestions

Reduction
- Participating customers reduce their energy and demand usage

Analysis
- Determine customers' kW reduction
- Assign partipation indicator (Y/N)

Follow up
- Post-event communication thanking customer for participating and providing link to Points and Rewards platform

Reward
- Customers can redeem their points for gift cards at any time with a number of different vendors through the Points and Rewards platform

Key PTR schedule items:[11]

PTR education communications	2nd Qtr. 2017
Launch event period	3rd Qtr. 2017 (and annually through September 2019)
Evaluation of PTR performance	4th Qtr. 2017

<u>VTOU Rate</u>

The VTOU rate[12] will be tested in Clifton Park on an opt-in basis. The VTOU rate, which became effective December 1, 2016, includes three rate periods: on-peak, off-peak and super-peak. Delivery rates differ for on-peak and off-peak usage, and commodity rates vary based on customers' on-peak, off-peak and super-peak usage. The specific time-of-use periods are as follows:

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[11] Time periods shown are predicated on having the engagement vendor under contract by the end of the 1st Qtr. 2017. If that is not achievable, dates shown will likely slip. Any schedule changes will be reflected in Project Quarterly Reports.

[12] *See* National Grid Electricity Tariff, Service Classification 1, Special Provision L, "Residential Optional Time of Use Delivery and Commodity Rate."

	Delivery Rate Period	Commodity Rate Period
On-Peak	7am-11pm	7am-11pm*
Off-Peak	11pm-7am	11pm-7am
Super-Peak		2pm-6pm (June-August)**

*Excluding Super-Peak period **Excluding weekends and holidays

Customers who elect the VTOU rate are placed on the rate for an initial one-year term, which continues month to month thereafter until canceled by the customer upon written notice to the Company. The VTOU rate is designed for the delivery and commodity portions of the customer bill, however, participating electric customers may choose to take supply from a retail access supplier in lieu of the VTOU commodity portion.

VTOU customers that receive supply service from a retail access supplier will receive the VTOU distribution delivery rate for their On-Peak and Off-Peak usage in the VTOU Delivery Rate Periods but their electric supply and corresponding supply charges will be provided by their retail access supplier. The electric supply provided by the retail access supplier will be provided in accordance with the Company's standard tariff retail access program and will not use the Commodity Rate Periods specified for the VTOU rate.

Additionally, if the customer received supply service from the Company during their initial one-year term on the VTOU rate, and provided a copy of their New York State Department of Motor Vehicles registration for a plug-in electric vehicle ("EV") at their Premise at the time they enrolled in the VTOU rate, they will be eligible for a one-time bill protection guarantee. The Company will perform a one-time comparison of 12 months of the customer's charges under the VTOU rate to what the customer would have paid under the standard tariff. If this comparison indicates the customer would have paid less on the standard tariff rate, the Company will credit the customer the difference in their next retail bill.

While the VTOU rate is available across the Company's service territory, its inclusion in the Project allows National Grid to test how enabling technology, such as AMF and associated energy insights and actionable information, influences the adoption of time-of-use rates.

National Grid will file a petition with the Commission to modify the VTOU rate for Project participants. Under the existing tariff provision, VTOU customers are required to pay an incremental customer charge of $3.36 per month (for metering required for the VTOU rate). The petition will request a modification to the VTOU customer charge to eliminate the incremental customer charge to reflect the use of AMF technologies funded through the Project and that no additional metering costs will be passed on to Project participants that adopt the VTOU rate.

Key VTOU Schedule items:

VTOU rate effective date	December 1, 2016
Petition modifying VTOU for participants	To be filed by February 2017
Billing system modified for VTOU AMF billing	To be completed by March 2017
VTOU marketing	April-September 2017

DER Services

In addition to reducing peak load through energy insights, actionable information and price signals, National Grid seeks to animate the market by working with third-party DER providers and/or facilitating DER providers' services as part of the Project. DER products and services will be opt-in offerings to customers, publicized via the customer engagement channels outlined above as well as community outreach. DER services may include energy efficiency, demand response, or renewable distributed generation opportunities.

DER providers will gain value by leveraging National Grid's communications channels to those customers opting in to receive such communications, and in turn, DER providers will contribute toward Project revenues in the form of referral incentive fees.

Direct Load Control ("DLC")

The National Grid Connected Solutions DLC program was launched across the National Grid service territory in 2016. The DLC program works with qualified smart appliances, including thermostats and water heaters, and aims to automatically reduce peak electric usage.

Customers that enroll in the DLC program will receive $30 in the first year and an additional $20 at the end of each following year as long as they participate in at least 80% of called events. Participants who opt in to the program will be notified when demand response events are scheduled to reduce overall demand during peak, critical hours of the electric summer capability period.

Participating customers will give National Grid the right to control their electric load during peak times (*e.g.*, automatically changing thermostat settings by 2 degrees during an event). Participating customers will receive electronic event notifications as well as emails. Customers will be able to opt out of any specific event.

National Grid will track enrollment rates resulting from Project-specific promotions of the DLC program within Clifton Park and report results annually.

Insulation and Air Sealing

DER providers will offer home energy assessments and energy efficiency retrofit services in Clifton Park to customers that have expressly opted in to receive such marketing.

Additional DER Products and Services

Based on Town and Project participants' feedback, National Grid will provide additional DER product and service opportunities to residents in Clifton Park that have expressly opted in to receive marketing materials such as an EV adoption campaign, and other distributed generation opportunities such as solar photovoltaic ("PV") technology.

CCA Support

National Grid has engaged with Clifton Park officials and community members on the potential for CCA. As directed in Staff's Assessment Report of the Project, community-level supply procurement activities would follow the framework outlined in the Commission's CCA proceeding.[13] Should the Town decide to move forward with CCA, National Grid will support the Town's efforts to identify opportunities where the Project and CCA could bring value to the Clifton Park community.

Potential areas of synergies between the Project and CCA may include:

- Opportunities to use the Project engagement and outreach platform to help inform Clifton Park customers of the Town's CCA actions and how CCA would interact with different Project elements;
- Opportunities for a selected energy supplier to partner in PTR though funding of rewards and ability to call PTR events based on day-ahead market prices, and/or
- Providing a platform to promote the selected retail supply provider's DER opportunities.

Project Opt-In / Opt-Out Summary

Table 6: Project Component Overview

	OPT IN	OPT OUT
Infrastructure		
AMF		X
VVO	*Distribution System Level*	
Communications		
Customer Outreach and Engagement		X
Deep Energy Insights and Actionable Information		X
Price Signals		
PTR		X*
VTOU	X	
DER Products and Services		
Energy Efficiency	X	
DLC	X	
Other DER (*e.g.*, EV, solar PV)	X	
CCA		
CCA Coordinated by Town		X**

* All customers with AMF will be included in PTR notifications on an opt-out basis. To receive PTR rewards, customers will need to enroll (opt in) and accept the PTR reward provider's terms and conditions.
** CCA opt out will be implemented in accordance with the Commission's requirements for a municipally-sponsored CCA.

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[13] Case 14-M-0224 – *Proceeding on Motion of the Commission to Enable Community Choice Aggregation Programs*. Order Authorizing Framework for Community Choice Aggregation Opt-Out Program (issued April 21, 2016).

TEST STATEMENTS

National Grid and its partners will test the validity of the hypotheses shown in Table 7, Test Statements, below. The results of hypothesis testing will be tracked and documented and then used to inform and modify subsequent offerings to Clifton Park residential customers.

Table 7: Test Statements

Test Statement…	**If…**	**Then…**
1. *Infrastructure*: Infrastructure investments will bring benefits to customers.	A. National Grid builds out the required infrastructure and offers AMF to Clifton Park residents...	Clifton Park residents will accept the technology and receive deep energy insights.
	B. VVO is installed in Clifton Park…	All Clifton Park customers will see a reduction in electric consumption as a result of distribution system efficiencies.
2. *Customer Engagement*: Timely, customized communications and information will enable Clifton Park residents to make electric and gas energy choices that align with REV principles.	A. National Grid and its partners deliver customized and actionable information to Clifton Park residents using channels preferred by customers...	Clifton Park residents will make informed and engaged energy choices resulting in greater satisfaction with their electric and gas energy providers.
3. *Price Signals*: Price signals can result in Clifton Park residents acting to reduce local and system peak electric loads.	A. Clifton Park residents have the opportunity to participate in a PTR program …	Clifton Park residents will be willing to reduce their electric energy usage resulting in points and rewards.
	B. Clifton Park residents targeted for increased electric rate education …	Clifton Park residents will be more likely to adopt the electric VTOU rate.

4. DER Services (Business Models and Revenue Streams): Informing customers about DER products and services will increase the adoption of DER and create new revenue streams for National Grid.	A. National Grid provides Clifton Park residents with information about specific value-added DER products and services from select partners...	Clifton Park customers will be more likely to adopt such DER products and services.
	B. If National Grid provides opportunities for select DER providers to educate Clifton Park residents who opt in to receive such products and services marketing …	These partners will share a portion of their incremental revenue with National Grid.
5. Community Supply Procurement: Utilities can add value to the CCA process.	A. Clifton Park pursues CCA… …	National Grid will use Project-specific outreach and education channels to support the Clifton Park CCA.

TEST POPULATION

The Town of Clifton Park represents a growing suburban region with increasing energy usage and is well positioned to adopt advanced energy options that will benefit residents. The Project will target the approximately 14,400 National Grid residential electric customers in the Town of Clifton Park. Approximately 86% of these accounts are also National Grid residential natural gas customers.

According to the 2010 US Census, the Clifton Park community has a population of 36,705 and is upper-to-middle class (median income: $80,908).[14]

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[14] http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=CF

TEST SCENARIOS

See Table 8, Test Scenarios, below, for all Project test scenarios and metrics.

Table 8: Test Scenarios

Scenario	**Description**
Infrastructure	
AMF:	Approximately 14,400 residential electric accounts in the Town of Clifton Park will be targeted for AMF installation on an opt-out basis. National Grid will test the deployment of AMF meters on an opt-out basis. Customers that do not opt out of AMF installation will have access to interval data on the customer portal and to deep energy insights.
VVO:	VVO will be deployed at two substations for the electric distribution system that combined serve about 90% of Clifton Park accounts. VVO is expected to be fully operational by December 2017. VVO performance will be verified through the VVO measurement and verification ("M&V") report. M&V activities include measuring system performance by turning the system on and off, and measuring voltages and loads.
Customer Outreach and Engagement / Deep Energy Insights and Actionable Information	
Energy Information and Engagement	National Grid will test customer engagement in response to energy information by examining customer awareness, interest, comfort, knowledge, and satisfaction with Project offerings through customer surveys. National Grid will seek to understand the role specific engagement campaign events have on VTOU and DER adoption rates. National Grid will use a variety of communications channels to educate customers about the Project and its offerings. National Grid will implement customer surveys approximately every six months to determine customer levels of awareness and understanding of Project offerings.

	The Customer Energy Portal is designed to leverage AMF data capabilities combined with energy education to enable customers to better understand and better manage their energy use. National Grid will determine overall differences in pre- and post-energy consumption of Project participants, and attempt to attribute savings across Project elements (*e.g.*, outreach, insights, PTR participation, VTOU adoption, DER adoption, etc.). Electricity and gas savings will be analyzed separately.
Price Signals	
Peak Load Reduction Test:	National Grid will test PTR event participation rates defined by the delta between expected and actual electric load as measured by AMF data. National Grid will track the number of customers participating in PTR events and their average load reduction, along with aggregate community load reduction during events. National Grid will track enrollment in Points and Rewards and reward earnings rates. All Clifton Park residential customers who do not opt out of AMF installation will be targeted for participation in PTR. Customers with AMF that enroll in Points and Rewards will be eligible to earn rewards for curtailing electric load at specified times. National Grid will also identify when PTR events overlap with DLC program events and examine the impact DLC program participation may have on overall curtailment of customers that participate in both programs.
VTOU Rate:	National Grid will compare the VTOU adoption rate in Clifton Park with that in the rest of the Company's service territory to test the impact of enabling technology and targeted communications on rate adoption. If TOU analysis tools are deployed, National Grid will examine their influence on adoption of VTOU.
DER	
Customer adoption of DER products and services	National Grid will test the impact of targeted communications and education on the adoption rate of DER products and services (*e.g.*, home assessments, insulation and air sealing, DLC, energy efficiency, etc.). Currently identified DER services include:

	• Insulation and air sealing, and home energy assessments • DLC, and • National Grid ETIP Portfolio. Future DER opportunities may include EVs, solar PV, and other offerings. National Grid will also monitor enrollment in the DLC program within Clifton Park and compare that to the existing benchmark of 7%.[15]
Development of new revenue streams for National Grid	National Grid will test the ability of the Company to earn revenues from generation of leads to DER providers.
CCA	
Town adoption of CCA	Should the Town decide to pursue CCA, National Grid will use demonstration-specific communication channels to help educate and inform customers about CCA and Town-specific CCA activities. These communications channels include the demonstration website, banner ads in the customer portal, HERs, and demonstration related mailings.

MILESTONES AND CHECKPOINTS

As the Implementation Plan is an evolving, working document, refinements to scope of work for Project partners and internal National Grid teams are expected as the Project progresses. Modifications will be captured in quarterly reports and meetings with Staff.

Milestones:

There are several points in the Project that will serve as critical milestones including:

• *First Article Meters Delivered to National Grid*	*January 2017*
• *Verizon Connectivity to Support First Article Testing*	*January 2017*
• *Meter First Article Approved*	*January 2017*
• *Phase 1 User Acceptance Testing Complete*	*February 2017*
• *CCA Decision by Town*	*1st quarter 2017*

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[15] Adoption rate is based on comparable adoption rate for National Grid DLC "Cool Kenmore" program.

- *Phase 1 Go-live Declared* *March 2017*
- *Completion of AMF Installation Expected* *May 2017*

Check Points:

Check Point	**Description**
Infrastructure	
AMF Opt Out:	National Grid will monitor ongoing customer opt-out rates of AMF meters. Measure: Customer opt-out rate of AMF meters. How and When: Meter opt-out rate will be assessed upon initial 30 day opt-out period, and during Project deployment. Resources: National Grid billing system and call center statistic tracking. Expected Target: Opt-out rate not to exceed 10%. Solution / Strategies in case of results below expectation: If the opt-out rate is greater than 10%, National Grid will obtain customer feedback through surveys to determine why and update the marketing strategy accordingly.
VVO System Benefits:	Measure: System level electric energy and demand reduction. How and When: VVO M&V will be conducted at the end of the Project and will include intermittent field testing and a VVO M&V report. Resources: Utilidata, National Grid Advanced Engineering Team Expected Target: • Save over 5.99 million kWh annually • Reduce demand by over 1.98 MW • Avoid over 4,216 metric tons of carbon dioxide emissions[16] Solution / Strategies in case of results below expectation: If the M&V Report shows significantly different results than anticipated, National Grid will engage the VVO partner for further examination of performance assumptions against results.
Customer Outreach and Engagement / Deep Energy Insights and Actionable Information	
Customer Outreach and Engagement and Deep Energy Insights and Actionable Information	Measure: Customer satisfaction with Project and Project-specific components such as outreach and education, customer portal and deep energy insights, electric savings (kWh, KW) and gas (dth) savings. How and When: Annual customer surveys will gather quantitative and qualitative insight to customers' experience with the Project. A baseline survey was performed in October 2016. A pre-/post-billing analysis will be performed after the Project is completed and there is sufficient consumption data available to do so.

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[16] Figure calculated using EPA generic conversion: 7.03×10^{-4} (eGRID, U.S. annual non-baseload CO^2 output emission rate, year 2012 data).

	Resources: National Grid Customer Insights Team Expected Target: • Expected increase in customer satisfaction of 2%, with stretch of 5%. • 5% reduction in electricity and gas usage. Solution / Strategies in case of results below expectation: Revisit engagement approaches based on survey results and customer inputs. If survey results demonstrate lack of awareness or understanding of Project offerings, outreach and engagement tools will be revisited to re-focus communications efforts.
Customer Energy Portal Engagement	Measure: Determine customer portal engagement levels. How and When: Tracked monthly throughout Project. Resources: Engagement vendor Expected Target: • Number of customer portal users • Login rates (total by month) • Web logins (all transactions by customers) • Top 5 visited site selections (by calendar month) • Customer enrollment in Points and Rewards campaign • Cumulative customer Points and Rewards events • Points and Rewards redemption. Solution / Strategies in case of results below expectation: National Grid and its partner will analyze portal metrics on a regular basis to identify if outreach efforts need to be redirected to increase online engagement.
Price Signals	
Peak Time Rewards:	Measure: Measure customer participation and load reduction across PTR events. How and When: After each event and end of capability period. Resources: National Grid Advanced Data Analytics and Meter Data Services Expected Target: • 40-50% participation rate per event • 0.50 kW average electric reduction per customer per event Solution / Strategies in case of results below expectation: If PTR participation rates are lower than expected, the communication strategies and reward structure will be revisited.
VTOU Rate:	Measure: Customer rate adoption and load shift. How and When: Throughout Project. Resources: National Grid Advanced Data Analytics Team and /or evaluation contractor Expected Target: • Benchmark of 6-38% adoption, with target of 24% adoption for VTOU rates. • A proxy for expected load shift is under development. Solution / Strategies in case of results below expectation: If VTOU adoption rates are lower than anticipated, communications strategies will be revisited.

DER	
DER Opportunities:	Measure: Customer adoption of DER products and services introduced through Project. How and When: Over project life. Resources: DER providers, National Grid Procurement Team Expected Target: Adoption rate specific to each DER provider. Expected DER adoption rates will be developed for individual DER offerings as they are included in the Project. Solution / Strategies in case of results below expectation: Revisit DER engagement strategy.
DER Related Revenue Streams	Measure: How many DER providers willing to share DER revenues. How and When: Over Project life. Resources: DER product and service providers, National Grid Procurement Expected Target: Potential revenues from DER providers will be determined based on individual DER offerings and providers, and National Grid's ability to provide leads within customer data sharing regulations. Solution / Strategies in case of results below expectation: Recruit additional DER providers based on customer interest solicited through customer surveys. Revisit revenue stream structure.
CCA	
CCA Test	Measure: If the Town pursues CCA, National Grid will use Project-specific outreach and education channels to support customer engagement in CCA. These channels include Project-specific web, customer portal banner space, HERs, and Project-specific mailings. How and When: At CCA initiation and during CCA opt-out period, using Project channels. Resources: Town leadership and National Grid. Expected Target: Three of four Project outreach channels. Solution / Strategies in case of results below expectation: If the Town CCA opt-out rate is higher than the Town expects, National Grid will work with the Town to supplement their outreach efforts.

Conditions and Barriers

Consumer Protections

Residential customers participating in the Project will continue to be protected under the Home Energy Fair Practices Act ("HEFPA") which includes provisions addressing termination of service for non-payment, offers of deferred payment agreements to customers in arrears, and a host of other consumer protections.

Staff's Assessment report addressed the sharing of customer data with third parties. National Grid will limit sharing of customer data in accordance with Company policy[17] and the proposed "Aggregated Data Privacy Policy Statement of National Grid" filed with the Commission on November 1, 2016 in accordance with the Track Two Order.[18] Based on Staff's direction, National Grid will not be required to seek a waiver for sharing confidential customer data with Project partners working on behalf of the Company to provide analytics associated with the Project.

Channel or Market Challenges

This Project is designed to bring a multitude of options and solutions to residents of Clifton Park to reduce participants' demand. National Grid is moving forward in a purposeful manner so as to not overwhelm customers with information and communications. Monitoring the tone and frequency of communications, while also making them relevant and actionable, should help to minimize the number of customers choosing to opt out. National Grid intends to monitor the opt-out rate closely to ensure that key information such as usage alerts, price signals, and opportunities to earn rewards continue to be accessible to the majority of participants.

PROJECT STRUCTURE AND GOVERNANCE

Project Team

Executive Sponsorship

National Grid has assigned an executive sponsor for each of its REV Demonstration Projects, recognizing that active sponsorship is a critical success factor for successful project management. Executive sponsor responsibilities include:

- Accountability for the ultimate success of the project;
- Vision and leadership throughout the project;
- Time commitment and active engagement throughout the project, and
- Addresses conflicts and ensures senior stakeholders are engaged and supportive.

Core Project Team

- Philip Austen, Director Solutions Delivery - Executive Sponsor
  (Tel.: 516-545-4753/ Email: pausten@nationalgrid.com)
- Melissa Piper, Solutions Delivery - Project Manager
  (Tel.: 315-428-5002/ Email: Melissa.Piper@nationalgrid.com)
- Ara Tadevossian, Information Solutions – Project Manager
- (Tel.: 315-428-6695/ Email: Ara.Tadevossian@nationalgrid.com)

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[17] National Grid Group Information Security Management, Data Privacy Policy, Global Information Security Policy, Issue 2.4.

[18] REV Proceeding, *supra* note 3, p. 157.

- John Spring, Partnerships and Joint Ventures
- (Tel.: 781-907-3694/ Email: John.Spring@nationalgrid.com)
- Paul Wassink, Customer Solutions
- (Tel.: 781-907-2681/ Email: Paul.Wassink@nationalgrid.com)
- Kara Fedors, Solutions Delivery
- (Tel.: 781-907-2244/ Email: Kara.Fedors@nationalgrid.com)

Internal Stakeholders

There are various departments within National Grid that are critical to the delivery of this Project. They include:

- Bill Project Management and Services
- Communications and Marketing
- Community and Customer Management
- I/S Relationship Network Strategy
- Legal and Regulatory
- Load Research and Analysis
- Meter Data Services
- Electric Pricing
- Strategic Communications
- Advanced Data and Analytics

Roles and Responsibilities

See Table 11, Roles and Responsibilities, below, for key Project responsibilities. Note that the roles and responsibilities in this document focus on the Project, and do not fully detail related activities.

Table 11: Roles and Responsibilities

National Grid Role / Responsibility	**Description**
Support conceptual design and lead detailed program implementation	Provide necessary data, and expertise for the Project design work
Engage community stakeholders	Gather qualitative data and interview stakeholders regarding expectations for various parts of the Project
Deploy advanced infrastructure	Work with stakeholders to obtain necessary approvals and implement infrastructure deployment
Manage and coordinate vendors and partners	Manage and coordinate third parties implementing various aspects of the Project
Deploy VTOU rate	Provide customers with educational information surrounding the VTOU rate
Secure waiver from VTOU tariff by filing a petition for Commission approval	Prepare and file petition for tariff waiver
Town of Clifton Park Role / Responsibility	**Description**
Feedback on Project plan	Evaluate National Grid Project plan
Represent residential community at-large	Represent residential constituency and serve as customer advocate for various Project components
Evaluate feasibility of pursuing a CCA	Decide if a CCA model is beneficial to the Town

Department of Public Service Staff, Public Service Commission Role / Responsibility	**Description**
Provide feedback on quarterly reports for Project	Review progress against Project objectives and recommend any corrective actions
Approve National Grid infrastructure proposals	Review infrastructure proposals and provide necessary approvals following appropriate review and oversight
Provide feedback to National Grid on rate plans	Review and provide recommendations on alternative rate plans that are aligned with PSC goals and provide customer value
Act on National Grid's petition for VTOU tariff waiver	Approve tariff waiver

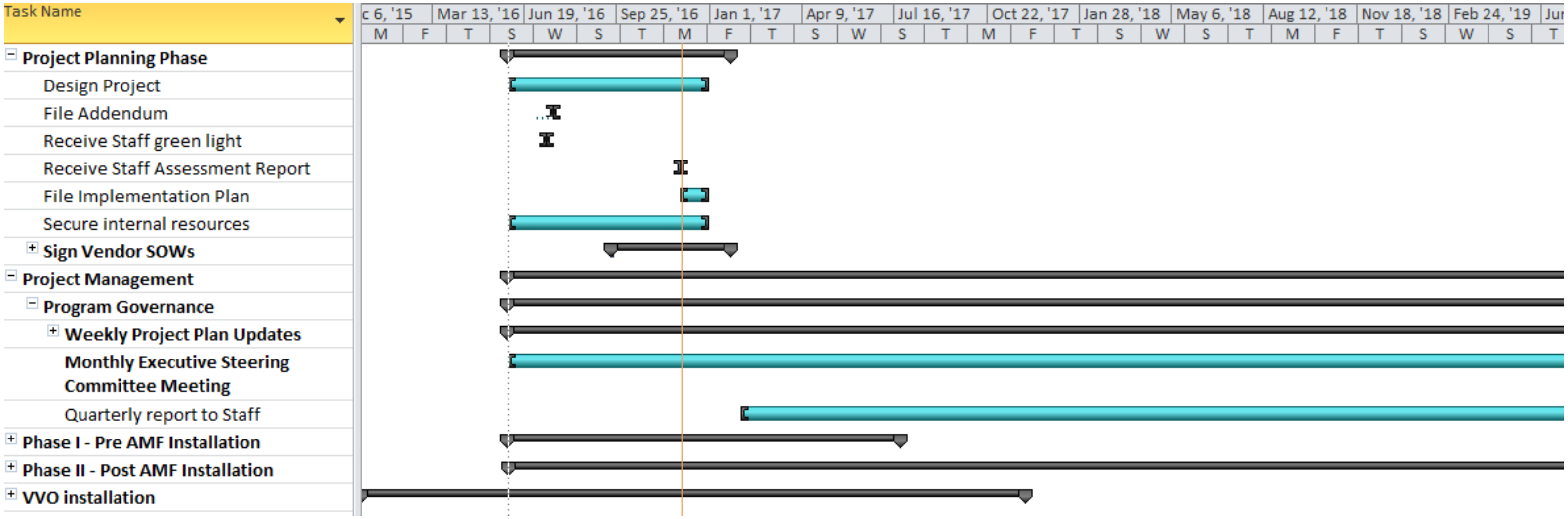
Governance

Project governance will include the Core Project Team (as set forth above) and will consist of monthly conference calls and in-person meetings at milestone points to report on Project schedule, identified risks, Project status, and the projected costs and benefits of services under development.

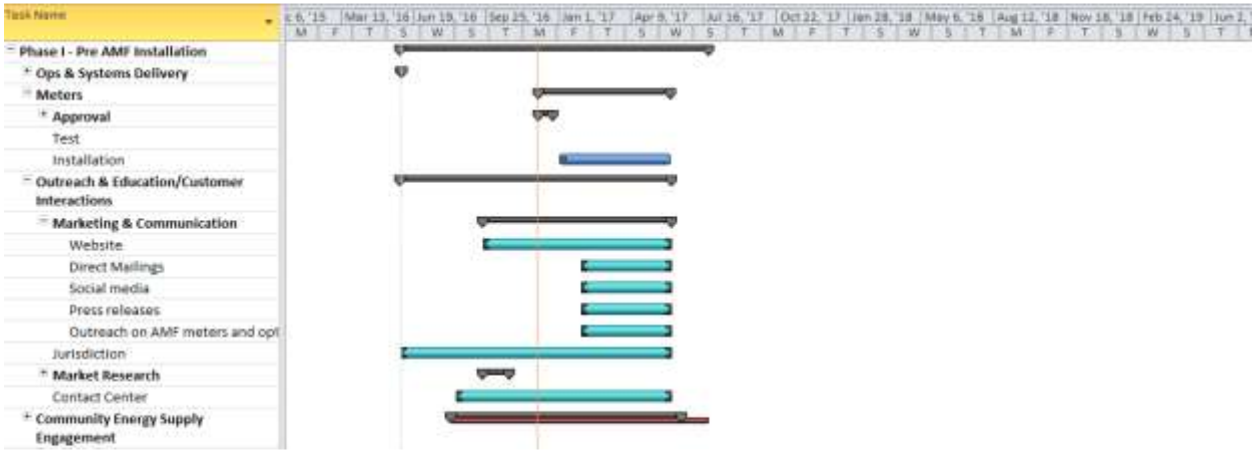
WORK PLAN

See Figure 16, Project Timeline and Milestones, below, for an overview of the Project work plan.

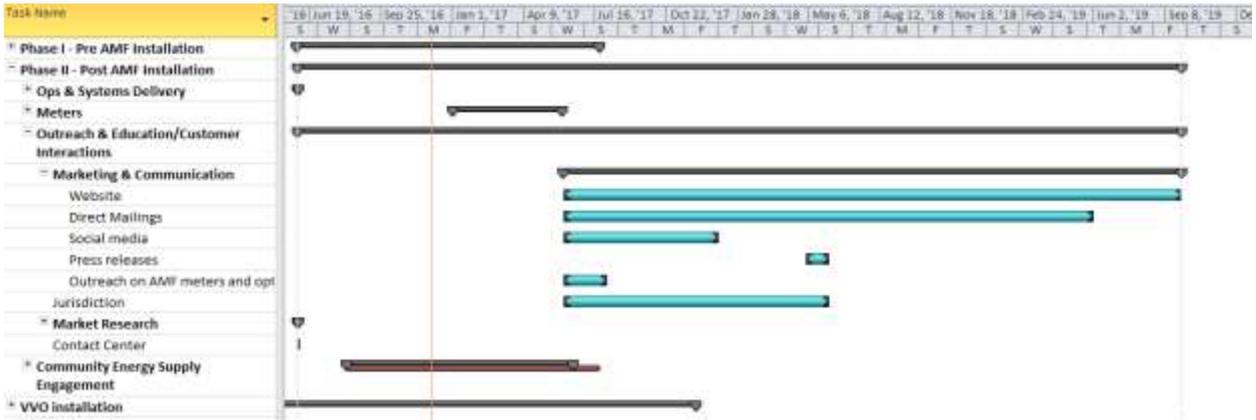
Figure 16: High Level Project Plan



Phase I: Pre-AMF Installations



Phase II: Post-AMF Installations



Phase I - Pre AMF Installation
Phase II - Post AMF Installation
  Ops & Systems Delivery
  Meters
  Outreach & Education/Customer Interactions
    Marketing & Communication
      Website
      Direct Mailings
      Social media
      Press releases
      Outreach on AMF meters and opt
    Jurisdiction
    Market Research
    Contact Center
  Community Energy Supply Engagement
VVO installation

PROJECT BUDGET

Summarized below in Table 13 is the Preliminary Budget with estimated costs for the first three years of the Project.

Table 13: Three-Year Preliminary Budget

Expense Type	**Year 1**	**Year 2**	**Year 3**
Capital	$9,059,785	$1,393,391	$0
O&M	$7,515,597	$4,628,086	$4,222,477
Total	$16,575,382	$6,021,477	$4,222,477

National Grid has held discussions to determine levels of interest in a revenue-sharing model for lead generation for DER services. National Grid will continue to work with Staff to determine the potential for a revenue-sharing model for DER services adopted by residents, recognizing that express consent from customers is necessary in order to market potential leads to DER service providers.

National Grid will only share data with partners or vendors if the act of sharing the data complies with Company policy and New York State rules and regulations governing the sharing of confidential personal information, unless the customer provides express consent to share such information.

REPORTING STRUCTURE

Quarterly progress reports will be provided to Staff. These reports will include an overview of project progress against timeline/plan and results as they become available. The quarterly report template is provided below in Figure 17, Quarterly Report Template, and will continue to be refined as the Project progresses.

Figure 17: Quarterly Report Template

QUARTERLY REPORTING TEMPLATE

Milestones
Last Project Milestone:
Next Project Milestone:

Tasks/Timeline
Completed Project Tasks Since Last Report:
Changes or Impacts to Schedule since Last Report:
Lessons Learned:
Work Stream Coordination:

Risks
Identified Risks:
Risk Mitigation Plan:

Finance
Total Incremental Spend to Date:
Target Incremental Spend:
Actual Incremental Spend:
Incremental Spend Variance:
Non-Incremental Spend:
In-kind and grant support (specifically for REV Demo):

Additional Notes:

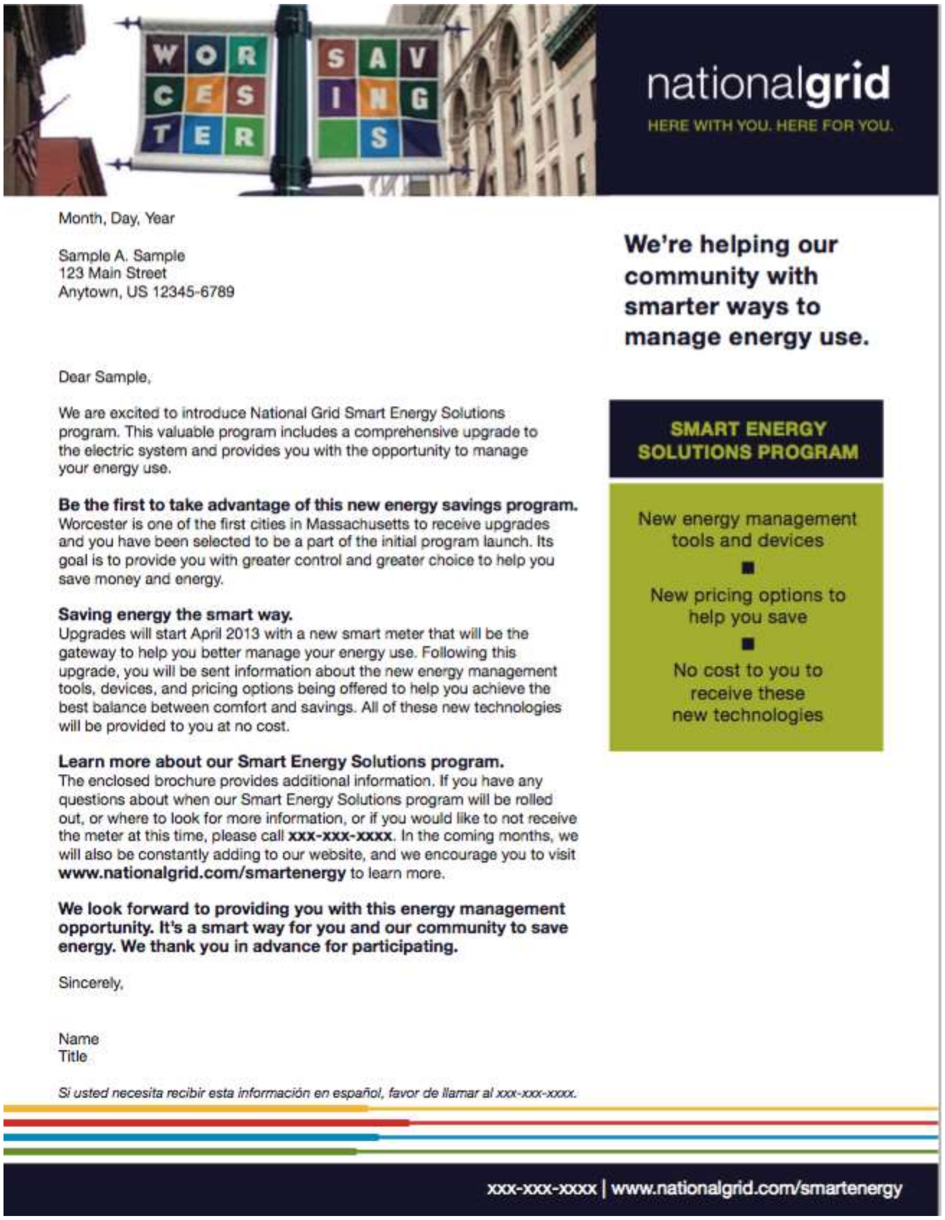
Appendix A – REV Alignment

REV Objective	Demonstration Alignment
Enhance customer knowledge and tools that will support effective management of the total energy bill	The Project leverages the capabilities of interval metering technologies on cellular networks to generate near real-time information on customers' electric and gas usage.
	This information will be shared via an interactive, customer-friendly portal as well as direct communications and alerts that educate and engage customers with actionable information that they can use to reduce their electric and gas energy use.
Market animation; leverage customer contributions	The Project animates the market by leveraging partnerships with DER providers in efforts to achieve wider deployment of DER.
	Additional energy industry-related services are animated by the Project, including technology and platform developers and providers delivering actionable information.
System wide efficiency	Through Peak Time Rewards, the Project tests the potential for mass-market participation in electric distribution system management opportunities.
	Participants in the Project will receive AMF meters and all customers in Clifton Park will benefit from VVO installation to further improve overall electric system efficiency.

System reliability and resiliency	The Project provides opportunities to manage the electric distribution system with aggregated mass-market demand-response and VVO.
Reduction of carbon emissions	The Project supports Clean Energy Standard goals of carbon emission reductions through reduced energy consumption.
Partnerships with third-party service providers	The Project has multiple, market-animating partnerships with DER, technology, and platform providers. It is designed to promote DER adoption.

Appendix B – Outreach and Engagement

Sample Smart Energy Introduction Letter to Customers



nationalgrid
HERE WITH YOU. HERE FOR YOU.

Month, Day, Year

Sample A. Sample
123 Main Street
Anytown, US 12345-6789

We're helping our community with smarter ways to manage energy use.

SMART ENERGY SOLUTIONS PROGRAM

New energy management tools and devices
■
New pricing options to help you save
■
No cost to you to receive these new technologies

Dear Sample,

We are excited to introduce National Grid Smart Energy Solutions program. This valuable program includes a comprehensive upgrade to the electric system and provides you with the opportunity to manage your energy use.

Be the first to take advantage of this new energy savings program.
Worcester is one of the first cities in Massachusetts to receive upgrades and you have been selected to be a part of the initial program launch. Its goal is to provide you with greater control and greater choice to help you save money and energy.

Saving energy the smart way.
Upgrades will start April 2013 with a new smart meter that will be the gateway to help you better manage your energy use. Following this upgrade, you will be sent information about the new energy management tools, devices, and pricing options being offered to help you achieve the best balance between comfort and savings. All of these new technologies will be provided to you at no cost.

Learn more about our Smart Energy Solutions program.
The enclosed brochure provides additional information. If you have any questions about when our Smart Energy Solutions program will be rolled out, or where to look for more information, or if you would like to not receive the meter at this time, please call **xxx-xxx-xxxx**. In the coming months, we will also be constantly adding to our website, and we encourage you to visit **www.nationalgrid.com/smartenergy** to learn more.

We look forward to providing you with this energy management opportunity. It's a smart way for you and our community to save energy. We thank you in advance for participating.

Sincerely,

Name
Title

Si usted necesita recibir esta información en español, favor de llamar al xxx-xxx-xxxx.

xxx-xxx-xxxx | www.nationalgrid.com/smartenergy

Sample Bill Insert from National Grid's Worcester Smart Grid Pilot

nationalgrid
HERE WITH YOU. HERE FOR YOU.

maximize your energy savings

Save energy and money with our Smart Energy Solutions!
www.nationalgrid.com/smartenergy

nationalgrid
HERE WITH YOU. HERE FOR YOU.

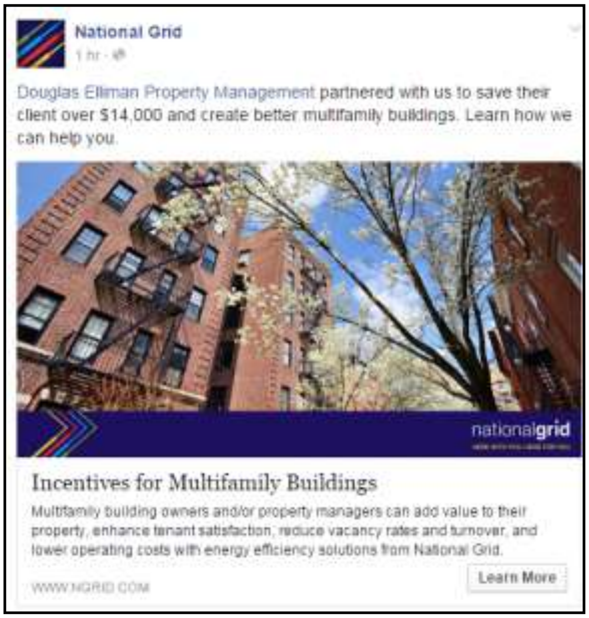
New pricing plans coming in June

Choose a pricing plan that works for you! Now save even more through our Smart Energy Solutions Program.

Learn more at **www.nationalgrid.com/smartenergy** or call **1-855-377-SMART** (**1-855-377-7627**).

EE5707 (5/14)

Sample National Grid Social Media Messages



National Grid
1 hr ·

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Incentives for Multifamily Buildings

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Date of Request: June 30, 2017
Due Date: July 10, 2017

Request No. DPS-469 MSZ-14
NMPC Req. No. NM-1046

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID
Case No. 17-E-0238 and 17-G-0239 –
Niagara Mohawk Power Corporation d/b/a National Grid – Electric and Gas Rates

Request for Information

FROM: DPS Staff, Mary Ann Sorrentino/Andrew Owens/Chris Graves

TO: National Grid, Advanced Metering Infrastructure Panel

SUBJECT: **ADVANCED METERING INFRASTRUCTURE**

Request:

In these interrogatories, all requests for data, workpapers, or supporting calculations should be construed as requesting any Word, Excel, or other computer spreadsheet models in original electronic format with all formulae intact.

With reference to Exhibit__(AMI-2), the Updated AMI Business case and BCA:

a. The business plan indicates that the AMI head-end and Meter Data Management (MDM) systems are assumed to be provided under a Software as a Service (SaaS) arrangement. Provide all internal documents regarding this business decision.

b. Provide estimates for the capital, OpEx associated with capital, and run-the-business cost of AMI assuming National Grid were not to enter into a SaaS agreement for the AMI head-end and MDM systems.

c. Provide the contract National Grid will use to procure the AMI head-end and MDM systems under SaaS.

d. Does the SaaS model limit the Company's access to data generated by the AMI system that is outside the scope of the contract?

e. Explain how the costs associated with AMI head-end and MDM systems under SaaS were determined and incorporated into the BCA.

f. Explain how National Grid will ensure that customer data is properly protected assuming AMI head-end and MDM systems are provided under SaaS.

<u>Response</u>:

a. There are no internal documents aside from the Updated AMI Business Case and BCA provided in Exhibit ___ (AMI-2). The Company's decision to base its cost estimates on use of Software as a Service ("SaaS") for the AMI head-end and Meter Data Management systems in the AMI Business Case was based on a number of considerations. Use of SaaS Cloud solutions will provide several benefits including faster implementation and enhancement adoption, fewer upgrades to legacy infrastructure, easier upgrades when needed, reduced risk of obsolescence in the future, and the opportunity to enhance security. SaaS also provides strategic advantages by facilitating external interfaces with third party partners and can be more easily scaled for additional capacity when required to enable growth.

b. The Company has not prepared a comparable estimate of the costs of a premise-based solution as part of the AMI Business Case. As described in the AMI Panel's testimony on pages 19-21, the Company is proposing a phased AMI implementation over a five-and-a-half year period. Phase 1 includes 18-months of detailed design, procurement, and back-office systems installation. During this phase (mid fiscal year 2019 through fiscal year 2020), the Company plans to issue requests for proposals and engage in competitive and strategic negotiations with vendors to evaluate a premise-based versus SaaS solution to obtain the best value for customers.

c. The Company has not yet entered into a contract to procure the AMI head-end and MDM systems under SaaS. As described in the response to part b. above, the Company plans to issue requests for proposals and engage in competitive and strategic negotiations with vendors to obtain the best value for customers during Phase 1 of the AMI implementation plan.

d. As noted in response to question c. above, the Company does not have a contract with an external vendor at this time. However, as part of the procurement process during Phase 1 the Company plans to develop contract terms that provide access to all data generated by the AMI system.

e. The costs associated with AMI head-end and MDM systems under a SaaS arrangement were estimated based on vendor supplied information and discussion. The vendor information was provided in the Company's response to DPS-059 (CG-1) as source document NG AMF ID 1070 of Attachment 7 (Confidential).

The SaaS costs included in the BCA model were provided in the Company's response to DPS-059 (CG-1) Attachment 2 (Confidential) as line items 502, 518, 519, 520, 521, 527, and 528. These line items are described in the BCA handbook that was provided as Attachment 3 (Redacted) to DPS-059 (CG-1).

f. A SaaS solution will be subject to the same security controls as a premise-based solution. Such controls were outlined in the Company's previous response to question 11 of DPS-406 (WEL-7).

Name of Respondent:	Date of Reply:
John Leana Aman Aneja John Plessas	July 10, 2017

Date of Request: June 30, 2017
Due Date: July 10, 2017

Request No. DPS-470 MSZ-15
NMPC Req. No. NM-1047

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID
Case No. 17-E-0238 and 17-G-0239 –
Niagara Mohawk Power Corporation d/b/a National Grid – Electric and Gas Rates

Request for Information

FROM: DPS Staff, Mary Ann Sorrentino/Andrew Owens/Chris Graves

TO: National Grid, Advanced Metering Infrastructure Panel

SUBJECT: **ADVANCED METERING INFRASTRUCTURE**

Request:

In these interrogatories, all requests for data, workpapers, or supporting calculations should be construed as requesting any Word, Excel, or other computer spreadsheet models in original electronic format with all formulae intact.

With reference to the Exhibit AMI-2, the Updated AMI Business case and BCA:

a. Provide the supporting documentation used to determine the 0.75% of incremental voltage reduction savings anticipated from AMI deployment. The EPRI "Losses in New York State" (NG AMF ID 1009), and the NG AMF ID 1045 work papers provided in response to DPS-59, do not contain the percentage improvement used in the model.

b. Provide any studies from the National Grid Smart Energy Solutions Pilot that demonstrate the Company's ability to achieve savings through smart grid solutions.

Response:

a. The Company proposed the deployment of VVO/CVR technologies on targeted feeders utilizing primary voltage monitoring as part of its capital investment plan as discussed in the Electric Infrastructure and Operations Panel's testimony. The deployment of AMI will enable the VVO/CVR control schemes to further optimize the voltage regulation along the feeder by providing additional voltage monitoring at the secondary level at key "bell weather" locations. The incremental 0.75% improvement is based on an estimate provided by a vendor that the Company and its affiliates have worked with on recent VVO/CVR projects. This estimate is included on page 4/6 of NG AMF ID 1045, where the vendor cites incremental savings of .5% – 1%. The Company used the midpoint of this range for its estimate. However, it appears that when this source file was submitted as part of DPS-059 (CG-1), the Company inadvertently truncated the last three pages of the email chain. Accordingly, the entirety of the source file has been included as Attachment 1 to this request.

b. As part of the Smart Energy Solutions Pilot, the Company did not deploy the centralized VVO/CVR control scheme currently proposed for Niagara Mohawk, nor did it incorporate AMI information for voltage management. Accordingly, the Company does not have any such studies.

Name of Respondent:	Date of Reply:
John Leana Rob Sheridan	July 10, 2017

Tencer, Brooke

From: Dicker, Andrew
Sent: Thursday, January 19, 2017 4:27 PM
To: Tencer, Brooke
Subject: FW: EXT || RE: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

PDF to 1045 please…

Andrew Dicker
Senior Manager | Utilities - Accenture Smart Grid Services
201 S College St #1900 | Charlotte, NC 28244
Mobile: (973) 919-7811
email: andrew.dicker@accenture.com

From: Perkinson, James [mailto:James.Perkinson@nationalgrid.com]
Sent: Thursday, January 19, 2017 3:17 PM
To: Dicker, Andrew <andrew.dicker@accenture.com>; Westfall, Jonathan <Jonathan.Westfall@nationalgrid.com>
Cc: Leana, John <John.Leana@nationalgrid.com>; Haritos-Buck, Michele <Michele.Haritos-buck@nationalgrid.com>; Horning, Steven R. <Steven.Horning@nationalgrid.com>; Gilbert, William G. <William.Gilbert2@nationalgrid.com>; Sheridan, Robert D. <Robert.Sheridan@nationalgrid.com>
Subject: RE: EXT | | RE: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

At the end of FY22, there would be 37 substations, 100 feeders, 160,249 customers, with a 3% demand reduction on all 560.78MVA (16.82MVA), and 3% energy reduction on 1850426MWhrs (55512.75Mwhrs). keep in mind that you would not see the benefit on the year that I have listed it (the year installed) but each following year.

From: andrew.dicker@accenture.com [andrew.dicker@accenture.com]
Sent: Thursday, January 19, 2017 3:06 PM
To: Perkinson, James; Westfall, Jonathan
Cc: Leana, John; Haritos-Buck, Michele; Horning, Steven R.; Gilbert, William G.; Sheridan, Robert D.
Subject: RE: EXT || RE: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

Thanks Jim –

Main question we have: For the data shown below, is each row additive or cumulative? In other words, if additive, then the cumulative total at end of FY 22 would be 37 substations,100 feeders impacting 160k customers.

Andrew

Andrew Dicker
Senior Manager | Utilities - Accenture Smart Grid Services
201 S College St #1900 | Charlotte, NC 28244
Mobile: (973) 919-7811
email: andrew.dicker@accenture.com

From: Perkinson, James [mailto:James.Perkinson@nationalgrid.com]
Sent: Thursday, January 19, 2017 1:50 PM
To: Dicker, Andrew <andrew.dicker@accenture.com>; Westfall, Jonathan <Jonathan.Westfall@nationalgrid.com>
Cc: Leana, John <John.Leana@nationalgrid.com>; Haritos-Buck, Michele <Michele.Haritos-buck@nationalgrid.com>; Horning, Steven R. <Steven.Horning@nationalgrid.com>; Gilbert, William G. <William.Gilbert2@nationalgrid.com>; Sheridan, Robert D. <Robert.Sheridan@nationalgrid.com>
Subject: RE: EXT || RE: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

Hi Andrew:

The current 5 year plan has the following costs/scope/benefits associated with it. This is the most detailed scope we currently have outlined. From here, we can project out the next 10 years. Note that the last column is a savings per year for that years scope. To find total yearly gains, you need to add all previous entries in that column.

	CAPEX VVO	OPEX VVO	COR VVO	# of substations	# of feeders	# of customers	MVA	MWh
FY19	$ 2,549,000	$ 519,600	$ 104,900	6	10	19610	58.57	193250
FY20	$ 5,169,000	$ 1,034,600	$ 199,200	9	25	33863	141.34	466360
FY21	$ 7,266,200	$ 1,793,700	$ 292,900	10	29	53107	171.41	565650
FY22	$ 8,371,700	$ 1,646,800	$ 352,900	12	36	53669	189.46	625165

Beyond year 6, assuming we keep this pace, we could estimate the following:

	CAPEX VVO	OPEX VVO	COR VVO	# of substations	# of feeders	# of customers	MVA	MWh
FY23- FY38	$8.0M	$1.5M	$ 0.3M	10	30	53k	175	565,000

This would assume no aggressive expansion due to an ADMS deployment.

From: andrew.dicker@accenture.com [mailto:andrew.dicker@accenture.com]
Sent: Thursday, January 19, 2017 10:49 AM
To: Perkinson, James; Westfall, Jonathan
Cc: Leana, John; Haritos-Buck, Michele; Horning, Steven R.; Gilbert, William G.
Subject: EXT || RE: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

Hi Jim –

Any updates on this? We need this information to support an executive readout on Monday and would appreciate this information by end of day today so we can incorporate into our model.

Two main data points are:

1. What is the expected MWh reduction associated with NY CVR deployment (ideally by year thru 2037)?
2. What is the average percentage reduction this represents for impacted circuits (eg 1MWh reduction could be 1% reduction in territory with 100MWh or 3% reduction in territory with 33MWh)?

Thanks,

Andrew

Andrew Dicker
Senior Manager | Utilities - Accenture Smart Grid Services
201 S College St #1900 | Charlotte, NC 28244
Mobile: (973) 919-7811
email: andrew.dicker@accenture.com

From: Perkinson, James [mailto:James.Perkinson@nationalgrid.com]
Sent: Tuesday, January 17, 2017 10:59 AM
To: Westfall, Jonathan <Jonathan.Westfall@nationalgrid.com>
Cc: Leana, John <John.Leana@nationalgrid.com>; Dicker, Andrew <andrew.dicker@accenture.com>; Haritos-Buck, Michele <Michele.Haritos-buck@nationalgrid.com>; Horning, Steven R. <Steven.Horning@nationalgrid.com>; Gilbert, William G. <William.Gilbert2@nationalgrid.com>
Subject: RE: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

Hi John-

Yes, I am still trying to get that information from the data. Hope to have something for you tomorrow.

From: Westfall, Jonathan
Sent: Tuesday, January 17, 2017 10:58 AM
To: Perkinson, James
Cc: Leana, John; andrew.dicker@accenture.com; Haritos-Buck, Michele; Horning, Steven R.; Gilbert, William G.
Subject: RE: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

Hi Jim –

Following up on our CVR conversation from 1/10/17…

Were you still looking to provide a forecast of the amount of the system that would have CVR deployment over time?

Thanks,
Jon

From: Perkinson, James
Sent: Tuesday, January 10, 2017 4:48 PM
To: Sheridan, Robert D.
Cc: Westfall, Jonathan; Leana, John; Haritos-Buck, Michele; Horning, Steven R.; Gilbert, William G.; andrew.dicker@accenture.com; brooke.tencer@accenture.com
Subject: RE: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

yes

From: Sheridan, Robert D.
Sent: Tuesday, January 10, 2017 4:45 PM
To: Perkinson, James
Cc: Westfall, Jonathan; Leana, John; Haritos-Buck, Michele; Horning, Steven R.; Gilbert, William G.; andrew.dicker@accenture.com; brooke.tencer@accenture.com
Subject: Re: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)

That additive correct? Meaning 3% goes to 3.5 or 4% correct??

In other words a meaningful improvement???

Sent from my iPhone

On Jan 10, 2017, at 4:35 PM, Perkinson, James <James.Perkinson@nationalgrid.com> wrote:

Utilidata's response:

From: William Pratt [wpratt@utilidata.com]
Sent: Tuesday, January 10, 2017 4:34 PM
To: Perkinson, James
Subject: EXT || RE: AMi Incremental benefit

.5% to 1.0% is what we project

From: Perkinson, James [mailto:James.Perkinson@nationalgrid.com]
Sent: Tuesday, January 10, 2017 4:27 PM
To: William Pratt <wpratt@utilidata.com>
Subject: AMi Incremental benefit

Hi Bill-

What is Utilidata's position on how much incremental savings could be gained by introducing AMI data to the system?

Thanks
-Jim P.

From: Westfall, Jonathan
Sent: Sunday, January 08, 2017 6:20 AM
Required: Westfall, Jonathan; Perkinson, James; Sheridan, Robert D.; Leana, John; Haritos-Buck, Michele; Horning, Steven R.; Gilbert, William G.; andrew.dicker@accenture.com; brooke.tencer@accenture.com
Subject: FW: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)
When: Tuesday, January 10, 2017 4:00 PM-5:00 PM.
Where: A163 & Remote Instructions Below

This meeting is trying to capture any benefits of AMI for CVR in NY. Your insight would be appreciated if you are available.

Thanks
Rob

-----Original Appointment-----
From: Westfall, Jonathan
Sent: Tuesday, January 03, 2017 4:53 PM
To: Westfall, Jonathan; Sheridan, Robert D.; Leana, John; Haritos-Buck, Michele; Horning, Steven R.; Gilbert, William G.; andrew.dicker@accenture.com; brooke.tencer@accenture.com
Subject: Conservation Voltage Reduction (CVR) and Benefits Cost Analayis (BCA)
When: Tuesday, January 10, 2017 4:00 PM-5:00 PM (UTC-05:00) Eastern Time (US & Canada).
Where: A163 & Remote Instructions Below

Updating to include handbook in the event we want to reference Item 14 (see page 71 of 107):

Purpose of Meeting:
To discuss CVR in the context of marginal benefits that could be provided

Dial-In Information:
Conference Call #: 866-844-9417
Participant Code: 4471007878
Leader Code: 6421693553

Live Meeting Links:
Attendee Link:
https://www.livemeeting.com/cc/ngt/join?id=C752J4&role=attend&pw=pG5%22D%3Fh
Presenter Link:
https://www.livemeeting.com/cc/ngt/join?id=C752J4&role=present&pw=tP9@XRK

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Date of Request: July 12, 2017 Request No. DPS-575 CK-23
Due Date: July 24, 2017 NMPC Req. No. NM-1161

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID
Case No. 17-E-0238 and 17-G-0239 –
Niagara Mohawk Power Corporation d/b/a National Grid – Electric and Gas Rates

Request for Information

FROM: DPS Staff, Chelsea Kruger and Monica Ferreri

TO: National Grid, Advanced Metering Infrastructure Panel

SUBJECT: **AMI CUSTOMER ENGAGEMENT METRICS**

Request:

In these interrogatories, all requests for data, work papers or supporting calculations should be construed as requesting any Word, Excel, or other computer spreadsheet models in original electronic format with all formulae intact.

1. The following questions refer to Pages 28-29 of the Panel's Pre-Filed Direct Testimony:

a. Explain in detail how the Company developed the metrics outlined on Page 28.

b. Explain in detail how the Company anticipates measuring and tracking the following metrics:
i. AMI Program Progress; and
ii. Customer Engagement.

c. Were the AMI Program Progress, Customer Engagement, and AMI Customer Survey metrics tracked during National Grid's Worcester, Massachusetts, SmartGrid Pilot Project? If so, provide monthly results for each year of the project. If not, explain why not.

d. Is the Company tracking these three metrics in Niagara Mohawk's Clifton Park demonstration project? If not, explain why not.

2. The following questions pertain to the proposed AMI Customer Survey Measure:

a. Does the Company plan to collaborate with Staff and other interested parties to develop the survey?

b. How does this Customer Survey Measure differ from the Customer Engagement Survey proposed as part of the Customer Engagement Earnings Adjustment Mechanism?

c. Will the Company conduct this survey? If not, provide the third party that will develop and/or conduct the survey.

d. How will this survey be conducted (e.g., telephone, e-mail, mail, social media)? Identify all applicable channels and explain why the Company chose this survey method.

3. With regard to the proposed AMI Customer Engagement Measure, how will the Company avoid double-counting customers? Include in your response all appropriate measures the Company will take to avoid such double-counts.

Response:

1a. The three metric areas, Program Progress Measure, Customer Survey Measure and Customer Engagement Measure, are consistent with the measurement approach the Company implemented in the Worcester, Massachusetts Smart Grid Pilot and is starting to implement for the Clifton Park Demand Reduction REV Demonstration project. Customer survey and engagement measures for both of these projects were provided in the Company's response to DPS-450 (CK-12).

1b. During Phase 1 of the AMI implementation, as described in the AMI Panel's testimony on pages 19 – 21, the Company will develop the detailed measurement program for these metrics. In so doing, the Company will utilize its experience with the metrics from the Worcester, Massachusetts Smart Grid Pilot and the Clifton Park Demand Reduction REV Demonstration project.

1c. Yes. The results for the AMI Program Progress Measure are included in Attachments 1-8. The results for the Customer Engagement and Customer Survey Measures were provided in the Company's response to DPS-450 (CK-12).

1d. Yes.

2a. Yes. During Phase 1 of the project the Company plans to collaborate with Staff and interested parties in the development of a detailed customer engagement plan including the Customer Survey Measure.

2b. The proposed AMI Customer Survey Measure will measure customer satisfaction with the AMI meter installation process and customer education and awareness of AMI benefits. The Customer Engagement Survey metric proposed as part of the Customer Engagement Earnings Adjustment Mechanism ("EAM") will measure customer satisfaction with the E-Commerce Platform and Residential Solar Marketplace through a survey of customers who make purchases through either platform.

2c. The Company will contract with a third party to conduct the customer survey. The third party will be retained during Phase 1 of AMI implementation.

2d. The Company will seek to offer this survey to customers in multiple formats to best attain a high volume of completions. A web-based survey is most valuable due to a streamlined and easy customer experience, as well as a low delivery cost. Furthermore, the Company can promote a web-based survey with a simple website link through multiple digital channels, including directs emails to customers and social media.

The Company will also seek to conduct outbound phone calls to obtain feedback from customers who may prefer to answer questions over the phone, may not have an email address, and who may have limited access to a computer and/or the internet that would be required to complete the survey online.

3. In reviewing progress with regards to the AMI Customer Engagement Measure, the Company will seek to avoid double counting customers by focusing primarily on the unique, not total, customer interactions with the various elements of the AMI Customer Engagement Measure, such as the Energy Management Portal and E-Commerce Platform. Focusing on unique customer interactions will eliminate the double counting of customer engagement interactions. Because each customer who visits the portal will be doing so having already logged into their online web account using a unique username and password (which requires a valid account number to create), this will generate a unique logon that can be tracked over time. Even if that same customer had logged on multiple times into a portal, that unique customer account will be counted only one time. This ensures that a clear representation of unique visitors is measured correctly as it pertains to engagement with the various portals and platforms.

In its Smart Grid pilot in Worcester, MA, the Company was able to successfully avoid double counting as it reported unique customer engagement. The Company will also avoid double counting in reporting its customer engagement metrics within its Clifton Park Demand Reduction REV Demonstration Project.

<u>Name of Respondent</u>:	<u>Date of Reply</u>:
John Leana Nick Corsetti Melissa Piper	July 24, 2017

Date of Request: July 20, 2017
Due Date: July 31, 2017

Request No. DPS-638 CLG-3
NMPC Req. No. NM-1258

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID
Case No. 17-E-0238 and 17-G-0239 –
Niagara Mohawk Power Corporation d/b/a National Grid – Electric and Gas Rates

Request for Information

FROM: DPS Staff, Christopher Graves

TO: National Grid, Advanced Metering Infrastructure Panel

SUBJECT: ***ENERGY PROFILER ONLINE***

Request:

In these interrogatories, all requests for data, workpapers or supporting calculations should be construed as requesting any Word, Excel, or other computer spreadsheet models in original electronic format with all formulae intact.

At the June 27, 2017 AMI Technical Conference, NMPC explained that the Energy Management Portal would replace Energy Profiler Online. Regarding this change:

1. How many NMPC customers are currently using Energy Profiler Online?

2. What do NMPC customers currently pay to access Energy Profiler Online?

3. Does the Company plan to add any features to Energy Manager Portal for large C&I customers that they do not currently have with Energy Profiler Online? Explain your response in detail.

4. Does the Company plan to remove any features of Energy Profiler Online from the large C&I customers' version of Energy Manager Portal? Explain your response in detail.

5. Has NMPC talked with Energy Profiler Online customers to determine what features they would like to see in the Energy Manager Portal?

Response:

1. 113 customers covering 140 accounts.

2. NMPC customers are charged $600 per account assessed on an annual basis for Energy Profiler Online.

3. The Company is not planning to add additional features to the Energy Management Portal for large C&I customers beyond what is currently provided within Energy Profiler Online (EPO). It is important to note that EPO is a service purchased by the Company from a third party provider and, therefore, the Company does not have the ability to make modifications or additions to the available features. However, the provider does periodically provide updates and new functions based on feedback and developments from the utility clients who use this service.

4. The Company does not envision at this time removing any features of EPO from the large C&I customers' version of the Energy Management Portal. As discussed at the June 27, 2017 AMI technical conference, the Company, as part of its proposed AMI Program, is committed to providing all AMI customers with near real-time access to interval usage data. Currently, large C&I NMPC customers with interval meters obtain this data either via a monthly download from the Company's website or through EPO. The greatest value of access to EPO for customers is the ability to obtain interval usage data in a much quicker time frame (*i.e.*, next day) rather than waiting until the billing month interval data is available for them to download off the Company's website.

   The Company will incorporate the functionalities of EPO (*i.e.*, usage data) into its proposed Energy Management Portal as a basic service offering at no additional cost for customers. This future offering within the Energy Management Portal will be linked with Green Button functionalities, such that customers would be able to download their interval data and/or authorize the Company to share it with third party entities in a specific format.

5. During Phase I of the AMI Program, the Company will engage with C&I customers who use EPO, as well as other interested stakeholders, to identify the most important use cases and features that they would prefer to see provided within the Energy Management Portal. This will lead to a more customer-focused offering that will provide more valuable information to a greater number of customers across the entire C&I service class.

Name of Respondent:	Date of Reply:
John Leana Nick Corsetti Michele Haritos-Buck	July 31, 2017

Date of Request: July 21, 2017
Due Date: July 31, 2017

Request No. DPS-648 CLG-4
NMPC Req. No. NM-1312

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID
Case No. 17-E-0238 and 17-G-0239 –
Niagara Mohawk Power Corporation d/b/a National Grid – Electric and Gas Rates

Request for Information

FROM: DPS Staff, Christopher Graves

TO: National Grid, Advanced Metering Infrastructure Panel

SUBJECT: ***ADVANCED METER INFRASTRUCTURE***

Request:

In these interrogatories, all requests for data, workpapers or supporting calculations should be construed as requesting any Word, Excel, or other computer spreadsheet models in original electronic format with all formulae intact.

1. How would a one-year delay to the deployment schedule of the AMI Business Plan affect the project cost and benefits? Provide a breakdown of how such delay would impact the project by the cost and benefit categories.

2. When will NMPC see initial results from its Clifton Park pilot?

3. What is the capital and O&M cost to fund each of the following steps: Advanced Planning; Ramp up; Design; Preparation of Requests for Proposals for an AMI Business Plan; Procurement; and Back-office System Installation and Maintenance? For each of these steps, provide:

a. A detailed list of activities to be performed; and

b. The level of costs included in the revenue requirement for the Rate Year, Data Year 1, and Data Year 2. Indicate where these costs are detailed in the Company’s rate filing.

4. For each project contained in Exhibit__(ISP-3), provide the portion of costs (Capital, OpEx associated with Capital, and Run the Business) allocated to AMI deployment.

Response:

1. The gas ERT replacement component of the AMI deployment plan cannot be delayed a year based on the remaining battery life of the installed ERTs. Either the deployment plan would need to be accelerated after the one-year delay or gas ERT installation would need to begin in advance of electric meter installation. If the later approach is implemented, the customer convenience and installation efficiency of replacing dual fuel gas and electric customer meters and ERTs at the same time that is built into the AMI Business Case would be impacted.

   Apart from the above issue, and assuming nothing else changes, a one year delay would result in the loss of one-year of steady-state savings.

2. Initial results will be available beginning this year as meter deployment is nearly complete. The customer engagement plan and monthly metrics that will be tracked are included in the Company's response to DPS-450 (CK-12), question 2.

3.
   a. As described in the AMI Panel's testimony on pages 19 – 21, the Company is proposing as Phase 1 of the project, an 18-month detailed design, procurement, and back-office installation phase. The elements of Phase 1 are described in the testimony, and in additional detail in Exhibit __ (AMI-2) section 3 of the AMI Business Case and BCA.

   b. Business cost estimates were not developed at an activity level but at a broader program level. The costs and their location within the case are described below.

      i. The electric and gas capital costs (excluding IS) included in the revenue requirement for Phase 1 of the AMI project are as follows:

	Rate Year	Data Year 1	Data Year 2
Electric	0	$2,736,590	0
Gas	0	$1,017,000	0

The capital costs are reflected on Exhibit (RRP-7CU), Schedule 1, Page 7 and are included in the net utility plant forecast in the revenue requirement.

      ii. The electric and gas opex costs (excluding IS) included in the revenue requirement for Phase 1 of the AMI project are as follows:

	Rate Year	Data Year 1	Data Year 2
Electric	$1,341,203	$5,790,931	0
Gas	$498,329	$2,023,072	0

The opex costs are reflected on Exhibit (RRP-3CU), Schedule 27, Page 9 and are included in the Other Initiatives forecast in the revenue requirement.

iii. IS capital related costs are included on Exhibit ___ (ISP-3). Expense costs are provided on page 9 of 10 of Exhibit __ (RRP-3). The allocation of these costs to AMI is included in response to question 4.

4.

Investment Name	INVP#	Bill Pool	% Allocated to AMI
DRMS for C&I Demand Response		5210E	-
Load and DER Forecasting (Acquisition of Remote Sensing Data - NY)	4729	C113	-
Plant Information Historian	4704K	G198	-
E-Commerce Marketplace	4704D	C113	100%
GIS Data Enhancements		5210E	-
AMI - Telecoms	4704I	5210E	26.45%
DG IOAP Tactical (Phase 2)	4704P	5210E	-
AMI - CSS Enhancements	4704A	C113	100%
Energy Monitoring Portal		5210E	100%
Green Button Connect	4704C	C113	100%
AMI - Telecoms	4704I	5210E	26.45%
Outdoor Lighting Inventory Panel	4704O	5210E	-
DRMS for C&I Demand Response (Renewal)		5210E	-
DSP - DG IOAP	4704F	5210E	-
Grid Mod - ABB/ADMS & D-SCADA	4704G	5210E	-
AMI - Telecoms	4704I	5210E	26.45%
AMI - Enterprise Service Bus & API Integration	4704J	C113	100% (30.57% of total)
AMI - Enterprise Service Bus & API Integration	4704J	5210E	-
AMI - Info Mgt & Advanced Data Analytics	4704L	C113	100% (17.28% of total)
AMI - Info Mgt & Advanced Data Analytics	4704L	5210E	-
IS - Cloud Computing & Data Lake	4704M	C113	100% (17% of total)
IS - Cloud Computing & Data Lake	4704M	5210E	-
Cyber Security	4704N	C113	100% (31.22% of total)
Cyber Security	4704N	5210E	-

Name of Respondent:	Date of Reply:
John Leana Mike Pawlowski James Molloy	July 31, 2017

Date of Request: May 23, 2017
Due Date: June 2, 2017

UIU Request No. UIU-2 KOH-89
NMPC Req. No. NM-562

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID
Case No. 17-E-0238 and 17-G-0239 –
Niagara Mohawk Power Corporation d/b/a National Grid – Electric and Gas Rates

Request for Information

FROM: Utility Intervention Unit, Kathleen O'Hare

TO: National Grid, Rate Design Panel

SUBJECT: **AMI PANEL**

Request:

Unless noted otherwise, each of the following information requests pertains to both Niagara Mohawk Power Corporation d/b/a National Grid's (Niagara Mohawk or the Company) electric and gas services. Please provide a separate answer to each such information request as it pertains to (a) electric and (b) gas.

89. The Company discusses the smart meter pilot project in Worcester, MA in the AMI Panel Testimony. What lessons learned from the smart meter project in Worcester, MA did the Company use to make their AMI proposal in this case? Please provide reports and any data the Company relied upon.

Response:

a. The Company's final evaluation report of customer activities for the Worcester Pilot (the "Pilot") is included as Attachment 1. A summary of the learnings from the Pilot is provided on pages 24 – 26 of 158 and are described in detail in section 5 of the report. From a customer engagement and stakeholder outreach perspective, the experience and learnings from the Pilot are reflected in the Company's AMI proposal in the following areas:

    i. Staged approach to customer engagement - As outlined in the AMI Panel's testimony (pages 25-27), the Company plans to implement the staged approach to customer engagement it has implemented and gained experience with in the Pilot.

    ii. Tools to support customer engagement - To support the staged engagement process mentioned above, tools that provide access to energy usage information, education materials, and product and service offerings must be fully developed at the beginning of the meter deployment phase. The Company's AMI proposal includes investments in such tools including Green Button Connect, the Energy Management Portal, and the E-Commerce Portal. These tools are scheduled to be completed prior to meter deployment so that customers can begin to immediately realize the benefits of AMI. Lessons learned including streamlined portal access, enhanced customized customer information, and bill presentment will be addressed during Phase 1.

iii. Viability of an opt-out design – The Pilot was structured as an opt-out customer program regarding both the AMI meters and a time-of-use rate with critical peak pricing. This led to strong customer participation, enrollment in smart in-home technology, high customer retention over the two years of the Pilot, and a strong customer satisfaction rate. The Company's benefit cost analysis presents both opt-in and opt-out time-variant pricing benefit scenarios.

iv. Consistent customer feedback is critical to program success – During the Pilot, the Company conducted multiple surveys and evaluations that provided customer feedback that was then integrated into program improvements. Examples include a more pronounced focus on customer flexibility and choice in how they receive alerts about critical peak periods and increased personalized information about how customers can better manage energy usage and costs. The Company's AMI proposal includes customer surveys and project management resources to elicit and address customer feedback and support continuous improvement.

From an operational perspective, the key learnings from the Pilot that have been incorporated into the AMI proposal include: (1) ensuring the communications network for all tiers is installed, tested, and enabled to provide for an efficient deployment of meters; and (2) program management to deliver and manage the enhanced solutions and technologies.

The Company's AMI proposal addresses the communications related learnings by incorporating a vendor communications support strategy. The AMI business case includes costs for a vendor installation manager with a technical team and field engineering support. These resources will oversee meter and field area network deployment. The need for program management is reflected in the AMI business case (Exhibit ___ (AMI-2), pages 8-14 of 49). The plan includes the key elements required to successfully resource and manage the AMI project.

b. Key learnings from the Pilot generally apply to gas AMI as well.

Name of Respondent: Date of Reply:
John O. Leana June 1, 2017

Exhibit__(SAMIP-1)

National Grid Smart Energy Solutions Pilot

Final Evaluation Report

Prepared for:

National Grid

Submitted by:
Navigant
1375 Walnut Street
Suite 200
Boulder, CO 80302

303.728.2500
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May 5, 2017

Prepared by:

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The following appendices are provided in a separate document:

- Appendix F – Graphs of Event Impacts by Hour for Residential Customers
- Appendix G – Graphs of Event Impacts by Hour for Commercial Customers
- Appendix H – Graphs of Event Impacts for Residential Customers by Demographic Subgroup

GLOSSARY OF KEY TERMS AND ACRONYMS

Pricing:

Critical Peak Pricing (CPP) – Referred to as Smart Rewards Pricing in National Grid's program marketing materials. In the Smart Energy Solutions program this rate structure combines a TOU rate with critical peak pricing in which customers are charged higher rates for energy during Peak Events.

Peak Time Rebate (PTR) – Referred to as Conservation Day Rebate in National Grid's program marketing materials. A rate structure in which customers are provided a credit, or rebate, for reducing their energy usage during Peak Events.

Time of Use (TOU) – A rate structure in which participants pay a predetermined tiered rate in which higher prices generally coincide with peak periods and lower prices with off-peak periods.

Customer Types:

Active Participant – An active participant is one who is deemed to have taken actions above simply being on a rate. This household or business is utilizing technology and taking actions to modify their behavior in reaction to the new rate and technology afforded by their participation in the Pilot. Specifically, for this evaluation active participants are those who have opted into a technology package above the default (e.g., opted into Levels 2, 3, or 4), or participants on the default technology package (Level 1) who have visited the WorcesterSmart web portal.

Passive Participant – A customer in the Pilot who is on the default technology package (Level 1) and has not visited the WorcesterSmart web portal.

Peak Times:

Peak Period – Weekdays from 8 a.m. to 8 p.m.

Off-Peak Period – All hours that are not defined as Peak Periods or Peak Events. Includes all weekend, evening, and holiday hours.

Conservation Day – A day on which a Peak Event is called.

Peak Event – A period of time for which critical peak pricing will be in effect. Customers are notified in advance of the specific Peak Event hours for a given Conservation Day. CPP customers are charged a higher rate during a Peak Event and PTR customers can earn a rebate for conserving during a Peak Event.

Enabling Technologies:

AMI (advanced metering infrastructure) Meter – An advanced meter, also referred to as a "smart meter", that records consumption in intervals and communicates that information via a communications network back to the utility for monitoring and billing purposes. AMI meters enable two-way communication between the meter and the central system.

Direct Load Control Device – Device that allows customers to manage large appliances, such as an electric hot water heater or pool pump, which is controlled via broadband Internet connection.

Homeview App – Also referred to as the “mobile app” or “app”. Allows customers to view their IHD remotely and access real-time energy usage and cost information. Also, allows customers to remotely monitor and control their Pilot thermostat if they have one.

In-home display (IHD) – Referred to as a digital picture frame in National Grid’s program marketing materials. An electronic graphical display device which provides information and graphics about energy usage and cost that is updated on a regular basis based on data from the utility meter. Customers may also upload their own personal photographs for display on this device.

Programmable-Controllable Thermostat (PCT) – A programmable thermostat, also referred to as a “smart thermostat”, which can also be controlled or signaled via the Home Area Network or another communications method.

Smart Plug – An intelligent 3-prong outlet that customers plug appliances into, which can also be controlled or signaled via the Home Area Network or broadband Internet connection.

WorcesterSmart Web portal – Also referred to as the “web portal”. An internet website accessible to all participants in the Pilot that enables them to see more advanced information on their energy consumption. The web portal also provides performance feedback for Pilot participants during Conservation Days.

Acronyms:
AMI: Advanced Metering Infrastructure
CAC: Central Air Conditioning
CPP: Critical Peak Pricing
DPU: Massachusetts Department of Public Utilities
DRMS: Demand Response Management System
EEAC: Energy Efficiency Advisory Council
GCA: Green Communities Act
IHD: In-Home Display
LEAN: Low-Income Energy Action Network
PCT: Programmable-Controllable Thermostat
PTR: Peak Time Rebate
SaaS: Software as a Service
TOU: Time of Use

DISCLAIMER

This report was prepared by Navigant Consulting, Inc. (Navigant) for National Grid. The work presented in this report represents Navigant's professional judgment based on the information available at the time this report was prepared. Navigant is not responsible for the reader's use of, or reliance upon, the report, nor any decisions based on the report. NAVIGANT MAKES NO REPRESENTATIONS OR WARRANTIES, EXPRESSED OR IMPLIED. Readers of the report are advised that they assume all liabilities incurred by them, or third parties, as a result of their reliance on the report, or the data, information, findings, and opinions contained in the report.

EXECUTIVE SUMMARY

Massachusetts Electric Company and Nantucket Electric Company d/b/a/ National Grid's (the Company or National Grid) Smart Energy Solutions Pilot program (the Pilot or Smart Energy Solutions) is an innovative smart grid pilot featuring deployment of a unique combination of advanced meters, customer-facing technologies, and time-of-use (TOU) rates. The informational portion of the Pilot began in 2013, rates went live in January 2015, and implementation ran through the end of 2016. National Grid filed for a two-year extension of the Pilot and the Massachusetts Department of Public Utilities (DPU) approved an interim extension that extends the Pilot until a final decision is reached in 2017. The Pilot also included advanced distribution grid-side technologies which are the subject of a separate report.[1] This evaluation, conducted by Navigant Consulting, Inc. (Navigant or the evaluation team), covers customer-side Pilot activities through the end of 2016. Navigant conducted the evaluation of the Pilot in accordance with the *Common Evaluation Framework*[2] produced by the Massachusetts Smart Grid Collaborative Technical Subcommittee (the Collaborative), a stakeholder group convened by the DPU to develop consistent evaluation themes and techniques across smart grid pilot programs in the state. Key findings include demonstration of significant energy and Peak Event savings, the important role of technology, and strong customer satisfaction (Figure E-1).

Figure E-1. Key Findings from Evaluation of Smart Energy Solutions

Energy and Demand Savings for Active Customers	• Load reductions from 4% to 31% (0.12 to 0.60 kW) during Conservation Day Peak Events depending on the combination of rate and technology • 5.4% (approximately 35 kWh per month) weighted average energy savings across the technology groups for CPP customers over the two years of the Pilot
Enabling Technologies Increased Demand Savings for Active Customers	• Customers with programmable communicating thermostats had the highest load reductions (25%-31% on CPP and 22%-29% on PTR) • Customers with in-home displays were next (17%-18% on CPP and 4%-9% on PTR), followed by customers with only Web Portal access (12%-15% on CPP and 10% on PTR)
Bill Savings	• Average per customer bill savings of $236 over the two years of the Pilot for customers on CPP • Average total rebates of $30 for Conservation Day Peak Events across both summers for customers on PTR
High Retention Rate	• 98% retention rate of customers in the Pilot at the end of 2016 after rates went live on January 1, 2015
Strong Customer Satisfaction	• 69% of customers rated their satisfaction with Smart Energy Solutions at least a 5 on a 7-point scale

Source: Navigant analysis
Note: CPP refers to Critical Peak Pricing and PTR refers to Peak Time Rebate.

---

[1] National Grid. *Interim Grid-Facing Evaluation Report*, March 31, 2016.

[2] D.P.U. 10-82, Massachusetts Smart Grid Collaborative Technical Subcommittee, *Common Evaluation Framework*, March 23, 2011.

There were several changes in the Pilot design and outcomes in its second year (2016) compared to its first year (2015), which are summarized in Figure E-2. The design changes were primarily made based on customer feedback collected during the first year of the Pilot,[3] and reflect National Grid's "listen, test, learn" philosophy regarding continuous improvement to program offerings.

Figure E-2. Key Changes in Pilot Design and Outcomes in 2016

Expanded efforts to educate customers about the Pilot design, based on feedback that customers wanted fewer and shorter Peak Events, and to reinforce the reasons for calling Peak Events. Much of this education took place through the Sustainability Hub.

Created Energy Signatures to give customers personalized savings tips once they self-identified with one of five common home energy usage profiles, such as "9 to 5ers" or "Late Nighters".

Expanded, simplified, and prioritized informing customers about the options for personalizing notifications in 2016, based on customer feedback regarding Peak Event notifications.

Added a rewards platform to the Pilot web portal in 2016 in response to results showing active customers acheived higher savings than passive customers. Participants earned points for activities, like saving energy, that could be redeemed for gift cards at local and national retailers.

Decreased degree setbacks on thermostats during Peak Events and varied Peak Event start and end times more in 2016 than in 2015 to increase customer comfort, especially on consecutive Conservation Days.

The number of active customers in the Pilot increased by 22% in 2016 compared to 2015. The majority of this increase occured among participants without in-home devices, indicating that the Company's efforts to increase web portal traffic were successful.

Demand savings for passive customers increased substantially in **2016** compared to 2015, which increased total Pilot savings. Savings increased from 1% to 4% for passive CPP customers and from 2% to 5% for passive PTR customers.

Source: Navigant analysis
Note: CPP refers to Critical Peak Pricing and PTR refers to Peak Time Rebate. Active participants are those who opted to receive one of the Pilot technology packages or who had no technology but visited the program web portal at least once; any customers without technology who did not visit the web portal are characterized as passive.

The Smart Energy Solutions Pilot

As shown in Figure E-3, Smart Energy Solutions was deployed in four phases.

Phase 1. **Meter Deployment & Awareness.** In this initial phase the Company raised awareness about and installed advanced metering infrastructure (AMI) meters (also referred to as "smart meters") in approximately 15,000 homes and businesses. Five percent of customers offered AMI meters refused them.

Phase 2. **Introduction of Benefits.** In the second phase the Company introduced Smart Energy Solutions to raise customer awareness and create an expectation of more to come. Customer education efforts continued throughout the Pilot.

Phase 3. **Choice.** In Phase 3 National Grid customers chose between two Pilot rates, a TOU Critical Peak Pricing (CPP) rate and a Peak Time Rebate (PTR) rate, and four technology packages that offered varying levels of information and control via web portal access, phone app, in-

---

[3] See Navigant. 2016. *National Grid Smart Energy Solutions Pilot Interim Evaluation Report.* Prepared for National Grid.

home displays (IHDs), programmable-controllable thermostats (PCTs), direct load control devices, and smart plugs.[4] The Sustainability Hub was also opened during Phase 3 as a resource for customers. The Hub provides hands-on education and engagement through a holistic approach, integrating various advanced technologies into a demonstration home.

Phase 4. **Focus on Customer Control.** Phase 4 began with the rates going live in January 2015. The Company called Conservation Days with specific Peak Event hours on high-demand days, educated customers about their bills, assisted them in using the tools available to understand and control their energy usage, and allowed them to customize their participation through the many options available in the Pilot.

Based on its experience with the Pilot, National Grid understands the importance of gradual and ongoing customer outreach and education to introduce new concepts and technologies. By introducing demand response and connected devices early on, the hope was customers would better understand and benefit from incremental savings that may be realized from the introduction of AMI and time-based rates. National Grid has filed for a two-year extension of the Pilot and the DPU has approved an interim extension. Under the interim extension, the Pilot will remain in effect until the DPU comes to a final decision. If the proposal for extending the Pilot is approved or if the Company's Grid Modernization Plan is approved, the Company envisions offering Smart Energy Solutions participants the option to receive similar savings and benefits as they have enjoyed to date, in line with what is proposed in the Company's Grid Modernization Plan in D.P.U. 15-120. Otherwise, the Pilot participants will revert to basic rates and will be eligible for the same demand response incentives as other customers in the Company's service territory. Pilot participants who received in-home devices will be able to keep them regardless of the outcome of the extension.

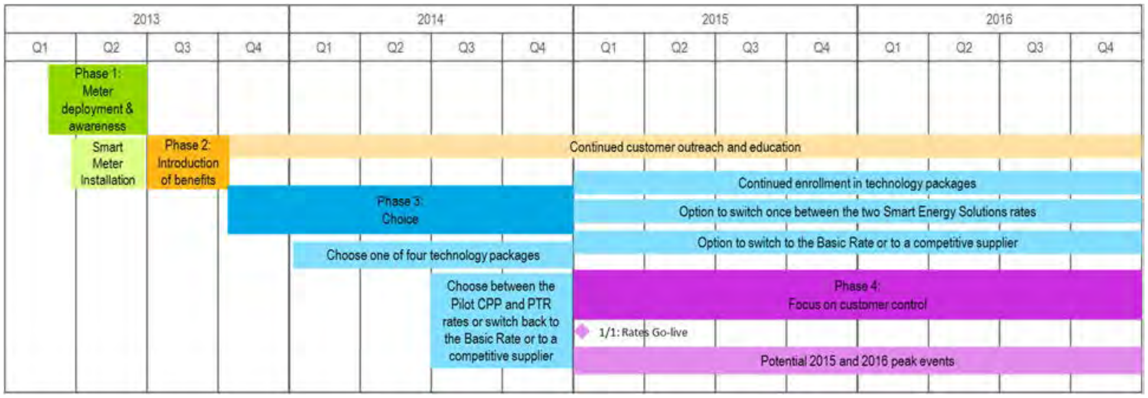
The Company hopes to transition to a more advanced and integrated demand response management system (DRMS) that will be deployed during the Grid Modernization plan period if approved. The functionalities of this enterprise DRMS include the ability to schedule, dispatch, control and conduct evaluation, measurement, and verification of load curtailment demand response events.[5]

---

[4] Customers also had the option to remain on the Basic Rate, effectively leaving the Pilot, or to leave National Grid by switching to a competitive supplier. As a result, the Pilot contained an "opt-out" element for customers who did not want TOU/CPP, and an "opt-in" element for customers who chose the PTR rate or any of the technology packages. This design and customer flexibility set the Pilot apart from other utility dynamic rate pilots. Therefore, comparisons to other programs are anecdotal, as direct comparisons do not exist.

[5] National Grid. D.P.U. 15-120. *Grid Modernization Plan at Attachment 8.* August 19, 2015.

Figure E-3. Four-Phase Rollout of Smart Energy Solutions



Source: Navigant and National Grid

Consistency with Green Communities Act

The Pilot design complied with and exceeded the requirements of Section 85 of the Green Communities Act (GCA or the Act) passed in Massachusetts in 2008. The Act mandated that each investor-owned electric utility conduct a smart grid pilot with the overall objective of reducing active participants' peak and average loads by at least 5%. The pilot program must include, at a minimum, the following:

- Deployment of advanced meters that measure and communicate electricity consumption on a real-time basis;
- Automated energy management systems in customers' home and facilities;
- Time of use or hourly pricing for a minimum of 0.25 percent of the company's customers;
- Remote monitoring and control equipment on the Company's electric distribution system; and,
- Advanced technology to operate an integrated grid network communication system in a limited geographic area.

The DPU has recognized four unique elements of Smart Energy Solutions that differentiate it from other Section 85 pilot programs.[6]

1. The Company ***implemented the customer-facing and grid-facing components of the Pilot within one city***, a portion of Worcester, to allow National Grid to ascertain whether a comprehensive deployment of smart grid technologies produced synergistic customer benefits.
2. The Company ***deployed the program on an opt-out basis***, meaning all eligible customers in the Worcester area were offered an AMI meter and enrolled in Smart Energy Solutions by default but had the option to opt-out if they weren't interested. Relative to opt-in programs where eligible customers must actively choose to participate, opt-out programs reach many more customers and thus have higher savings potential.

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[6] D.P.U. Order 11-129. *Petition of Massachusetts Electric Company and Nantucket Electric Company, each d/b/a National Grid for approval of a smart grid pilot program.* August 3, 2012.

3. The ***default pricing option for the Pilot is a TOU rate, and the vast majority of Pilot participants remained on this rate***. Additionally, nearly 1,000 customers opted into technology packages which included in-home devices. Having a significant number of customers on a TOU rate with enabling technologies represented a unique opportunity to study these smart grid pilot components across a broad segment of the population.
4. National Grid's ***comprehensive outreach and education campaign combined both traditional and community-based elements***. It was designed to encourage customers to permanently change their energy consumption behavior in response to the price signals and other Pilot messaging. The Pilot also included the creation of the Sustainability Hub which serves as a model energy center in the community where National Grid provides hands-on education and engagement through a holistic approach, integrating various smart elements into a demonstration home.

Definition of Active Customers

In the context of an opt-out pilot, the GCA's goal of reaching 5% savings for "active" customers must be interpreted carefully. Some of the participants in an opt-out pilot will never actively engage with the program components. For evaluation purposes, Navigant defined active participants as anyone who opted into any in-home technologies and anyone with no in-home technology who logged into the Pilot web portal at least once.[7] Customers with no in-home technology who never logged into the web portal were considered "passive" participants in the Pilot. In other words, the passive customers did not adopt technologies or check their electricity usage; these customers could still take actions to save energy as they were enrolled in the Pilot rates and received notifications for the Peak Events. By this definition, just under 25% of the Pilot participants were active at the end of 2016. This increased from just under 20% at the end of 2015.

Customer Decision-Making and Flexibility

Among smart grid pilots, Smart Energy Solutions was relatively complex with several key decision points for customers, as illustrated in Figure E-4.

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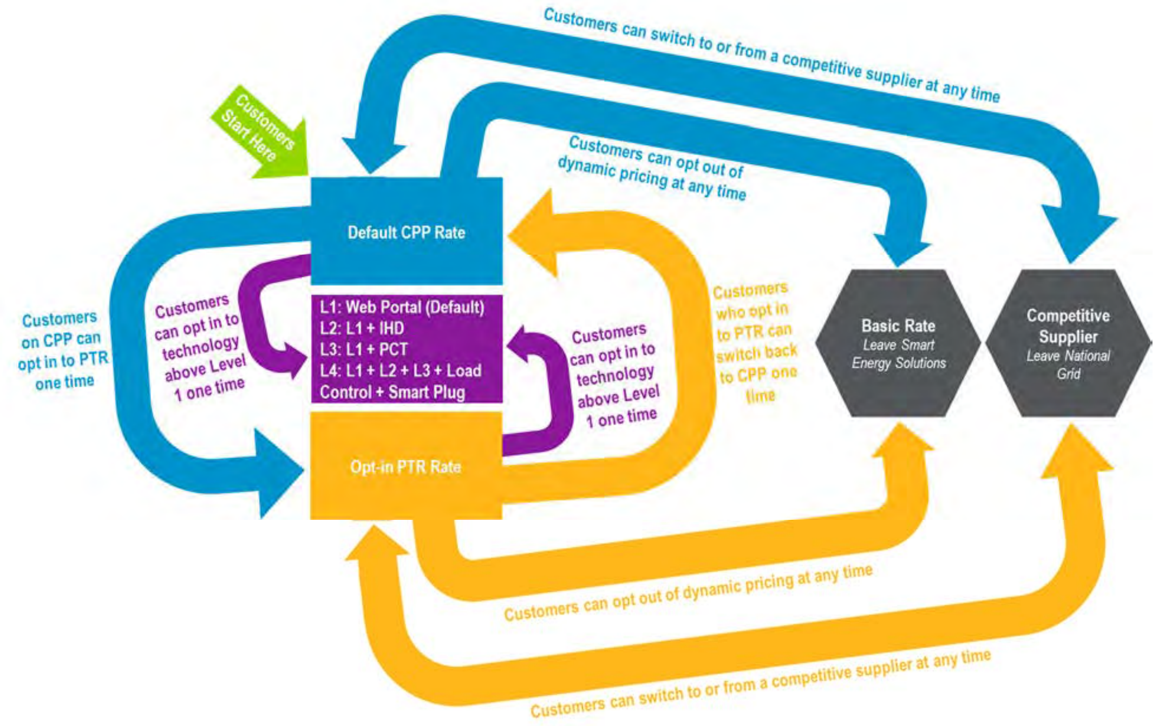
[7] Active customers were defined as of October 12, 2016, which was after the last Peak Event of the 2016 summer season.

Figure E-4. Smart Energy Solutions Customer Decision Points



Source: Navigant
Note: L1 = Technology Level 1, L2 = Technology Level 2, L3 = Technology Level 3, L4 = Technology Level 4, IHD = in-home display, PCT = programmable-controllable thermostat.

Smart meters and choice of rates. Eligible customers in the Worcester area who accepted a smart meter were enrolled onto the CPP rate by default.[8] Customers had the option to opt into the PTR rate one time during the Pilot; customers who initially opted into the PTR rate could switch back to the CPP rate one time. Customers could also choose to switch back to the Basic Rate, thus opting out of the Pilot, or to switch to and from a competitive supplier, thus leaving or returning to National Grid, at any time.

Technology choice. Customers on the CPP and PTR rates also had a choice of four technology packages, with Level 1 (web portal only) as the default. Some of the technology packages had eligibility requirements related to internet access and central air conditioning.[9] Technology options became more advanced, offering more electricity usage information and control, from Level 1 to Level 4:

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[8] Customers had the option to decline the smart meter and, therefore, opt out of the Pilot at the onset. Five percent of customers offered an AMI meter declined to accept it.

[9] For example, in order to be eligible for the Level 2 package with a digital picture frame, customers had to have a high-speed broadband Internet connection. To be eligible for Level 3 with a PCT, customers had to have central air conditioning. To be eligible for Level 4 with a PCT and a smart plug and/or load control device, customers had to have central air conditioning and a high-speed broadband Internet connection.

- Level 1: Personal electric use information, via access to a web portal;
- Level 2: Level 1 plus an IHD with energy use and real time cost information and access to this information through the web portal;
- Level 3: Level 1 plus a programmable-controllable thermostat (PCT) and a mobile app to view the PCT schedule; or,
- Level 4: Level 1, Level 2, and Level 3 plus a smart plug and, for some customers, a wired load control device, and additional capability in the mobile app to show load control and smart plug usage.

Conservation Days. During each summer of the Pilot (2015 and 2016), National Grid called 20 Conservation Days on days with expected high demand. Customers received notifications one day ahead and could opt to receive them the day of each Conservation Day as well. On these days, the price of electricity increased during designated hours, called Peak Event hours, which varied between Conservation Days. In 2015, the Peak Events averaged 6.75 hours in length and totaled 135 hours. Events were slightly longer in 2016, averaging 6.95 hours in length and totaling 139 hours. National Grid's events were longer and called more days in a row than events from other comparable programs. For example, one of the most well-known critical peak pricing programs, Southern California Edison's, is limited to 60 hours per year,[10] and NSTAR's[11] smart grid pilot included a total of 15 events from 3-5 hours each over two summers.[12] On the CPP rate, customers were incented to conserve electricity, or shift usage to non-Peak Event hours, and thus avoid paying the high electricity prices during Peak Event hours. On the PTR rate, customers received a rebate for any electricity conserved during those hours.

Community Partnership and Sustainability Hub

To ensure that the Pilot was a collaborative effort with the community, National Grid partnered with the City of Worcester to host the September 2011 Green2Growth Summit (Summit). The Summit provided valuable insights into customers' visions regarding the future of energy delivery in their city. National Grid learned that its customers are increasingly aware of new opportunities to manage their energy consumption and are open to learning more about the potential uses and benefits of smart technology. Based on information gathered through the Summit, the Company revised the Pilot's Outreach & Education plan, implemented in Phases 2-4 of Figure E-3, and developed a Sustainability Hub in Worcester to continue engaging customers. The Sustainability Hub was envisioned and built as a focal point for the successful implementation of the Pilot. In addition to being the physical presence of the Pilot in Worcester, the Sustainability Hub serves as a model energy center in the community, where National Grid provides hands-on education and engagement through a holistic approach, integrating various smart elements into a demonstration home. As of the end of 2016, over 8,200 people had visited the Sustainability Hub, and it was mentioned by many customers as a useful source of information alongside direct mail, the Smart Energy Solutions website, and National Grid's Customer Contact Center (see Figure 2-15). A survey administered by the Sustainability Hub also found that customers ranked the Hub

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[10] Summer Advantage Incentive fact sheet <https://www.sce.com/wps/wcm/connect/d0d870bf-68f5-41b0-a930-3c082652b443/NR580V40410_CPP.pdf?MOD=AJPERES>

[11] NSTAR is now called Eversource Energy.

[12] NSTAR Smart Grid Pilot Final Technical Report, AMR BASED DYNAMIC PRICING. DE-OE0000292. Prepared for: U.S. Department of Energy On behalf of NSTAR Gas and Electric Corporation. August 4, 2014.

highly as a source of information (see APPENDIX C).

Statewide Common Evaluation Framework

Navigant conducted the evaluation of the Pilot in accordance with the *Common Evaluation Framework*[13] produced by the Massachusetts Smart Grid Collaborative Technical Subcommittee (the Collaborative), a stakeholder group convened by the DPU to develop consistent evaluation themes and techniques across smart grid pilot programs in the state. The evaluation included quantitative measures of energy, demand, and customer bill impacts, as well as qualitative measures for customer engagement, satisfaction, and perceptions through customer surveys, interviews, and focus groups.

Impact Assessment

This evaluation addresses the impacts of the Pilot on demand during Peak Events, overall energy consumption, and customer bills. The impact findings in this report are primarily focused on residential customers. Commercial customers were a very small portion of the Pilot participants and outcomes were explored for them to the extent possible based on the constraints of the small sample. Where possible, each set of impacts was broken out by technology/price groups as prescribed by the Common Evaluation Framework. For Level 1, Navigant evaluated each of the impacts for both active and passive customers.

Table E-1 shows total and percentage demand and energy savings and total bill savings for residential customers in the Pilot. Total savings are the sum of savings across all residential customers in the program. For the Peak Event savings, the total savings are shown for the "average event", which is the average across all Peak Event hours across all 20 Peak Events of each summer, and for the "maximum event", which is the single Conservation Day with the highest average savings across the Peak Event hours. Percentage savings are the weighted average of savings across the residential technology/price plan groups.

Table E-1. Total and Percentage Savings for Residential Customers

Impact Category		2015 Total Savings	Percentage for Active Customers	Percentage for All Customers	2016 Total Savings	Percentage for Active Customers	Percentage for All Customers
Peak Event Savings	Average Event*	0.55 MW	16.8%	3.9%	1.02 MW	16.8%	7.2%
	Maximum Event**	1.59 MW	29.0%	12.3%	2.28 MW	24.0%	14.3%
Energy Savings ***		215 MWh	4.3%	0.2%	1,358 MWh†	6.3%	2.0%
Bill Savings‡		$997,621	-	-	$772,879	-	-

Source: Navigant analysis
* This is the total demand savings among all participants, averaged across all 20 events in the summer of each year.
** This is the total demand savings for 6/23/2015 and 7/25/2016, the Conservation Days with the highest savings for each summer.
*** This includes energy savings for CPP customers only, as energy savings were neither expected nor found for PTR customers.
† The considerable increase in energy savings in 2016 was driven primarily by a spike in savings in July, Navigant did not find any evidence suggesting this result was erroneous. This is discussed more fully in Section 3.2.1.
‡ This includes total bill savings for CPP customers and rebates for PTR customers.

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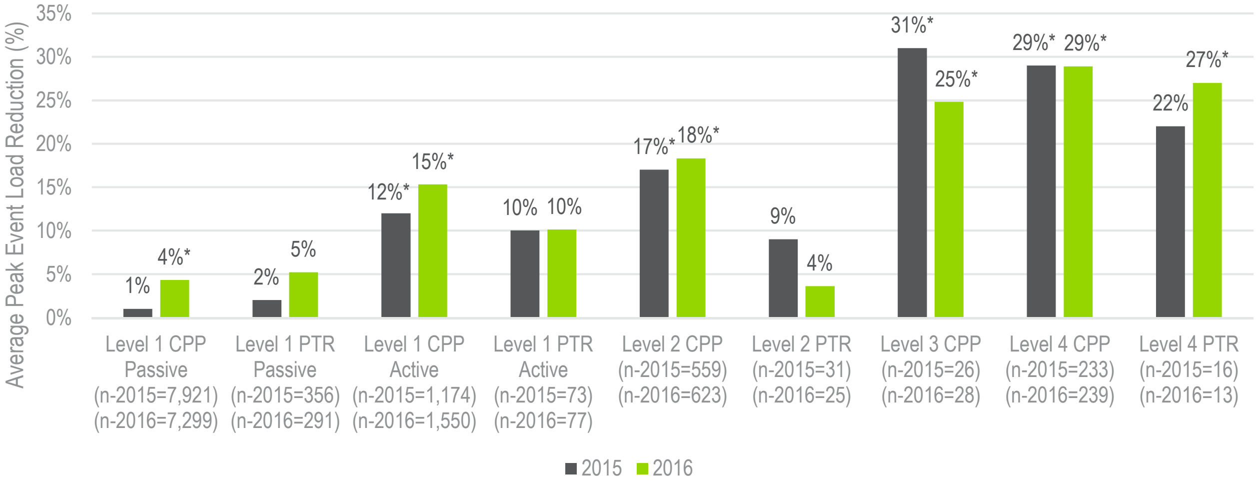
[13] D.P.U. 10-82, Massachusetts Smart Grid Collaborative Technical Subcommittee, *Common Evaluation Framework*, August 10, 2011.

The Pilot was developed to meet the GCA goal of achieving peak and average load reductions of 5% or greater for the active customers in the Pilot. In Navigant's analysis, peak load reduction was examined in the demand analysis and average load reduction in the energy analysis. In both 2015 and 2016, active residential customers in the Pilot achieved an average of a 17% peak load reduction during Peak Events. Active CPP participants achieved an average load reduction of 4.3% in 2015 and 6.3% in 2016, which averaged to 5.4% over the whole of the Pilot.[14] Demand savings in 2015 and 2016 may be slightly underestimated because hourly data from 2014 was used to estimate the baseline. In 2014 customers had access to usage information through the Pilot web portal but the Pilot rates were not yet live, so they may have already been conserving relative to their pre-2014 usage as they were more aware of their electricity usage.[15]

Active customers achieved average Peak Event load reductions of up to 31%, and in-home technology increased demand savings. Figure E-5 shows the average percentage peak load reduction across the 20 events of each summer for each of the technology/price groups. Whether on the CPP or PTR rate, customers achieved greater demand reductions with more advanced technology. The savings for CPP customers were statistically significant at the 90% confidence level for all active participants in both years, and for passive participants in 2016. The savings for customers on the PTR rate were not statistically significant at any technology level in 2015, and only for Level 4 in 2016. The lack of statistical significance for the PTR rate was due to small sample sizes on that rate. At each technology level, active CPP customers conserved more electricity than their PTR counterparts. Passive PTR customers saved more than passive CPP customers, which could be due to a higher level of engagement since they had to opt in to the PTR rate.

Figure E-5. Average Peak Event Load Reductions by Technology/Price Group



Source: Navigant analysis

Note: An asterisk (*) indicates that the majority of the event hours throughout the summer were statistically significant at the 90% confidence level for the indicated group. Additionally, n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

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[14] Energy savings, or average load reductions, were neither expected nor found for PTR customers as these customers were not on a TOU rate.

[15] Hourly data prior to April 2014 when smart meters were installed was not available.

Absolute peak load reductions for each technology/price group in each summer are shown in Table E-2.

Table E-2. Average Absolute Peak Event Load Reductions per Customer by Residential Technology/Price Group

Technology/Price Group	2015 Absolute Savings (kW)	2016 Absolute Savings (kW)
Level 1 CPP Passive	0.01	0.05
Level 1 PTR Passive	0.03	0.07
Level 1 CPP Active	0.13	0.17
Level 1 PTR Active	0.12	0.12
Level 2 CPP	0.20	0.21
Level 2 PTR	0.13	0.05
Level 3 CPP	0.53	0.49
Level 4 CPP	0.56	0.60
Level 4 PTR	0.50	0.60

Source: Navigant analysis

Peak Event savings were comparable to other dynamic rate pilots. In percentage terms, the peak event impacts for active customers in the Pilot were similar to those from other, primarily opt-in, programs.[16] Comparisons of the Pilot to several other programs around the country are shown in Figure E-6. The comparisons include the average, maximum, and minimum impact when possible, or the average impact when the minimum and maximum could not be found. The comparisons are grouped by the Pilot's technology/price groups, and the comparison programs are matched to the Pilot groups based on the descriptions of the price plans and the enabling technologies in the comparison program's report. The Pilot groups are highlighted in gray in 2015 and green in 2016.[17]

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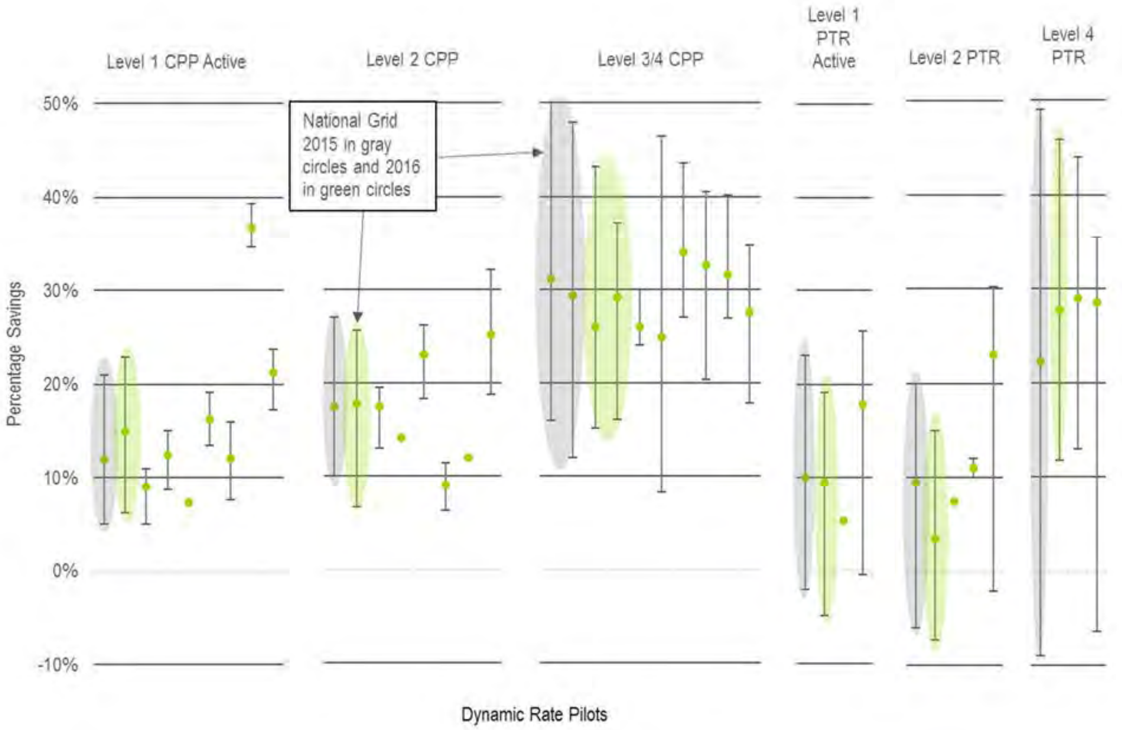
[16] Passive customers in Level 1 also had savings, but they are not shown in Figure E-6 because all of the comparison programs are opt-in. Passive customers in an opt-out program are fundamentally different from customers in an opt-in program in terms of their motivation to participate in a program.

[17] The specific utility for each of the comparable pilots can be seen in Figure 3-2.

Figure E-6. Peak Event Impacts Percentage Comparisons to Other Utilities



Source: Navigant analysis and the Smart Grid Investment Grant Program

Low-income customers achieved Peak Event impacts similar to other customers in two of the three technology/price groups examined. Three technology/price groups (Level 1 CPP Active, Level 1 CPP Passive, and Level 2 CPP) had enough low-income customers to analyze whether their Peak Event impacts differed from the larger group. In the two Level 1 groups, the impacts for low-income customers were not statistically different from the rest of the group; 87% of all Pilot participants were in the Level 1 CPP groups, meaning for the bulk of the Pilot low-income customers had the same impacts as other customers. However, in Level 2 the low-income customers had lower Peak Event savings than the group as a whole. As discussed further in Section 3.1.3, possible reasons for this difference in Level 2 include (1) lower central air conditioning penetration for the low-income customers, (2) low-income customers may have less discretionary energy usage and thus less energy to save, and (3) low-income customers may have been less able to shift their usage than other residential customers. The difference could also be a spurious finding since low-income customers had the same impacts as other customers in two of the three groups analyzed.

CPP customers achieved average energy savings of up to 8% over the two years of the Pilot.

Figure E-7 shows the average percentage energy impacts with 90% confidence intervals for CPP customers in different technology levels in each year of the Pilot.[18] In both years, energy savings for

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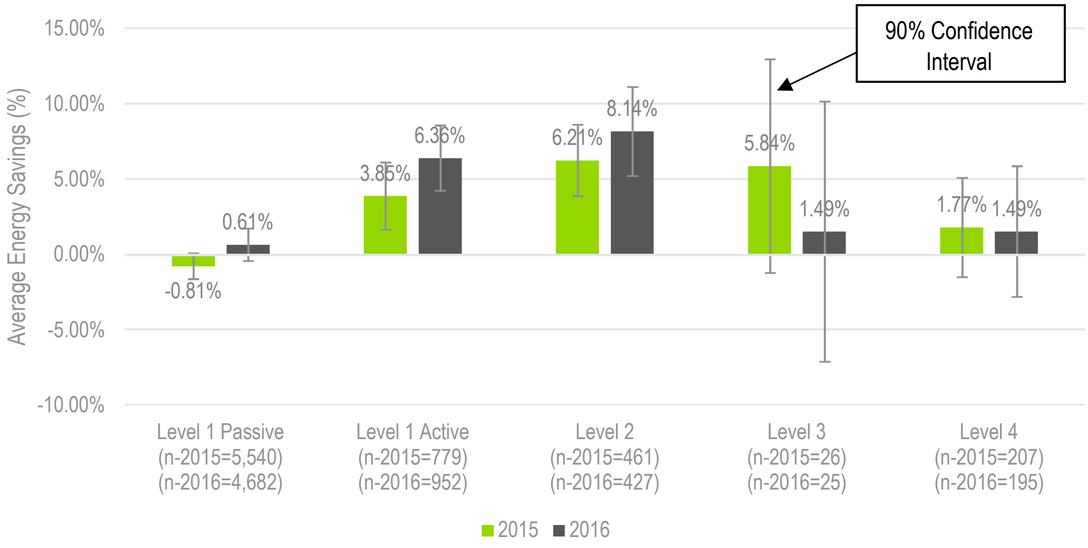
[18] Navigant also examined energy savings for PTR customers but did not find any significant savings outside of peak events; PTR customers were not expected to achieve significant energy savings because they did not pay TOU rates.

active participants were highest for Level 2 customers (49 kWh per month) and lowest for Level 4 customers (12 kWh per month). Active Level 1 customers saved 32 kWh per month, and Level 3 customers saved 25 kWh per month. Although the point estimates of energy savings changed from 2015 to 2016, the changes were not statistically significant indicating the energy savings were similar across the two years of the Pilot. It is unclear why Level 4 customers saved less than Level 3 customers in 2015 since the two groups had similar technologies; however, the 90% confidence bounds for the two estimates overlap and the sample sizes are relatively small for monthly billing analysis, which may have contributed to the discrepancy; additionally, the discrepancy disappeared in 2016 when the point estimate for Level 3 customers fell considerably. The estimates of energy savings for passive customers in Level 1 were very small and not statistically significant in either year.

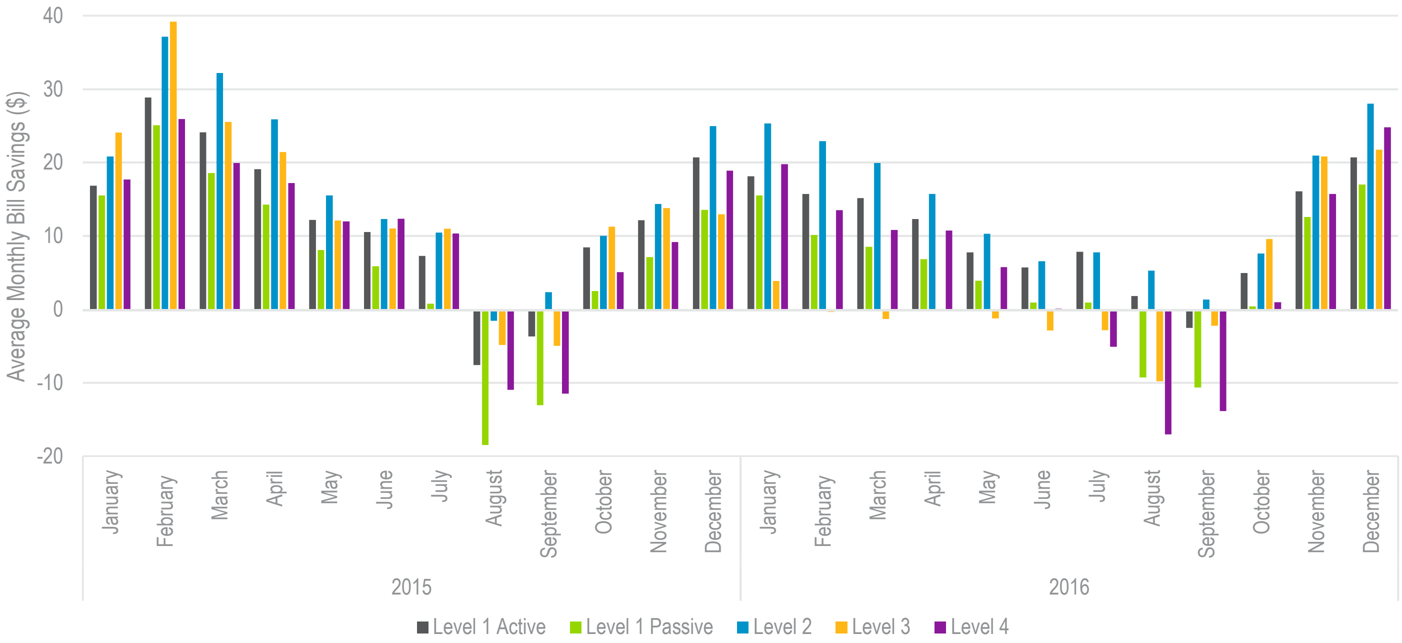
Figure E-7. Average Energy Impacts for CPP Customers by Technology Level



Source: Navigant analysis
Note: n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

CPP customers averaged $236 in bill savings over the two years of the Pilot. Figure E-8 shows the average bill savings by month and year for CPP customers. The month of each bill was defined as the last day of the billing period. This means that on average, bills in each month contain an equal number of days in the current month and the previous month, for example bills in May reflect usage in the second half of April and the first half of May. On average across technologies, bill savings were highest in February 2015, which reflects January and February 2015 usage, when customers were still adjusting to the new TOU rate. Unless there was a Peak Event, customers saved money on the TOU rate because the TOU rate was lower than the Basic Rate for non-Peak Event hours. Customers' bills went up in August and September of each year and July of 2016, reflecting usage in July, August, and September, which was expected, since July and August were when the majority of the Peak Events were called each year. The expectation was that summer bills, when Peak Events occurred, would increase but this would be balanced by bill savings throughout the rest of the year. Average per-customer bill savings over the two years of the Pilot were $375 for Level 2, $272 for active customers in Level 1, $206 for Level 3, $191 for Level 4, and $136 for passive customers in Level 1. For each group, bill savings were higher in 2015 than in 2016 despite the fact that energy savings were higher in 2016. Increases in energy savings do not necessarily produce increases in bill savings because of the high price during Peak Events. For example, the highest energy savings occurred in July 2016, but that did not produce high bill savings in that month because eleven Peak Events were called, increasing bills in that month for many customers.

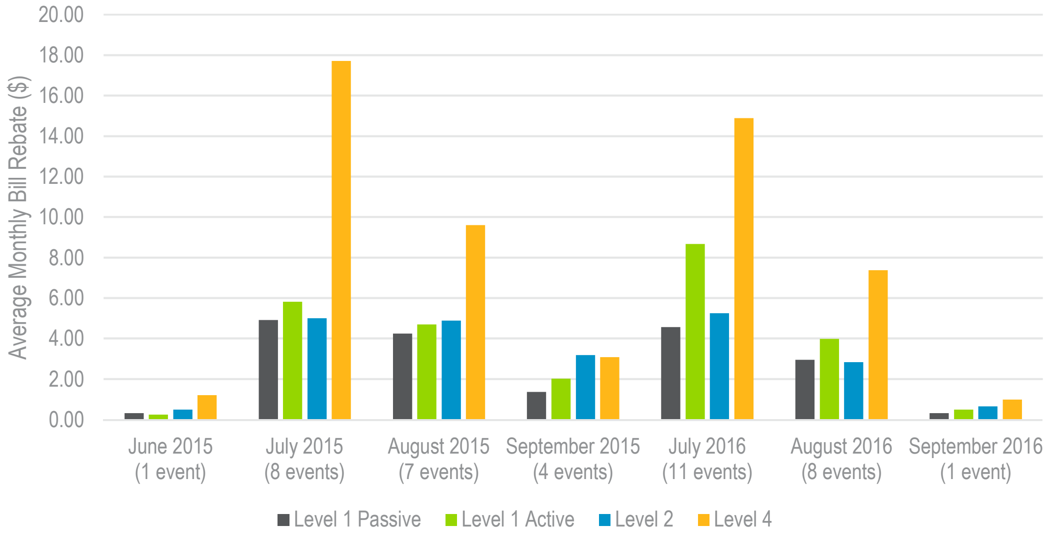
Figure E-8. Average Bill Savings for CPP Customers



Source: Navigant analysis

PTR customers averaged approximately $30 in bill rebates over the two years of the Pilot. The bill savings for PTR customers came from the monthly rebate earned during Peak Events based on the payments made by National Grid. Figure E-9 shows the average bill rebates by month and year for PTR customers. Over the two years, Level 4 customers achieved the highest average rebate of $1.37 per event, active Level 1 customers averaged $0.65 per event, Level 2 customers averaged $0.56 per event, and passive Level 1 customers averaged $0.46 per event. As with CPP customers, bill rebates for PTR customers were slightly lower in 2016 than in 2015 for most of the technology groups, while active customers in Level 1 had essentially the same rebate in both years (increasing by $0.02 in 2016 compared to 2015).

Figure E-9. Average Bill Rebates for PTR Customers



Source: Navigant analysis

The Pilot exhibited small load shifting impacts. Navigant examined load shifting around Peak Events (i.e., in the hours just before (pre-cooling) or after (snapback) the Peak Event), from weekdays to weekends, and from peak to off-peak times on non-Conservation Days. CPP customers were expected to exhibit all three types of load shifting because of the TOU nature of the rate, whereas PTR customers may have shifted load around Peak Events but did not have a strong incentive to exhibit the other two types of load shifting. Overall, Navigant found that each type of load shifting was: (1) small compared to the Peak Event impact, (2) mostly larger for CPP than PTR customers as expected, and (3) mostly larger for customers with higher levels of technology.

Customer Engagement and Experience

This evaluation addresses customers' experiences with Smart Energy Solutions through the end of 2016. It looks at customers' expectations of the program, their reasons for participating, and their experience during the two summers of Conservation Days. Key findings include strong customer satisfaction, a desire to continue with the Pilot, and a high retention rate (i.e., few customers dropping out of Smart Energy Solutions and going back to the Basic Rate).

Strong satisfaction. As shown in Figure E-10, 69% of customers reported satisfaction with the Pilot of at least 5 on a 7-point scale,[19] with 18% rating their satisfaction a 7 out of 7.[20] The weighted average satisfaction was 5.06. This satisfaction rating was similar to those from several dynamic rate pilots from

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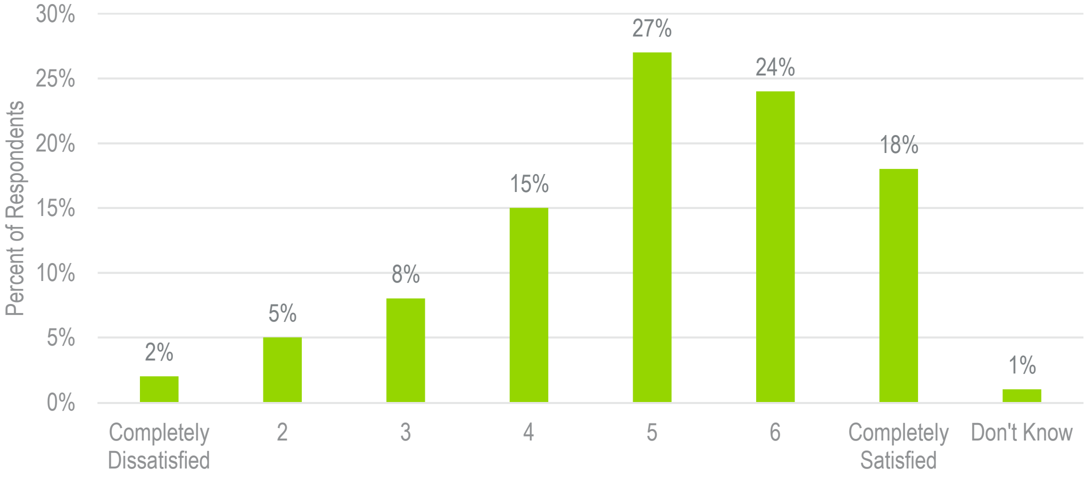
[19] National Grid customers could also indicate that they were "unsure/don't know" or refuse the question.

[20] In 2015, 72% of customers reported being "Very" or "Somewhat" satisfied with the Pilot on a 3-category scale. The satisfaction scale was changed in 2016 to better align with DPU guidelines.

other utilities, including NSTAR, DTE, and MN Power. Converted to a 7-point scale, NSTAR customers gave their pilot an average satisfaction rating of 5.6, 86% of DTE customers rated their pilot at least 4.2 out of 7, and MN Power customers rated their Pilot an average of 3.9 – 4.3 out of 7. As an opt-out Pilot, it is commendable that Smart Energy Solutions achieved satisfaction ratings similar to opt-in pilots, because customer motivations are different between opt-in and opt-out programs.

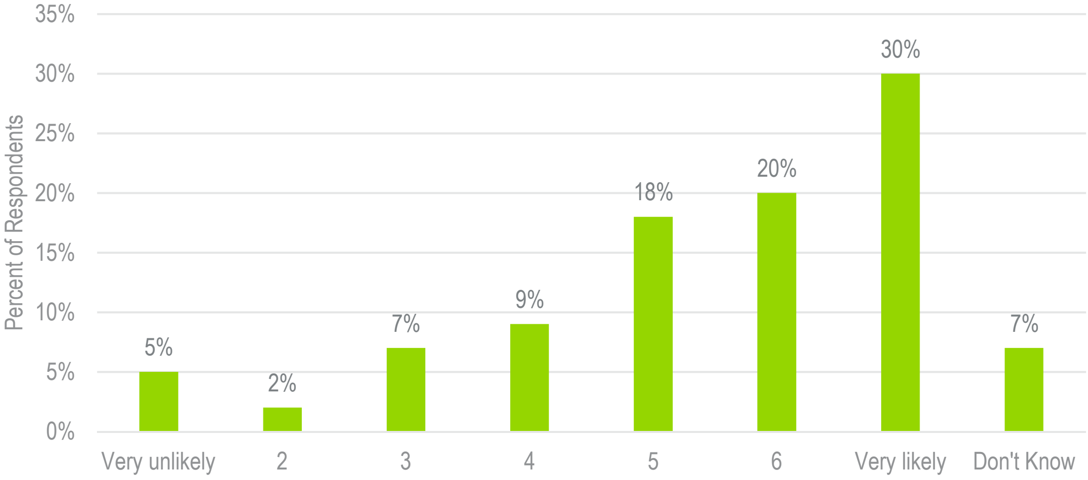
Figure E-10. Participant Overall Satisfaction with Smart Energy Solutions



Source: Navigant analysis of 2016 end of pilot survey (N=615)

Desire to Continue with the Pilot. Over two-thirds of participants indicated that they would like to continue with the Pilot if it were extended with the same conditions (Figure E-11). Almost one-third of customers (30%) indicated that their likelihood of continuing was a 7 on a 7-point scale, suggesting that these customers were enthusiastic about their experiences to date.

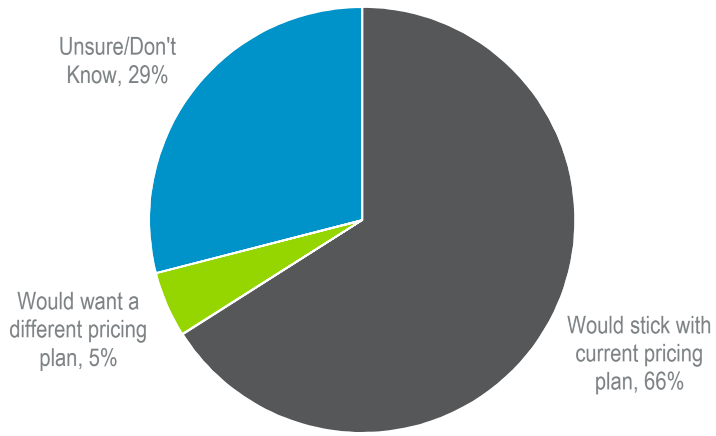
Figure E-11. Customers' Likelihood to Continue with Smart Energy Solutions



Source: Navigant analysis of 2016 end of pilot survey (N=615)

Additionally, most customers (66%) indicated that they would choose to stay on their current rate if the Pilot were extended, as shown in Figure E-12. Only 5% said they would definitely want to switch rates, with the rest being unsure.

Figure E-12. Customers' Interest in Continuing with Current Pricing Plan



Source: Navigant analysis of 2016 end of pilot survey (N=615)

High acceptance and retention rates. Since a foundational aspect of the Pilot was customer acceptance of AMI meters, National Grid monitored the percentage of customers who declined to install a meter and found it to be approximately 5% out of approximately 15,000 sites. Navigant surveyed a sample of 70 decliners. Three-quarters of those refusing the meter had no initial interest in participating in the program. Taking the categories of all reasons for declining the meter, the most common was 'Generic', which included not believing they would benefit and just not wanting a smart meter.

The CPP and PTR rates went live in January 2015 and almost 11,000 customers were enrolled.[21] Compared to one-year customer retention rates in other utility dynamic rate pilots, National Grid had high customer retention, even after two years, as shown in Figure E-13.[22] One thing of note is that, as an opt-out program, the Pilot was quite large compared to the size of a typical opt-in program. Opt-out program design is a relatively new industry concept, and based on research to date, retention rates appear to be similar for opt-in and opt-out programs.[23] However, by definition, customers in an opt-in program have a

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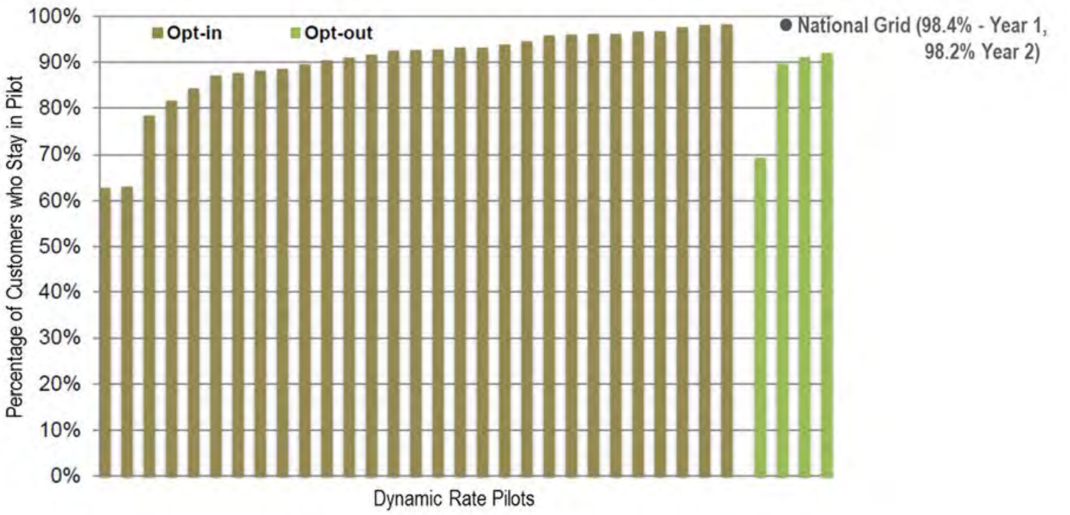
[21] The difference between the 15,000 customers offered an AMI meter and the 11,000 enrolled in the Pilot is accounted for by customers who get electricity from a competitive supplier, moved out before the Pilot rates went live, or chose to drop out of the Pilot before it started.

[22] Figure E-13 shows U.S. Department of Energy Smart Grid Investment Grant (SGIG) dynamic rate pilot retention rates. Ten utilities undertook several pilot studies during the SGIG period and reported their experience in recruiting and retaining customers. Each bar in the chart represents a single treatment group within one of the utility pilots.

[23] Cappers, P., H. Liesel, R. Scheer. *American Recovery and Reinvestment Act of 2009: Interim report on customer acceptance, retention, and response to time-based rates from the consumer behavior studies*. LBNL-183029. June 2015.

different motivation to participate in a dynamic rate pilot than customers in an opt-out program. Customers who participate in opt-in programs tend to be enthusiastic early adopters and not likely to drop out of a program they signed up for. Opt-out programs capture all customers, many of whom may follow “default bias”, which means that they tend towards the default offering rather than accepting alternative offerings. Yet, given the fact that opt-out programs target the general population, we would anticipate lower retention rates over time. The 98% retention rate achieved by National Grid after two years running the Pilot—coupled with the fact that the Company called more event days in each summer than any other dynamic rate pilot—is remarkable.[24]

Figure E-13. Customer Retention Rate Based on Whether the Utility Used Opt-In or Opt-Out Recruitment



Source: Lawrence Berkeley National Laboratory and Navigant analysis

Low impact of bill protection on CPP rate customers. CPP customers were eligible for bill protection if they stayed on the CPP rate for at least 12 consecutive months; bill protection meant that if at the end of the year their bills were higher than they would have been on the Basic Rate, the customer received a credit in the amount of the difference. At the end of the Pilot, almost half of the customers on the CPP rate (40%) said that they were aware of the bill protection feature. However, as shown in Figure E-14, over two-thirds of those who knew about it said that the feature made no difference in their efforts to manage their electricity use. This means that most CPP customers likely did not reduce their energy savings behaviors because they knew they would get bill protection at the end of the year. Approximately 20% of the CPP participants did say that knowing about bill protection made them put “somewhat less” or “much less” effort into saving energy. To explore this further, Navigant matched the survey results to the usage data and examined the Peak Event impacts for active customers in Level 1 CPP who said they

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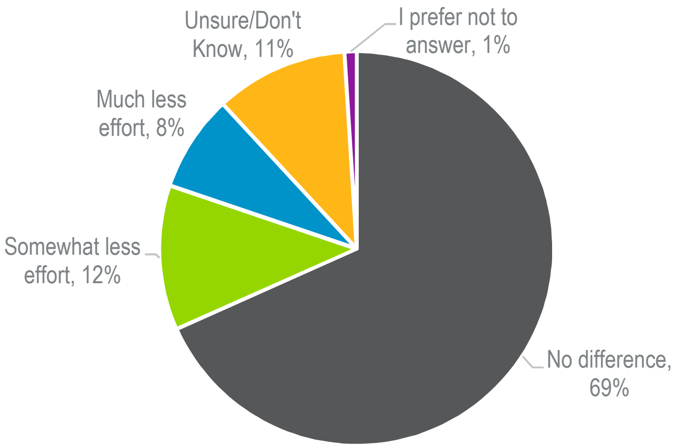
[24] Over time, customer retention reflects how many customers remain in the Pilot rather than dropping out. The retention rate considers only those customers who actually drop out of the Pilot and excludes those who moved or switched to a competitive supplier, which could have happened for any number of reasons unrelated to the Pilot.

were aware or unaware of the bill protection feature.[25] This analysis did not reveal statistically significant differences in impacts and neither group had consistently higher or lower impacts than the other, supporting the conclusion that bill protection awareness did not influence customers' actions in the Pilot.

Figure E-14. Effect of Bill Protection on Customers' Efforts to Manage Electricity



Source: Navigant analysis of 2016 end of pilot survey (N=229)

Lessons Learned from Program Implementation Staff

National Grid identified lessons learned from the Pilot through meetings with members of National Grid's implementation team. This process captured key learnings, including aspects that worked well and also opportunities identified during Pilot implementation. Lessons learned that are relevant to the customer-facing evaluation in this report were identified in the following areas:

- Advanced Metering Infrastructure (AMI)
- Billing
- Outreach and Education
- Customer Service
- Peak Events
- In-Home Technology Installation

Table E-3 identifies the key success and opportunity in each of these areas. Chapter 5 discusses each of these learnings in more depth.

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[25] We examined active customers in Level 1 CPP because this group contained the largest number of customers who answered this question. In this group, there were 71 customers who were aware of bill protection and 101 who were unaware.

Table E-3. Key Successes and Opportunities Compiled by Program Implementation Staff

Pilot Area	Success	Opportunity
AMI	National Grid found that the opt-out approach to the pilot was instrumental in simplifying the planning, scheduling, communication, and initial technology successes, including the Early Field Trial.	Implementing business process improvements that would streamline and accommodate evolving customer scenarios in AMI deployment and management.
Billing	National Grid was able to successfully support a wide variety of billing scenarios, under both current tariffs and Smart Grid tariffs, using AMI meter data.	Innovative bill design and presentment will allow National Grid to demonstrate the energy and bill savings to the customer.
Outreach and Education	Extensive outreach and education were critical to creating awareness and interest among customers and motivating them to participate actively in the Pilot.	Providing more customized information to help customers maximize savings in light of their specific energy usage characteristics would have supported higher savings and enhanced the customer experience.
Customer Service	Providing access to dedicated support services and the Sustainability Hub allowed customers to receive quick access to information and resolution of issues.	Increasing accessibility of the web portal via a streamlined account creation process would support customers in coming to view online access as a key interface with National Grid.
Peak Events	Optimizing peak event communications by providing and promoting communication options, and customizing peak event characteristics to make participation easier for customers, supported the achievement of higher participation and savings levels in the second year.	Creating greater understanding of the purpose of Peak Events, the ways in which they are determined, and the benefits of in-home technologies in enabling customers to save.
In-Home Technology Installation	The installation and customer education process received positive feedback from customers.	Making the steps of the installation process very clear to customers to reduce the incidence of incomplete and cancelled technology installations.

Source: National Grid

Key Learnings from Smart Energy Solutions

Before and throughout the Pilot, National Grid implemented a “listen, test, learn” approach that is based on “on the ground” conversations and reflections on the Pilot. This feedback, combined with learning, generally leads to continuous improvement in program delivery. National Grid conducted extensive program marketing in the lead up to initiating meter installations, the first phase of the program. These activities included convening a public summit to discuss the proposed program, development of brochures explaining the program, and establishment of the staffed, physical Sustainability Hub within the Pilot program area. National Grid also partnered with local schools to offer Energy Ambassador internships at the Sustainability Hub. Clark University offered annual internships, and Worcester Polytechnic Institute students worked at the Sustainability Hub as part of the Energy Ambassador program they created. Ambassadors host Sustainability Hub tours and attend outreach events to educate customers throughout the community. Presenting the personal side of the Company is the backbone of “listen, test, learn”, and is the inspiration for sending National Grid employees and Ambassadors into the community. It is also the basis for hosting visitors at the Sustainability Hub for the dual purpose of educating customers and listening to their concerns and feedback. The application of the “listen, test, learn” approach throughout the Pilot led to several important changes from the first summer to the second, which were outlined in Figure E-2.

Several broad themes emerged regarding customer response to the Pilot design and implementation.

Impacts for active customers (17% peak load reduction and 5.4% average load reduction over the two years of the Pilot) met the goals established through Section 85 of the GCA, and the majority of customers were satisfied with the Pilot. Figure E-15 summarizes key learnings from the two years of Smart Energy Solutions.

Figure E-15. Key Learnings from Smart Energy Solutions

Smart Energy Solutions shows the viability of opt-out design.

- The program enrolled ~11,000 participants, which is many more than could have been recruited in an opt-in design.
- The retention rate after two years was 98%, which is higher than many comparable opt-in programs.
- Program satisfaction was strong, with 69% of participants rating the Pilot at least a 5 on a 7-point scale.

It is important to choose the default options in an opt-out program carefully.

- Smart Energy Solutions defaulted customers onto the CPP rate and web portal, with no additional in-home technology.
- Approximately 95% of customers were still on the default price plan and 90% on the default technology level after the two years of the Pilot.
- Although satisfaction was strong, "default bias" is likely to be a factor in customers staying on the default enrollment options in the opt-out design.

Long Peak Events and Peak Events called on consecutive days did not significantly affect savings or satisfaction.

- Despite calling more Peak Events (including on consecutive days) and longer Peak Events than similar programs, Smart Energy Solutions acheived similar satisfaction and savings.
- However, some customers did express a desire for shorter events ending earlier in the evening.

In-home devices increased demand savings, but much of the total savings were acheived with just a web portal.

- Customers with in-home devices had significantly higher demand savings (up to 31%) than those without any technology (up to 15%).
- Customers without technology who visited the program web portal saved approximately twice as much in the second year of the Pilot as those who did not visit the web portal (this may be attributable to differences in motivation as well as to the web portal itself).
- Customers without technology made up 90% of the participants in the Pilot and approximately 70% of the total Peak Event savings.
- Customers with IHDs saved the most energy, followed by those with web portal access only. Those with PCTs had higher demand savings but lower energy savings.

Customers on the CPP rate saved more than those on the PTR rate.

- At each technology level, active customers on the CPP rate saved more than those on the PTR rate.
- Passive customers saved more on the PTR rate, but that could be due to a slightly higher level of engagement since they had to opt in to the PTR rate.
- The motivations to save on the CPP rate are greater than for the PTR rate, as on the CPP rate customers face higher bills if they don't save.

The PTR rate may be more appropriate than the CPP rate for those on fixed budgets or with health issues.

- Although the CPP rate saves money over the course of the year, bills do increase for many customers in the summer, potentially making the PTR rate a better choice for customers on a fixed or limited income.
- Additionally for those who have a limited ability to reduce their energy usage (because of elderly, ill, or limited mobility household members, pets who need cooler temperatures, electric medical equipment, etc.) the PTR rate may be more appropriate.

Information needs to be provided multiple times via multiple channels.

- Despite a plethora of communication from National Grid, half of customers without technology did not know it was available, and of the 40% who knew it was available, many did not understand the benefits.
- Additionally, many customers (56%) did not realize they had the option to switch price plans.
- Based on the focus groups, low-income customers had low awareness of the rates and technologies despite the high potential benefits to this group.

Customers want options to personalize notifications.

- Customers cited issues with the amount and methods of Conservation Day notifications in 2015, and responded well to additional promotion and simplification of personalization options in 2016.

Source: Navigant analysis

Evaluation Report Structure

This report is organized in the following chapters:

- **Chapter 1: Introduction**, describes the Pilot and summarizes the evaluation focus and objectives;
- **Chapter 2: Smart Energy Solutions Program Design**, summarizes rate design and technology choice, as well as program marketing, participation and segmentation;
- **Chapter 3: Impact Assessment**, summarizes the results of the peak event impact analysis, energy impact analysis, bill savings, and load shifting;
- **Chapter 4: Customer Experience Assessment**, summarizes participation drivers, participant awareness, engagement, and satisfaction;
- **Chapter 5: Lessons Learned from Program Implementation Staff**, discusses key learnings identified by program implementation staff, including aspects that worked well and also opportunities identified during Pilot implementation;
- **Chapter 6: Key Findings and Learnings**, draws everything together to provide key findings;
- **Appendices A through E,** provide detailed methodologies and results; and
- **Appendices F, G, and H** are provided as separate documents, and show graphs of event impacts by hour for residential customers, graphs of event impacts by hour for commercial customers, and graphs of event impacts for residential customers by demographic subgroup, respectively.

1. INTRODUCTION

Massachusetts Electric Company and Nantucket Electric Company d/b/a/ National Grid's (the Company or National Grid) Smart Energy Solutions Pilot program (the Pilot or Smart Energy Solutions) is an innovative smart grid pilot combining deployment of advanced meters, customer-facing technologies, and time-of-use (TOU) rates. The informational portion of the Pilot began in 2013, rates went live in January 2015, and implementation ran through the end of 2016. National Grid has filed for a two-year extension of the Pilot and the Massachusetts Department of Public Utilities (DPU) has granted an interim extension while they make a final decision. The Pilot also includes advanced distribution grid-side technologies which are the subject of a separate report.[26] This Pilot recruited customers through an opt-out model for residential customers and small businesses across a range of income and other demographic characteristics, providing a case study across a broad population sample. This evaluation, conducted by Navigant Consulting, Inc. (Navigant or the evaluation team), covers customer-side Pilot activities through the end of 2016. Navigant conducted the evaluation of the Pilot in accordance with the *Common Evaluation Framework*[27] produced by the Massachusetts Smart Grid Collaborative Technical Subcommittee (the Collaborative), a stakeholder group convened by the DPU to develop consistent evaluation themes and techniques across smart grid pilot programs in the state.

1.1 Smart Energy Solutions Pilot Description

Smart Energy Solutions was built on two important design principles focused on the customer and the distribution grid, respectively. First, the Pilot provided a new customer experience with regard to electricity delivery in the form of dynamic pricing, load control, and advanced communication interfaces. Second, the Company enhanced grid operations through advanced distribution technologies designed to markedly improve system reliability and operational efficiency. More specifically, Smart Energy Solutions included the following components:

- **Dynamic pricing** including TOU, critical peak pricing (CPP), and peak time rebates (PTR);
- **Advanced customer-side technologies**, including in-home displays (IHDs), programmable communicating thermostats (PCTs or smart thermostats), and other load controlling devices; and,
- **Advanced grid-side technologies**, including advanced communication systems, capacitor controls, and grid automation.

As shown in Figure 1-1, Smart Energy Solutions was deployed in four phases.

Phase 1. **Meter Deployment & Awareness.** In this initial phase the Company raised awareness about and installed advanced metering infrastructure (AMI) meters (also referred to as "smart meters") in approximately 15,000 homes and businesses. Five percent of customers offered AMI meters refused them.

Phase 2. **Introduction of Benefits.** In the second phase the Company introduced Smart Energy Solutions to raise customer awareness and create an expectation of more to come. Customer

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[26] National Grid. *Interim Grid-Facing Evaluation Report*, March 31, 2016.

[27] D.P.U. 10-82, Massachusetts Smart Grid Collaborative Technical Subcommittee, *Common Evaluation Framework*, March 23, 2011.

education efforts continued throughout the Pilot.

Phase 3. **Choice.** In Phase 3 National Grid customers chose between two Pilot rates, a TOU CPP rate and a PTR rate, and four technology packages that offered varying levels of information and control via web portal access, phone app, IHDs, PCTs, direct load control devices, and smart plugs.[28] The Sustainability Hub was also opened during Phase 3 as a resource for customers. The Hub provides hands-on education and engagement through a holistic approach, integrating various advanced technologies into a demonstration home.

Phase 4. **Focus on Customer Control.** Phase 4 began with the rates going live in January 2015. The Company called Conservation Days with specific Peak Event hours (Peak Events) on high-demand days, educated customers about their bills, assisted them in using the tools available to understand and control their energy usage, and allowed them to customize their participation through the many options available in the Pilot.

Based on its experience with the Pilot, the Company has observed the importance of gradual and ongoing customer outreach and education to introduce new concepts and technologies. By introducing demand response and connected devices early on, the hope was that customers would better understand and benefit from incremental savings that could be realized from the introduction of AMI and time-based rates. National Grid has filed for a two-year extension of the Pilot and the DPU has approved an interim extension. Under the interim extension the Pilot will remain in effect until the DPU comes to a final decision. If the proposal for extending the Pilot is approved or if the Company's Grid Modernization Plan is approved, the Company envisions offering Smart Energy Solutions participants the option to receive similar savings and benefits as they have enjoyed to date, in line with what is proposed in the Company's Grid Modernization Plan in D.P.U. 15-120. Otherwise, the Pilot participants will revert to basic rates and will be eligible for the same demand response incentives as other customers in the Company's service territory. Pilot participants who received in-home devices will be able to keep them regardless of the outcome of the extension.

The Company hopes to transition to a more advanced and integrated demand response management system (DRMS) that will be deployed during the Grid Modernization plan period if approved. The functionalities of this enterprise DRMS include the ability to schedule, dispatch, control and conduct evaluation, measurement, and verification of load curtailment demand response events.[29]

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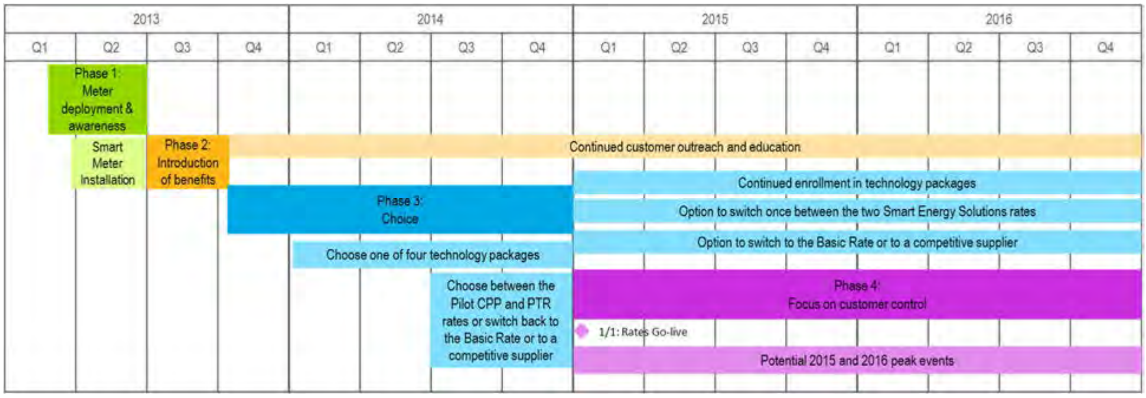
[28] Customers also had the option to remain on the Basic Rate, effectively leaving the Pilot, or to leave National Grid by switching to a competitive supplier. As a result, the Pilot contained an "opt-out" element for customers who didn't want TOU/CPP, and an "opt-in" element for customers who chose PTR or any of the technology packages. This design and customer flexibility set the Pilot apart from other utility dynamic rate pilots. Therefore, comparisons to other programs are anecdotal, as direct comparisons do not exist.

[29] National Grid. D.P.U. 15-120. *Grid Modernization Plan at Attachment 8*. August 19, 2015.

Figure 1-1. Four-Phase Rollout of Smart Energy Solutions



Source: Navigant and National Grid

1.1.1 Consistency with the Green Communities Act

The Pilot design complied with and exceeded the requirements of Section 85 of the Green Communities Act (GCA or the Act) passed in Massachusetts in 2008. The Act mandated that each investor-owned electric utility conduct a smart grid pilot with the overall objective of reducing active participants' peak and average loads by at least 5%. The pilot program must include, at a minimum, the following:

- Deployment of advanced meters that measure and communicate electricity consumption on a real-time basis;
- Automated energy management systems in customers' home and facilities;
- Time of use or hourly pricing for a minimum of 0.25 percent of the company's customers;
- Remote monitoring and control equipment on the Company's electric distribution system; and,
- Advanced technology to operate an integrated grid network communication system in a limited geographical area.

The Company adhered to these GCA principles by:

- Offering an opt-out TOU pricing option to approximately 15,000 customers, who make up more than 0.25% of National Grid's approximately 1.3 million customers;
- Seeking to achieve, for those customers who actively participated in Smart Energy Solutions, peak and average load reductions of at least 5%; and,
- Utilizing advanced technology to operate an integrated grid network communication system in a limited geographic area, including but not limited to:
    - Smart meters that provide real-time measurement and communication of energy consumption;
    - Automated load management systems embedded within current demand-side management programs; and,
    - Remote status detection and operation of distribution system equipment.

The Massachusetts Department of Public Utilities (DPU) recognized four unique elements of Smart Energy Solutions that differentiate it from other Section 85 pilot programs.[30]

1. The Company ***implemented the customer-facing and grid-facing components of the Pilot within one city***, a portion of Worcester, to allow National Grid to ascertain whether a comprehensive deployment of smart grid technologies produced synergistic customer benefits.
2. The Company ***deployed the program on an opt-out basis***, meaning all eligible customers in the Worcester area were offered an AMI meter and enrolled in Smart Energy Solutions by default but had the option to opt out if they weren't interested. Relative to opt-in programs where eligible customers must actively choose to participate, opt-out programs reach many more customers and thus have higher savings potential.
3. The ***default pricing option for the Pilot was a TOU rate, and the vast majority of Pilot participants remained on this rate***. Additionally, nearly 1,000 customers opted into technology packages which included in-home devices. Having a significant number of customers on a TOU rate with enabling technologies represented a unique opportunity to study these smart grid pilot components across a broad segment of the population.
4. National Grid's ***comprehensive outreach and education campaign combined both traditional and community-based elements***. It was designed to encourage customers to permanently change their energy consumption behavior in response to the price signals and other Pilot messaging. The Pilot also included the creation of the Sustainability Hub which serves as a model energy center in the community where National Grid provides hands-on education and engagement through a holistic approach, integrating various smart elements into a demonstration home.

1.1.2 Definition of Active Customers

In the context of an opt-out pilot, the GCA's goal of reaching 5% savings for "active" customers must be interpreted carefully. Some of the participants in an opt-out pilot will never actively engage with the program components. For evaluation purposes, Navigant defined active participants as anyone who opted into any in-home technologies and anyone with no in-home technology who logged into the Pilot web portal at least once.[31] Customers with no in-home technology who never logged into the web portal were considered "passive" participants in the Pilot. In other words, the passive customers did not take any actions to adopt technologies or check their electricity usage; however, these customers could still take actions to save energy as they were enrolled in the Pilot rates and received notifications for the Peak Events. By this definition, just under 25% of the Pilot participants were active at the end of 2016. This increased from just under 20% at the end of 2015.

1.1.3 Customer Decision-Making and Flexibility

Among smart grid pilots, Smart Energy Solutions was relatively complex with several key decision points

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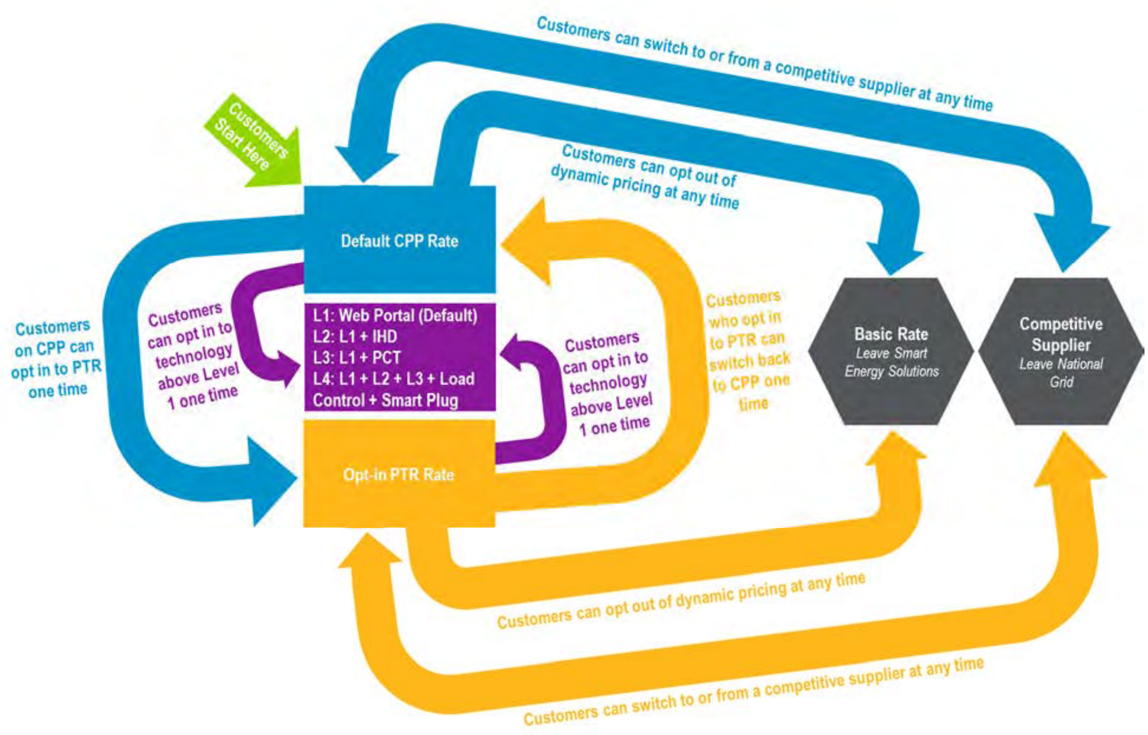
[30] D.P.U. Order 11-129. *Petition of Massachusetts Electric Company and Nantucket Electric Company, each d/b/a National Grid for approval of a smart grid pilot program.* August 3, 2012.

[31] Active customers were defined as of October 12, 2016 which was after the last Peak Event of the 2016 summer season.

for customers, as illustrated in Figure 1-2.

Figure 1-2. Smart Energy Solutions Customer Decision Points



Source: Navigant
Note: L1 = Level 1, L2 = Level 2, L3 = Level 3, L4 = Level 4, IHD = in-home display, PCT = programmable communicating thermostat.

Smart meters and choice of rates. Eligible customers in the Worcester area who accepted a smart meter were enrolled onto the CPP rate by default.[32] Customers had the option to opt into the PTR rate one time during the Pilot; customers who initially opted into the PTR rate could switch back to the CPP rate one time. Customers could also choose to switch back to the Basic Rate, thus opting out of the Pilot, or to switch to and from a competitive supplier, thus leaving or returning to National Grid, at any time. Customers using a competitive supplier effectively left the pilot, thus reducing the program population.

Technology choice. Customers on the CPP and PTR rates also had a choice of four technology packages, with Level 1 (web portal only) as the default. Some of the technology packages had eligibility

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[32] Customers also had the option to decline the smart meter and, therefore, opt out of the Pilot at the outset.

requirements related to internet access and central air conditioning.[33] Technology options became more advanced, offering more electricity usage information and control, from Level 1 to Level 4:

- Level 1: Personal electric use information, via access to a web portal;
- Level 2: Level 1 plus an IHD with energy use and real time cost information and access to this information through the web portal;
- Level 3: Level 1 plus a programmable-controllable thermostat (PCT) and a mobile app to view the PCT schedule; or,
- Level 4: Level 1, Level 2, and Level 3 plus a smart plug and, for some customers, a wired load control device, and additional capability in the mobile app to show load control and smart plug usage.

Conservation Days. According to the approved Pilot design, National Grid could call up to 30 Conservation Days each year on days with expected high demand. High humidity (dew point levels) in combination with high temperatures typically drove customer usage upward and initiated the process of calling a Conservation Day. On these days, the price of electricity increased during designated hours, called Peak Event hours. On the CPP rate, customers were incented to conserve electricity, or shift usage to non-Peak Event hours, and thus avoid paying the high electricity prices during Peak Event hours. On the PTR rate, customers received a rebate for any electricity conserved during these hours.

National Grid used day-ahead ISO New England (ISO-NE) usage data and day-ahead weather forecasts for the City of Worcester to project whether to call a Conservation Day for customers in the Pilot. The ISO-NE usage forecast was adjusted based on the Worcester weather forecast and an event was proposed if a specific MW threshold[34] was met or exceeded for the next day. The suggested number of Peak Event hours (including start and end time) and the thermostat override temperature were then sent for Director approval. If approved, the event was scheduled through the CEIVA Entryway system and notifications were made to all customers the day before the event through the customer's preferred communication methods (email, SMS text message, and/or phone call). Customers who opted into day-of notification were also notified on the day of the Peak Event.

National Grid called twenty Peak Events in each summer of the Pilot (2015 and 2016). Events ranged from four to eight hours in length and maximum temperature and relative humidity ranged from 79°F to 92°F and 67% to 100%, respectively. The Peak Events averaged 6.75 hours in length and totaled 135 hours in 2015. Events were slightly longer in 2016, averaging 6.95 hours in length and totaling 139 hours. Nine of the Peak Events in 2015 and 10 in 2016 ran for the maximum length of eight hours. Seventeen of the 20 events in 2015 and 16 of the 20 events in 2016 were part of a back-to-back series, when events occurred multiple days in a row. The length of the event and weather are shown for each Peak Event in Figure 1-3.

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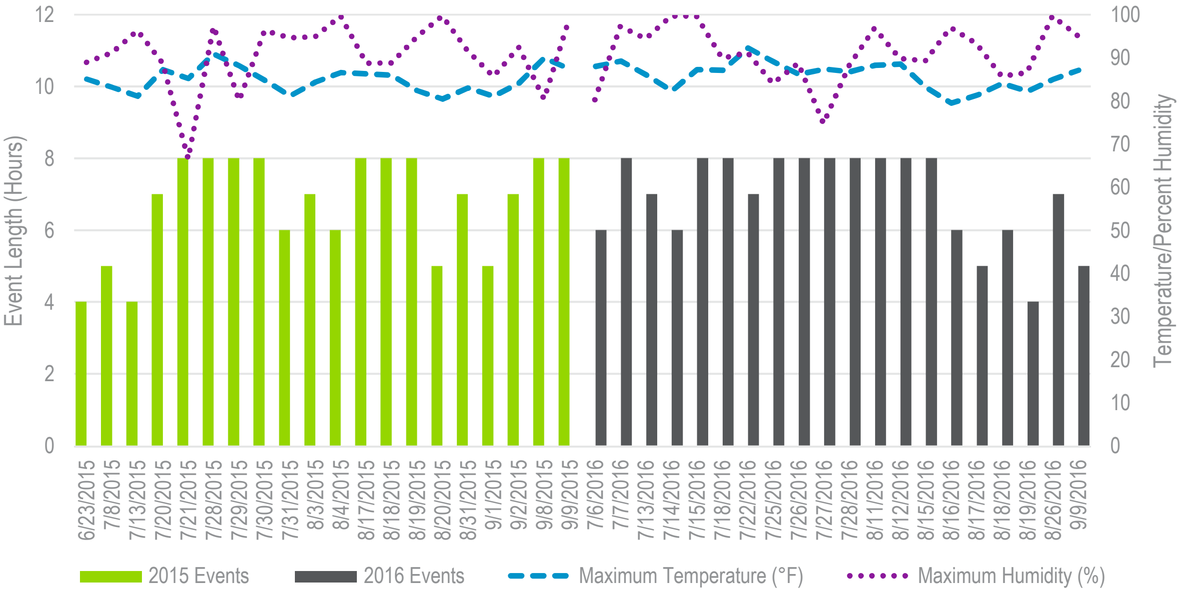
[33] For example, in order to be eligible for the Level 2 package with a digital picture frame, customers had to have a high-speed broadband Internet connection. To be eligible for Level 3 with a PCT, customers had to have central air conditioning. To be eligible for Level 4 with a PCT and a smart plug and/or load control device, customers had to have central air conditioning and a high-speed broadband Internet connection.

[34] As of the writing of this report, the threshold was 22,315 MW.

Figure 1-3. Summary of Peak Event Length, Temperature, and Humidity



Source: Navigant analysis

The weather was relatively similar across the two summers of the Pilot. The average Conservation Day temperature was 75°F in 2015 and 76°F in 2016. Similarly, the average maximum temperature on Conservation Days was one degree hotter in 2016 than 2015, going from 85°F to 86°F. The Conservation Day humidity was also similar, averaging 67% in 2015 and 65% in 2016 and achieving average maximums of 91% in each year.

Compared to 2015, the Peak Event start and end times were more varied in 2016, especially on days of back-to-back Peak Events as shown in Figure 1-4. Additionally, the degree setbacks for the customers with PCTs were lower in 2016 than in 2015. In 2015 degree setbacks were 3 or 4°F, averaging 3.4°F, and in 2016 degree setbacks were 2 or 3°F, averaging 2.6°F. These changes were made in response to customer feedback at the end of the 2015 Peak Event season.

Figure 1-4. Summary of Peak Event Start and End Times and Degree Setback

Source: Navigant analysis

1.1.4 Community Partnership and Sustainability Hub

To ensure that the Pilot was a collaborative effort with the community, National Grid partnered with the City of Worcester to host the September 2011 Green2Growth Summit (Summit). The Summit provided valuable insights into customers' visions regarding the future of energy delivery in their city. National Grid learned that its customers are increasingly aware of new opportunities to manage their energy consumption and are open to learning more about the potential uses and benefits of smart technology. Based on information gathered through the Summit, the Company revised the Pilot's Outreach & Education plan, implemented in Phases 2-4 of Figure 1-1.

As an additional means of engaging customers, based on information gathered through the Summit, the Company developed a Sustainability Hub in Worcester (Figure 1-5). The Sustainability Hub serves as a model energy center in the community where National Grid provides hands-on education and engagement through a holistic approach, integrating various smart elements into a demonstration home. At the end of 2016, over 8,200 people have visited the Sustainability Hub since it opened, and it has been mentioned by many customers as a useful source of information alongside direct mail, the Smart Energy Solutions website, and National Grid's Customer Contact Center.[35] A survey administered by the Sustainability Hub also found that customers ranked the Hub highly as a source of information (see APPENDIX C).

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[35] As of January 3, 2017.

Figure 1-5. National Grid Sustainability Hub

Source: National Grid

1.1.5 Statewide Common Evaluation Framework

Navigant conducted the evaluation of the Pilot in accordance with the *Common Evaluation Framework*[36] produced by the Massachusetts Smart Grid Collaborative Technical Subcommittee (the Collaborative), a stakeholder group convened by the DPU to develop consistent evaluation themes and techniques across smart grid pilot programs in the state. The evaluation included quantitative measures of energy, demand, and customer bill impacts, as well as qualitative measures for customer engagement, satisfaction, and perceptions through customer surveys, interviews, and focus groups.

1.2 Evaluation Focus and Objectives

Smart Energy Solutions focused on understanding the customer experience with dynamic rates and advanced technologies. As shown in Figure 1-6, National Grid had multiple communications channels to provide customers with information about the program and the rates and technologies available. This evaluation focused on customer awareness of smart meters, rates, and technologies; the choices customers made to adopt and use smart meters, rates, and technologies; and the savings that resulted from the use of each technology.

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[36] D.P.U. 10-82, Massachusetts Smart Grid Collaborative Technical Subcommittee, *Common Evaluation Framework*, March 23, 2011.

Figure 1-6. National Grid's Multiple Program Communication Channels with Customers

Source: Navigant analysis

1.2.1 Impact Evaluation Objectives and Approach

The primary focus of the impact evaluation was on whether the expected energy and demand savings were realized. In particular, the impact evaluation estimated the following:

1. **Peak Event Impacts,** which are demand savings (MW) during Peak Events called in the summers of 2015 and 2016;
2. **Energy Impacts,** which are energy savings (MWh) from the Pilot in 2015 and 2016; [37]
3. **Bill Impacts,** which are dollar savings on customer bills in 2015 and 2016; and,
4. **Load Shifting** around Peak Events, including snapback and pre-cooling, and from peak to off-peak times in 2015 and 2016.

Each of these objectives is explored for customers in different price plans with different levels of enabling technology. Where possible, Navigant also explored these impacts for different demographic subgroups. The impact findings in this report are primarily focused on residential customers. Commercial customers were a very small portion of the Pilot participants and outcomes were explored for them to the extent possible based on the constraints of the small sample. Short descriptions of each methodology are

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[37] To a lesser extent, Navigant also examined savings from 2014 when the informational portion of the Pilot was in effect but the Pilot pricing had not yet gone into effect.

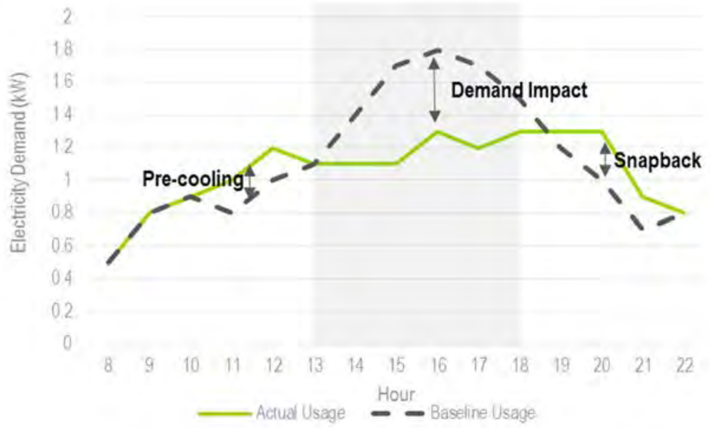
presented here and detailed explanations are included in APPENDIX A.

Peak Event Impacts

Navigant estimated demand savings during each Peak Event by regression to predict fitted usage from 8 a.m. to 10 p.m. on each Conservation Day controlling for temperature, humidity, day of the week, month, and a customer fixed effect that controlled for all observed and unobserved customer-specific variables that do not change through time.[38] 2014 was used as the pre-program baseline for each year with Peak Events. Demand savings were then determined as follows:

1. Fitted usage is the model's prediction of what usage would have been in the absence of a Peak Event, and forms the baseline or "counter-factual" usage.
2. The regression coefficient which estimated the demand savings in each hour of each Peak Event is the same as subtracting actual usage from the fitted baseline for each hour of the Peak Event.[39] The possibility of pre-cooling and snapback were also accounted for in this process, which is illustrated in Figure 1-7.

Figure 1-7. Illustration of Hypothetical Demand Impacts for an Event from 1 p.m. to 6 p.m.



Source: Navigant

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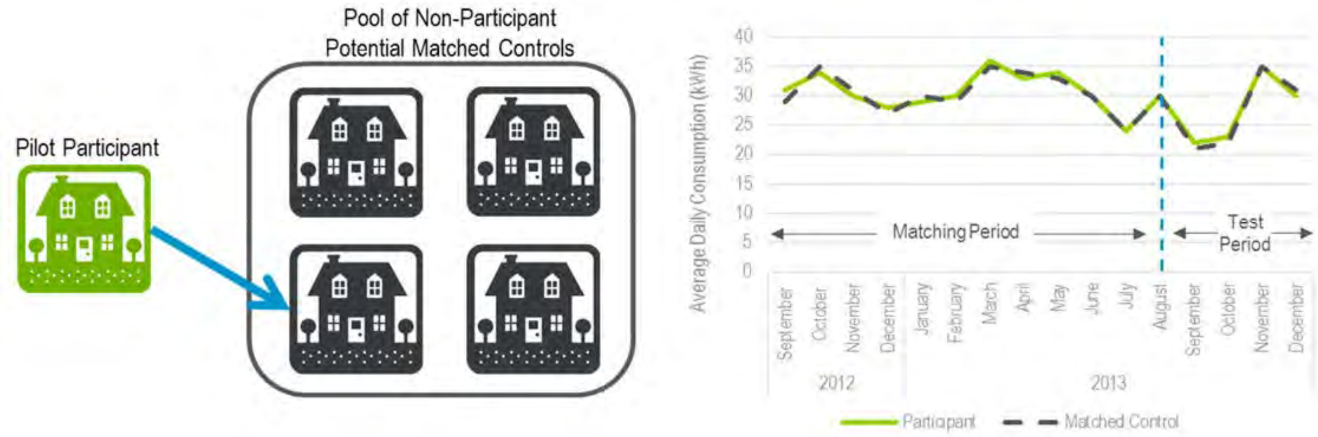
[38] Navigant's method to determine Peak Event savings differed from the method National Grid used internally. National Grid calculated reduced usage as the difference between metered usage during the Event and "normal" usage, defined as average usage during the ten prior non-holiday, non-Conservation Day weekdays after accounting for a day of adjustment to capture weather differences, time of event, pre-cooling, etc. Details of National Grid's method can be found in: D.P.U. No. 1237, Tariff for Basic Service, September 3, 2014. Both of these methods are consistent with MA evaluation protocols and are intended for different purposes. National Grid's method is intended to produce faster feedback on the program results in support of monthly customer billing, whereas Navigant's method uses more data over a longer time horizon to allow for the most robust estimate of savings for the Pilot as a whole, making it more appropriate for post hoc evaluation.

[39] In 2015, a day-of adjustment was used to make fitted usage a more accurate approximation for the actual usage that would have occurred if a Conservation Day had not been called by National Grid. For this adjustment, actual usage was subtracted from fitted usage for each Conservation Day for the time from 8 a.m. until the start of the Peak Event. This day-of adjustment was dropped in 2016 to simplify the calculation of standard errors. The adjustment was very small and did not make a statistically significant difference in program peak savings impacts.

Energy Impacts

In order to calculate energy impacts, the evaluation team selected a group of matched control customers from a large pool of non-participant households. Participants were matched by identifying a non-participant that had energy usage similar to that of each participant over a 12-month period before the Pilot started to provide the counter-factual usage if the participants had not been in the Pilot.[40] The 12-month matching period went from September 2012 to August 2013, leaving a 4-month test period from September 2013 to December 2013 to ensure that the matches were performing well (i.e., continued to have usage similar to the participants) outside of the matching period but before the program started. This matching process is illustrated in Figure 1-8. Regression analysis of monthly billing data using the participants and matched controls was then used to estimate the annual reduction in energy usage for 2014 and the reduction by month in 2015 and 2016.

Figure 1-8. Hypothetical Illustration of Choosing Matched Control Households with Similar Pre-Pilot Energy Usage



Source: Navigant

Bill Impacts

Bill savings for customers on the CPP rate were calculated by subtracting the actual participant bill amount from the counter-factual bill amount if the participant had not joined the program. The counter-factual bill amount was based on the counter-factual usage estimated by the energy impact analysis.

Bill savings for customers on the PTR rate came from the rebates paid by National Grid for reducing peak consumption during Peak Events on Conservation Days. National Grid calculated reduced peak consumption as the difference between metered usage during the Peak Event and “normal” usage, defined as average usage during the ten prior non-holiday, non-Conservation Day weekdays after accounting for a day-of adjustment to capture weather differences, time of event, pre-cooling, etc. The reduction was multiplied by the cost of the rebate to determine the rebate due to the customer.[41]

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[40] To avoid the issue of control customers moving out, only controls who had billing data through the end of 2016 were used.

[41] Details can be found in: D.P.U. No. 1237, Tariff for Basic Service, September 3, 2014.

Load Shifting

The regressions to estimate demand savings also included coefficients to capture load shifting attributable to the Pilot. Navigant captured load shifting on the same day as a Peak Event by estimating pre-cooling and snapback. Load shifting from weekdays, when TOU rates were in effect for CPP customers, to weekends, when customers were charged a flat rate, was also estimated. Navigant also examined whether the Pilot caused non-event peak impacts where customers shift loads from on-peak to off-peak times on days when a Peak Event was not called. Load shifting to the weekend and non-event peak impacts are expected for TOU customers, but not necessarily for PTR customers since these customers were not charged a higher peak time rate which would incent them to shift usage to off-peak times or weekends.

1.2.2 Customer Experience Evaluation Objectives and Approach

The primary focus of the customer experience evaluation was on customer engagement and experience. The Smart Energy Solutions evaluation plan was developed by an independent consultant in accord with the *Common Evaluation Framework*[42] produced by the Collaborative, a stakeholder group convened by the DPU to develop consistent evaluation themes and techniques across the three smart grid pilot programs in Massachusetts. The Collaborative recognized that each program had some unique characteristics, particularly the National Grid opt-out program design, so the framework was made broad enough to accommodate different program designs but still provide comparable data from each. The Collaborative included National Grid and other participating investor-owned utilities, the Low-income Energy Action Network (LEAN), the Massachusetts Attorney General, and the Energy Efficiency Advisory Council (EEAC) chief evaluation consultant. As part of the *Common Evaluation Framework*, the Collaborative developed a base set of required surveys, reporting requirements, protocols, and reporting tables.

The Collaborative raised a number of key research questions related to customer experience in the Pilot. These research questions focused on marketing and education. As Smart Energy Solutions was an opt-out program, wherein customers could opt out of the smart meter and opt out of the default time-based rate, the evaluation team applied the *Common Evaluation Framework* marketing questions that apply to meter installations, rate selection, and adoption of the program's technology offerings. Additionally, the framework applies to marketing means and messages used for recruiting and their effects, results of multiple recruiting waves and techniques, how participants learned of the program, and their reasons for participation or nonparticipation; these topics were not particularly applicable to the Pilot due to its opt-out nature.[43] To address the framework topics, extensive surveying was conducted over the two years of the Pilot (Figure 1-9).[44] The evaluation also included convening focus groups for low-income participants in both years and interviewing commercial participants to gain additional insights to supplement the surveys. In total, the surveys, focus groups, and interviews achieved approximately 4,800 completes.

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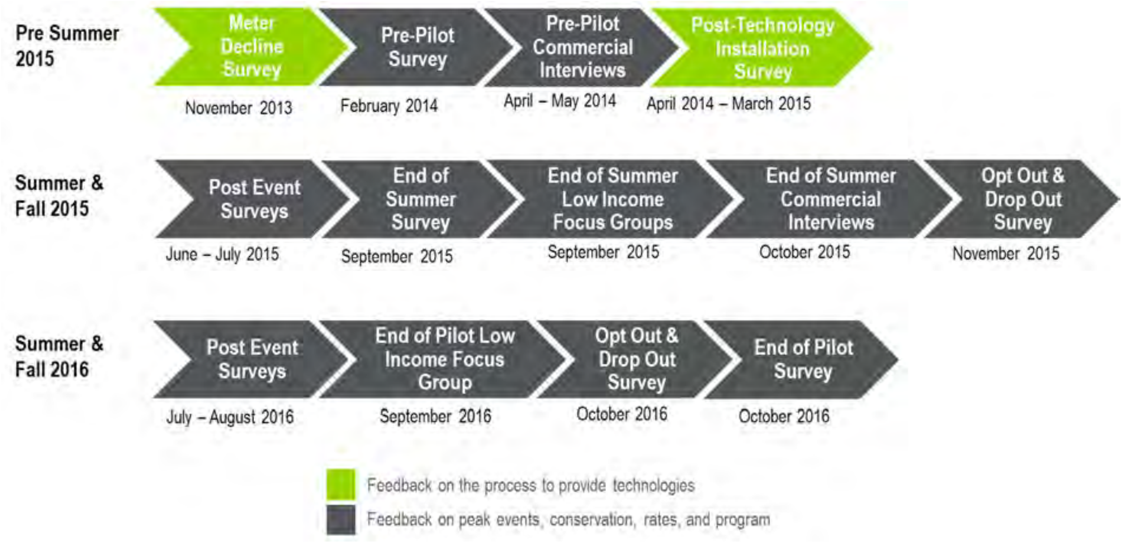
[42] D.P.U. 10-82, Massachusetts Smart Grid Collaborative Technical Subcommittee, *Common Evaluation Framework*, March 23, 2011.

[43] Survey findings regarding motivations driving customer participation in the Pilot are included in Section 4.1, and mechanism for how customers heard about the Pilot are included in APPENDIX C.

[44] The surveys were designed by Navigant and implemented by Bellomy Research, a professional survey company, at several key points in the program. All surveys, excepting the pre-pilot survey, were conducted online, using email to invite participants to survey links. Online responses were supplemented by telephone contacts, using both inbound (participants called in) and outbound techniques, to ensure a broader sample of survey participants.

Figure 1-9. Smart Energy Solutions Surveys, Interviews, and Focus Groups



Source: Navigant analysis

Below is a description of the activities depicted in Figure 1-9 and the elements of the customer experience they sought to capture.

- **Meter decline survey:** Determine why customers declined a smart meter and whether they were aware that not installing one would preclude them from participating in Smart Energy Solutions.
- **Pre-pilot survey:** Characterize participant demographics, appliance saturations, and living conditions that might impact participants' ability to adjust their energy usage during regular peak hours (8 am to 8 pm) and Peak Event hours, such as household members who require air conditioning or special medical equipment that must operate during Peak Events.
- **Pre-pilot commercial interviews:** Through five interviews in 2014, anecdotally characterize commercial customer understanding of the program, rates, and knowledge and acceptance of program technologies, as well as their ability to adjust their energy usage during Peak Events.
- **Post installation survey:** Evaluate the experiences of customers who signed up for technology Level 2, 3, or 4 (refer to Section 2.2 for more detail on the technology levels), which provided no-cost in-home installation of an IHD, smart thermostat, and smart plug and load control device, respectively. This survey asked about the promptness and quality of the installation, problems encountered, the conduct of installers, and related issues.
- **Post event surveys:** These surveys were conducted within a one to ten day period after two of the 20 Peak Events called during each summer to learn about the methods and efficacy of National Grid's pre-event information, energy-related actions taken by the customer before and during the event, comfort levels during the event, satisfaction with program technology, and overall satisfaction with the program.
- **2015 end of summer survey:** After the last Peak Event called during the summer of 2015, this survey aimed to understand customer experiences with the program over the course of the summer, including how they coped with multi-day events, events lasting several hours, changes in household patterns resulting from the events, and how well technology performed and how

useful it was. The survey also looked for trends or changes in these areas over the course of the summer.

- **2015 end of summer low-income focus groups:** Navigant hosted two low-income focus groups at the end of the 2015 summer – one for Level 1 customers and one for Level 2 customers – to gauge their understanding of the program and rates, experiences with the program over the course of the summer, technology use (for Level 2 customers only), and recommendations to improve the program.
- **2015 end of summer commercial interviews:** Through four interviews in 2015, anecdotally characterize commercial customer understanding of the program, rates, and technologies, assess their experiences with the program over the course of the summer, and collect their recommendations to improve the program.
- **Opt-out and drop out surveys:** Ascertain customer perceptions and motivations for moving from one rate to the other and/or dropping out of the program altogether. There were very few participants who took either of those actions during the Pilot. Customers who switched to competitive suppliers, and therefore are no longer National Grid supply customers, were not surveyed.
- **2016 end of pilot survey:** After the last Peak Event called in the two-year Pilot, this survey aimed to understand customer experiences with the program over the course of the entire Pilot, including many of the same themes from the 2015 end of summer survey. This survey also asked about knowledge of and response to bill protection and how customers changed their behavior from the first summer to the second. Additionally, the survey looked for trends and changes over the course of the Pilot.
- **2016 end of pilot low-income focus group:** Navigant hosted one low-income focus group at the end of the Pilot for customers with and without technology. The topics were similar to those covered in the focus groups at the end of the 2015 summer.

2. SMART ENERGY SOLUTIONS PROGRAM DESIGN

Smart Energy Solutions offered customers a choice between two new dynamic rates and four technology packages that provided electricity usage information and control. The technology packages offered varying levels of information and control via a web portal, mobile app, IHD, PCT, smart plug, and direct load control device. Starting in the spring of 2014, customers began selecting their rate plan and technology package. To support customer choice, the Pilot allowed customer to change rates one time and technology package enrollment any time.

The three key elements of this chapter are:

1. **Rate Design –** the dynamic rate that applies to Pilot participants, depending on whether they accepted the default CPP rate or opted into the PTR rate.
2. **Technology Choice –** the set of in-home and communications technologies selected by participants and provided by National Grid to provide customers with pricing and usage information, conservation tips, and the ability to better control their energy consumption.
3. **Program Marketing, Participation, and Segmentation –** the self-selection of customers into the various rate and technology categories, the strategy used to recruit customers into the different rates and technologies, and the demographic breakdown of the eligible customer population.

2.1 Rate Design

Smart Energy Solutions offered two dynamic rate designs: 1) a TOU rate combined with CPP and 2) a PTR rate. Participating customers had the opportunity to save money on both rates, but CPP customers could potentially incur higher bills if they did not reduce consumption during higher priced periods. These rates went live at beginning of 2015 and remained active through December 2016.[45] As discussed in Section 1.1, customers could leave the Pilot at any point by opting out of the dynamic rates or switching to a competitive electricity supplier, and they could switch between the two Pilot rates once.[46]

According to the Pilot design, National Grid could call up to 30 high demand days per year, called Conservation Days (Figure 2-1). Customers chose the frequency and method of Conservation Day notification. Everyone was notified of Conservation Days one day ahead and they could choose to be notified on the day of the event as well. The price of electricity increased during designated hours, called Peak Event hours, on these days. The length of the Peak Event varied across the Conservation Days. On the CPP rate, customers paid reduced rates outside of Peak Event hours and were incented to conserve electricity to avoid paying high electricity prices during Peak Events. On the PTR rate, customers received a rebate for conserving electricity during these hours.

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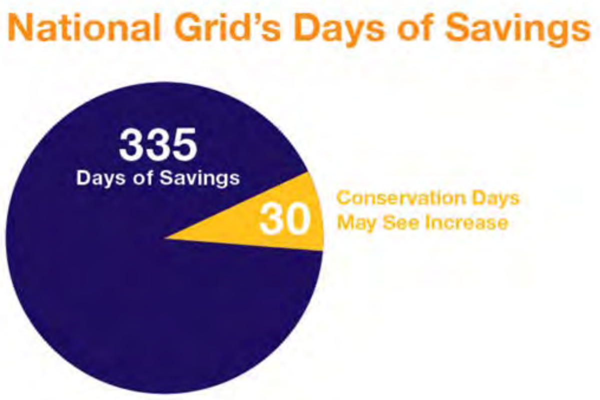
[45] The rates continue in 2017 under the interim extension of Smart Energy Solutions granted by the DPU.

[46] Customers who left National Grid for a competitive supplier received a letter from National Grid informing them that they could no longer participate in Smart Energy Solutions because they were no longer a National Grid customer. Customers could of course return to National Grid, and if they did so they received a letter informing them that they would be re-enrolled in the Pilot on the default CPP rate.

Figure 2-1. Smart Energy Solutions Conservation Days

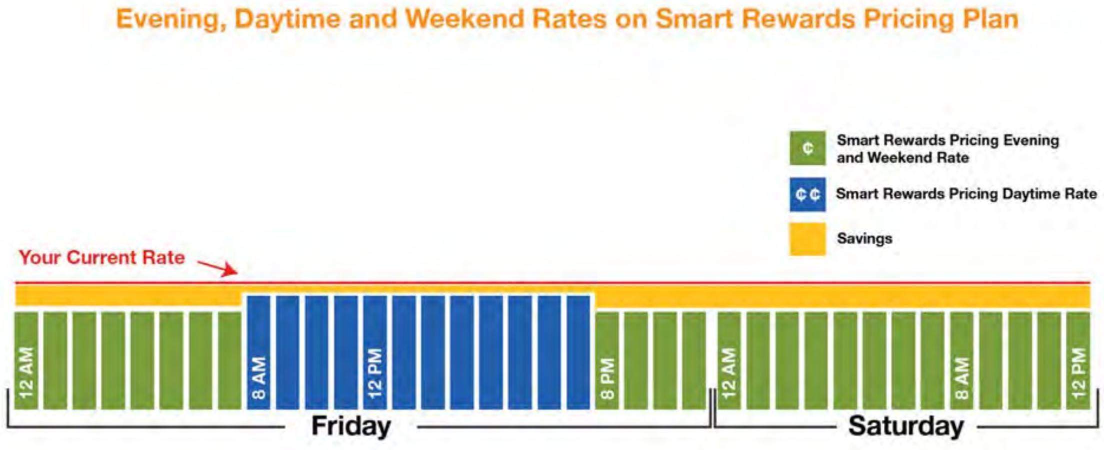


Source: National Grid

2.1.1 Critical Peak Pricing

The Pilot CPP rate combined a daytime TOU rate and a critical peak rate during Peak Event hours. The Pilot CPP rate offered a base TOU structure with lower daytime rates and even lower night, holiday, and weekend rates. Customers were encouraged to shift energy-intensive weekday activities to any time before 8:00 a.m., after 8:00 p.m., or to weekends. As shown in Figure 2-2, customers paid a lower rate than the current Basic Rate every day of the year. The TOU Evening and Weekend rate was in effect all day on weekends and holidays, and every weekday from 8:00 p.m. to 8:00 a.m. From 8:00 a.m. to 8:00 p.m. on weekdays, customers paid a slightly higher rate, called the Daytime Rate.

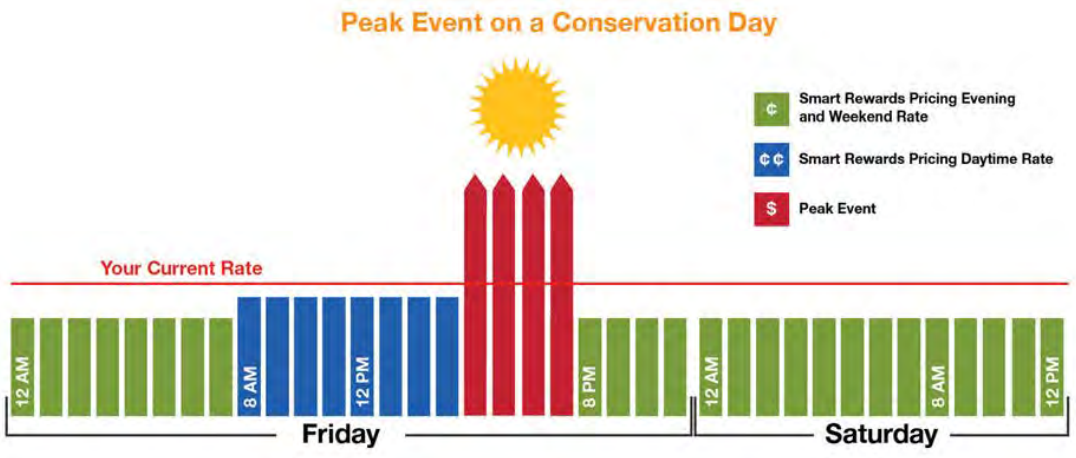
Figure 2-2. TOU for Evening, Daytime, and Weekend Rates



Source: National Grid
Note: "Your Current Rate" refers to the Basic Rate customers were on before the start of Smart Energy Solutions.

In addition to the TOU rate in effect every day, National Grid called Conservation Days where a higher rate was charged during certain Peak Event hours. An example of these hours and the associated CPP prices is shown in red in Figure 2-3. These customers were eligible for bill protection if they stayed on the CPP rate for at least 12 consecutive months; this meant that if at the end of the year their bills were higher than they would have been on the Basic Rate, the customer received a credit in the amount of the difference.

Figure 2-3. Critical Peak Pricing During a Conservation Day Peak Event



Source: National Grid
Note: "Your Current Rate" refers to the Basic Rate customers were on before the start of Smart Energy Solutions.

2.1.2 Peak Time Rebate

The PTR rate allowed customers to stay on their current service rate, rather than switching to the CPP rate, and earn a rebate when they reduced consumption below their normal use during Peak Event hours on Conservation Days. The rebate was given to customers in the form of a monthly credit applied at the end of each billing cycle, which was the cumulative rebate for all of the Peak Events that occurred during that billing cycle.

The rebate was based on a per-kWh credit that applied to any reduced energy usage during Peak Event hours. National Grid calculated reduced usage as the difference between metered usage during the Event and "normal" usage, defined as average usage during the ten prior non-holiday, non-Conservation Day weekdays after accounting for a day-of adjustment to capture weather differences, time of event, pre-cooling, etc.[47] Customers were not penalized for usage which was higher than normal.

2.2 Technology Choice

The core components of National Grid's smart technology end-to-end solution were advanced metering infrastructure (AMI), in-home energy management devices, two-way communications systems, cloud computing, National Grid system modifications and data processing, and distribution grid communication and standards. These components directly supported the customer-facing portion of Smart Energy Solutions. National Grid offered Smart Energy Solutions customers an assortment of in-home energy

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[47] D.P.U. No. 1237, Tariff for Basic Service, September 3, 2014.

management tools and technologies for free. Customers could sign up on the National Grid website, by mail, by calling National Grid, in person at the Sustainability Hub, or at any of the community events that National Grid attended with a Smart Energy Solutions information booth. As discussed in Section 1.1, National Grid allowed customers to select from these technologies throughout the Pilot in order to maximize customer choice and provide opportunities for new customers who moved into the Pilot area to sign up.

The technologies provided by National Grid included both a foundational infrastructure and several optional in-home devices:

1. **Foundational Infrastructure -** consisted of smart meters and access to a web portal with electricity usage information via desktop computer or mobile device. This foundational infrastructure was provided to all participants, even those passive participants who accepted a smart meter but otherwise did not actively participate in the Pilot.
2. **In-Home Devices –** consisted of any of three additional levels of devices including a communicating digital picture frame or in-home display (IHD) (Level 2), a Wi-Fi-enabled smart thermostat, or programmable communicating thermostat (PCT) (Level 3), and smart plugs and load control devices (Level 4).

2.2.1 Foundational Infrastructure

To enable Smart Energy Solutions, National Grid installed two-way AMI communications and smart meters, developed cloud computing capabilities, and, on an ongoing basis, offered customers a variety of in-home devices (further detailed in Section 2.2.2). AMI communications consist of a meter headend, wireless mesh network and cellular backhaul, and a network manager, which is integrated with the Company's software as a service (SaaS) systems. As a result, National Grid can provide real-time interconnection for customers to control their smart thermostats remotely and monitor their electricity usage from any online or mobile device, anytime and anywhere. The two-way communication infrastructure is also being used to enable the Pilot's distribution automation equipment, which supports reliability and efficiency gains and can facilitate distributed energy resources and electric vehicle charging station integration.

National Grid offered four technology packages, or levels, for customers to choose from. Pilot participants were automatically enrolled in Level 1 and had the option to opt into one of the three higher technology levels with in-home devices. Customers who opted in to a higher level still had access to Level 1.

In Level 1, illustrated in Figure 2-4, customers had access to their electricity usage information via the Smart Energy Solutions web portal that is accessible by desktop and mobile devices, which provided personalized online graphical electric usage information, comparisons to friends and neighbors, and the opportunity to participate in contests to win prizes for conserving electricity.[48] In 2016, the web portal also included a rewards platform which allowed customers to earn points for saving energy and engaging with the program. Points could be redeemed for gift cards at national and local retailers.

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[48] Logging into this web portal at least once distinguished active customers from passive customers in Level 1.

Figure 2-4. Level 1: Web Portal (Accessible by Desktop and Mobile Device)

Source: National Grid

2.2.2 In-Home Devices

Figure 2-5 shows Level 2, which provided a digital picture frame—also called an IHD—that provides real-time energy usage and cost information as well as conservation tips from National Grid.

Figure 2-5. Level 2: Web Portal, Mobile App, and Digital Picture Frame

Source: National Grid

Interested customers with central air conditioning (CAC) qualified for Level 3, which included a smart thermostat, also called a PCT, which can be remotely controlled by National Grid (Figure 2-6). The PCT allowed these customers, if they so chose, to “set it and forget it” on Conservation Days, ensuring their participation in a Peak Event. Customers with a smart thermostat also had the option to opt out of a Peak

Event before it started, maintaining the set temperature of their thermostat, or to override the utility setback temperature at any time during a Peak Event.

Figure 2-6. Level 3: Web Portal, Mobile App, and Smart Thermostat

Source: National Grid

Lastly, customers could opt to install all of the aforementioned devices along with smart plugs and load control devices in their home through Level 4 (Figure 2-7). The smart plugs allow customers to remotely adjust any appliance plugged into them, such as a window unit air conditioner. The load control devices, installed for only some customers in Level 4, work with devices such as water heaters and/or pool pumps.

Figure 2-7. Level 4: Web Portal, Mobile App, Digital Picture Frame, Smart Thermostat, Smart Plug, and Load Control Devices

Source: National Grid

2.3 Program Marketing, Participation, and Segmentation

Before and throughout the Pilot, National Grid implemented a “listen, test, learn” approach that is based on “on the ground” conversations and reflections on the Pilot. This feedback, combined with learning, leads to continual improvement. National Grid conducted extensive program marketing in the lead up to initiating meter installations, the first phase of the program. These activities included convening a public summit to discuss the proposed program, development of brochures explaining the program, and establishment of the staffed, physical Sustainability Hub within the Pilot program area. National Grid also partnered with local schools. Clark University offered annual internships, and Worcester Polytechnic Institute created a student Sustainability Ambassador program. Ambassadors host Sustainability Hub tours and attend outreach events to educate customers throughout the community. Presenting the personal side of the Company is part of the “listen, test, learn” approach, and is the inspiration for sending National Grid employees and Ambassadors into the community. It is also the basis for hosting visitors at the Sustainability Hub for the dual purpose of educating customers and listening to their concerns and feedback.

As the program progressed, additional materials were developed and disseminated, including descriptions of the technology levels, rates, and events; welcome kits; and so on. National Grid conducted extensive recruiting campaigns for the program technology options, including a variety of incentives and promotions, but found participant response in 2014 to be somewhat less than expected resulting in an extended signup period that extended throughout the Pilot.[49]

2.3.1 Technology and Rate Enrollment

Table 2-1 shows the distribution of customers in the various technology levels as of January 1, 2017. At that time, approximately 91% of Pilot participants were subscribed to Level 1, followed by 6% of participants in Level 2, 2% of participants in Level 4, and only 0.3% of participants in Level 3. Approximately 95% stayed on the default CPP rate.

Table 2-1. Customer Enrollment by Technology Level and Price Plan (as of January 1, 2017)

Level	Price Plan	Number of Residential Customers	Number of Commercial Customers
1 (AMI meter + web portal + mobile app)	CPP - Active	1,456	26
	CPP - Passive	7,459	456
	PTR - Active	92	1
	PTR - Passive	338	18
2 (Level 1 + digital picture frame)	CPP	640	1
	PTR	32	0
3 (Level 1 + smart thermostat)	CPP	28	0
	PTR	4	0
4 (Level 1 + Level 2 + Level 3 + load control devices)	CPP	237	0
	PTR	15	2
Total		**10,301**	**504**

Source: Navigant analysis
Note: The active/passive status of Level 1 customers was determined as of October 12,2016 which was after the final event of the 2016 summer season.

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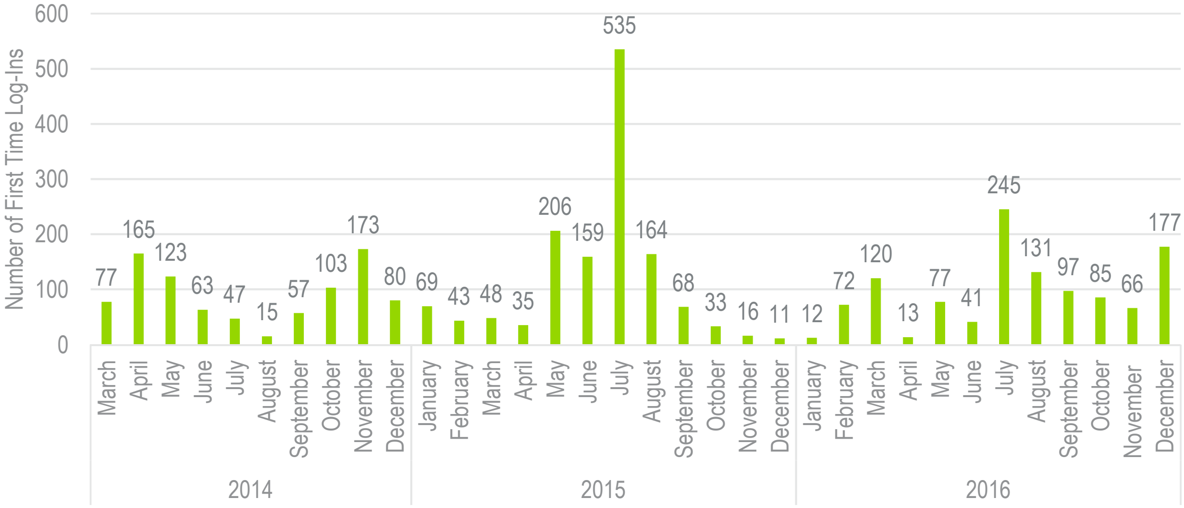
[49] Although active promotion ended in 2015, Pilot customers were able to enroll in the technology packages through the end of 2016 if they wished to do so and met the eligibility requirements.

There were a total of 2,504 active customers in the Pilot at the end of 2016; an increase of 478 (or 22%) compared to the end of 2015. This is the net increase, meaning it includes increases resulting from new customers joining the Pilot and achieving an active status, increases from passive customers shifting to active (either by accessing the web portal or opting into a technology package), and decreases due to active customers leaving the Pilot. National Grid undertook efforts to increase active participation in the second summer of the Pilot, such as launching the rewards platform, described further in Section 2.3.2.

Figure 2-8 shows the first time that active customers logged into the portal throughout the pilot by month. In both 2015 and 2016, the highest frequency of initial log-ins to the portal was in July, which is also when Conservation Days ramped up in each summer. The high frequency of initial log-ins in July indicates that Peak Events piqued customers' interest in Smart Energy Solutions. May and June of 2015 also had a high frequency of initial log-ins, which likely related to increased program marketing before the Pilot Conservation Days started, as well as the test event held in May 2015. There was also an uptick in initial log-ins in February and March of 2016, which is when the rewards platform was launched.

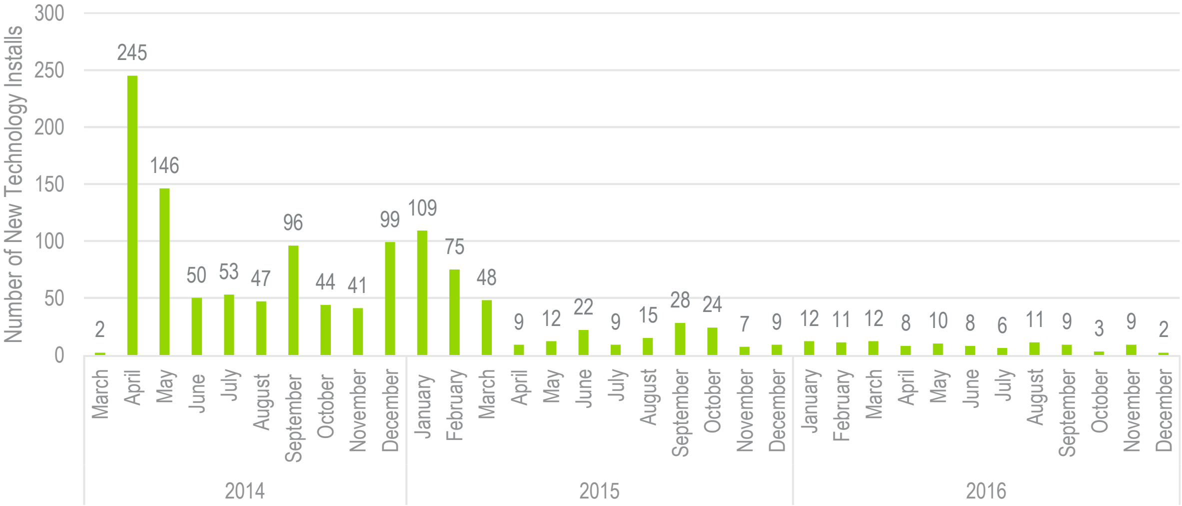
Figure 2-8. Frequency of First Time Web Portal Log-ins by Month



Source: Navigant analysis

In addition to tracking web portal log-ins, National Grid tracked when customers installed technology packages. As shown in Figure 2-9, technology installs peaked at the start of the program. There continued to be over forty new installations per month through March 2015. New technology installations tapered down significantly after the first quarter of 2015 but continued throughout 2015 and 2016. There were slight upticks in installs in June, September, and October of 2015 which may be related to messaging around the test event and first real Conservation Day in May and June and the wrap up of the first summer of Peak Events in September and October.

Figure 2-9. Number of Technology Installs by Month



Source: Navigant analysis

Although National Grid's Pilot design was unique and challenging to compare to other pilots for many reasons, a few comparisons suggest that National Grid's customers adopted technologies at comparable rates to other pilots. The Company offered customers several technology packages, which customers were able to sign up for throughout the Pilot. In contrast, NSTAR's opt-in 2012-2013 time-based rate pilot offered customers specific rate and technology combinations – standard rate with an IHD, PTR with an IHD and PCT, CPP with IHD and PCT, and CPP with IHD. National Grid and NSTAR customers opted for the IHD at similar rates: 9% for National Grid and 7% for NSTAR.[50,51]

At the end of the Pilot, National Grid asked Level 1 customers why they did not sign up for a technology package. Approximately 40% of Level 1 customers were aware of the technologies; however, those who were aware showed a lack of understanding of the benefits of the technologies and a lack of interest in them; this is discussed further in Section 4.2.2. As of May 7, 2015,[52] 15% of customers who ordered a technology package had to cancel it due to technical issues at their home. The prevalence of reasons for cancelling are shown in Figure 2-10. These reasons were categorized into six areas:

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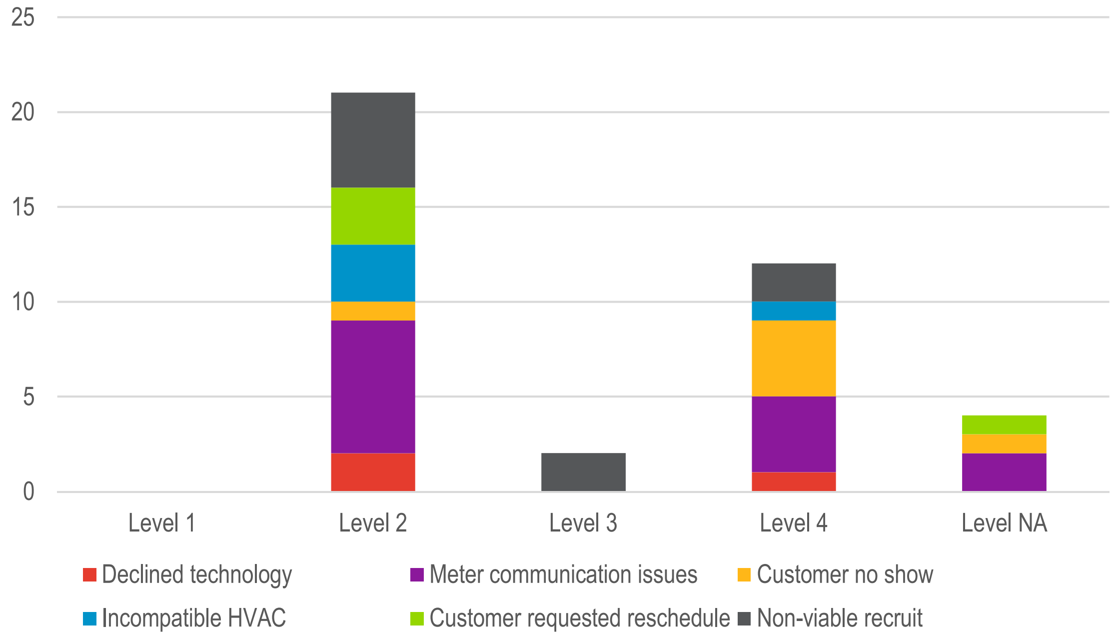
[50] NSTAR (Eversource) pilot customers opted in to the pilot voluntarily, and were randomly assigned to one of the rate and technology combinations to the extent possible, given that they needed to have central air conditioning to use the PCT. All customers received an IHD when they decided to participate in the Pilot, so the IHD enrollment rate was determined to be the same as the Pilot enrollment rate of 7%. All National Grid customers who signed up for technology packages 2 and 4 received an IHD. As of January 1, 2017 the combined enrollment rate for these two technology levels was 9%.

[51] Navigant. *NSTAR Smart Grid Pilot Final Technical Report: AMR Based Dynamic Pricing*. DE-OE0000292. Prepared for U.S. Department of Energy on behalf of NSTAR Gas and Electric Corporation. August 2014.

[52] National Grid summarized reasons for customer cancelation in a response to an information request to the Massachusetts Attorney General (Information Request AG-1-7) in D.P.U. 10-82.

1. "Declined technology" indicated that the customer changed their mind or did not want any technology on the spot. In one case, the landlord had ordered the technology but did not live at the home and the tenant declined the technology;
2. "Meter communication issues" were due to technology not receiving a signal from the meter, typically because it was too far away from where the customer wanted to install the technology;
3. "Customer no show" were instances of the technician showing up to install the technology but the customer was not home and was unresponsive to phone calls;
4. "Incompatible HVAC" were instances of furnace or central air conditioning that were incompatible with the PCT, or instances where customers did not have central air conditioning in order to use the PCT;
5. "Customer requested reschedule" were due to emergencies, or customers needing to install Wi-Fi in order to connect the technologies;
6. "Non-viable recruit" were customers who wanted the technology but could not install it for a reason other than those listed above. These reasons included inability to schedule an appointment even after the Company made multiple attempts to reschedule, inability to connect technology to the internet because they didn't have it or their equipment was incompatible, and inability to install technology because a tenant did not have landlord permission.

Figure 2-10. Reasons for Customer Cancelation of Technology Installation by Technology Level as of May 7, 2015[53]



Source: Navigant analysis

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[53] Level NA = customer's requested technology level not recorded.

2.3.2 Marketing and Recruitment

In an effort to attract as many customers as possible into the Pilot and the higher technology levels, National Grid used the following recruitment strategies:

- Conducted a door-to-door campaign in Fall 2014 to advertise the Pilot and enroll customers, with a specific focus on enrolling high-potential Level 3 and Level 4 customers;
- Held a continued stream of events and educational sessions at the Sustainability Hub to educate customers about and showcase the various technologies;
- Sustainability Ambassadors from the Sustainability Hub attended community events (including farmers' markets, community sporting events, concert series on town commons, community festivals, and Worcester Public Library events) around Worcester to promote, discuss, and enroll customers in the technology levels;
- Sent customers rate enrollment packages, technology enrollment packages, monthly reports, and quarterly newsletters with Pilot updates;
- Allowed customers to enroll in technology Levels 2, 3, and 4 throughout the Pilot;
- Conducted practice Peak Events in May 2015 and May 2016 to test customer communications, meter signals and event loading, as well as to market the rates and technologies to customers;
- Included a technology enrollment form in the monthly paper report mailed to customers in August 2015 and included consistent reminders about the available technologies in other communications;
- Launched a rewards platform in February 2016 allowing customers to earn points for saving energy and engaging with the program, which could be redeemed for gift cards at national and local retailers; and,
- Created new collateral that built on data collected from the first year of the Pilot. An example is the Energy Signature graphics that illustrated the most common customer usage patterns with specific tips on how to more effectively save energy and money given the design of the Pilot. These graphics were shared with customers through existing communication channels and through the Sustainability Hub.

After the Pilot began, National Grid continued its marketing campaign in order to keep customers engaged and informed about their technology and rate options. National Grid used op-eds in the Worcester Telegram & Gazette, direct email newsletters, conservation tips to customers, bill inserts, and mailed materials in its marketing efforts.[54] Figure 2-11 shows an example of a Smart Energy Solutions bill insert, sent before the summer 2015 season began, which is illustrative of the materials sent by email as well. National Grid continued to send these tips and newsletters and held a Smart Energy Solutions event in August 2015 at the Worcester Public Library to answer customer questions about the program. Customers could also get their questions answered anytime at the Sustainability Hub.

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[54] Though not part of National Grid's marketing effort, local media channels covered the Pilot, providing publicity and insights for customers. Refer to APPENDIX E for examples of media coverage.

Figure 2-11. Excerpt from Smart Energy Solutions Bill Insert Sent in May 2015

nationalgrid
HERE WITH YOU. HERE FOR YOU.

Claim your energy kit and manage your peak events.

Smart Energy Solutions provides you technology options, at no additional cost to you, to help you make informed decisions about your energy use and then turn that into real savings on your bill.

- There'll be no more than 30 conservation days throughout the year.
- Events will last between 2 and up to 8 hours.

Claim your kit @ www.nationalgrid.com/smartenergy or simply call 1-855-377-7627

Source: National Grid

After receiving customer feedback via surveys, low-income customer focus groups, and commercial customer interviews, National Grid responded to customers' need for additional information, specifically about event notifications and potential savings. Figure 2-12 is an illustrative example from one of National Grid's mailers to customers in October 2015, which reminds customers that they can be notified of Peak Events via several channels, not just phone calls. This example also shows anticipated savings achieved by customers who were notified by these alternative channels. This mailer echoes materials sent by National Grid throughout the Pilot to customers reminding them that they could choose to be notified about events via multiple communication channels.

Figure 2-12. Excerpt from Smart Energy Solutions Mailer Sent in October 2015

It Pays to Be in the Know! Get Text Alerts and Log in to Save More

Peak Event results are in. What did we learn? National Grid's ability to communicate with you matters! During the Peak Event hours on Conservation Days held this summer, customers who engaged with text alerts and www.worcestersmart.com saved more energy (and money!) than those who did not.

Average Energy Savings During Peak Event Hours

How did you do?

Create your online profile at **www.worcestersmart.com** to view a recap of your past Peak Event performance and tips for increasing your savings.

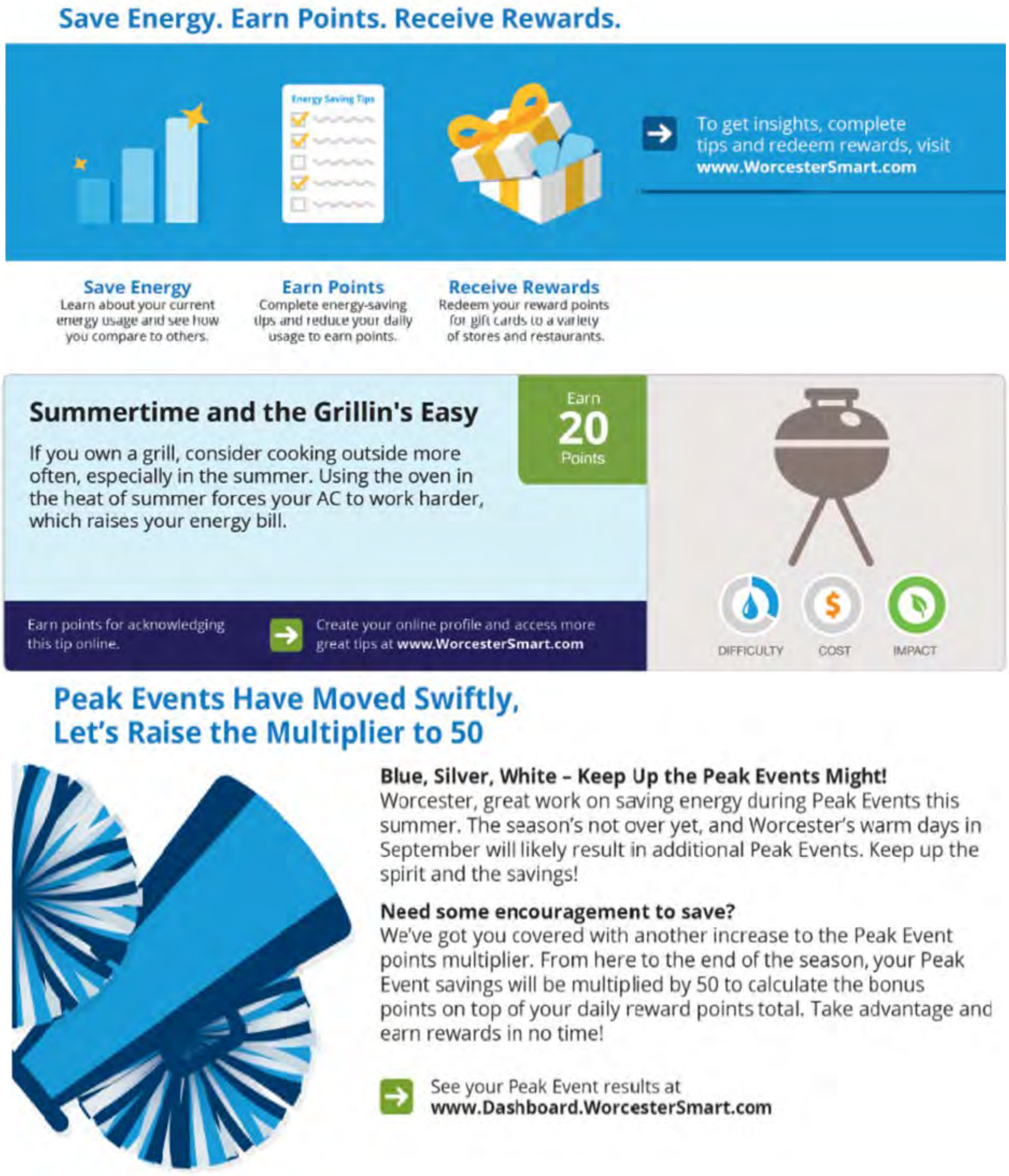
Source: National Grid

National Grid added a rewards platform to the Pilot web portal in February 2016 aimed at increasing engagement with the program. Points were earned in a variety of ways. For example, Smart Energy Solutions customers could earn points every day through saving energy. The customer's daily earnings were based on energy savings compared to their energy consumption on past similar weather days, so the more they saved the more points they earned. Customers also earned points by completing energy-savings tips, logging into the web portal for the first time, taking certain actions such as enrolling in or completing selected National Grid programs, signing up to receive Peak Event notifications via text message, completing the home profile on the WorcesterSmart web portal, or visiting the National Grid Sustainability Hub. Points could be redeemed for a variety of gift cards to national and local food, entertainment and retail establishments. Figure 2-13 contains a few illustrative examples from National Grid mailers highlighting the rewards platform. The outcomes of National Grid's internal assessment of the reward platform's effectiveness are shown in APPENDIX D. Highlights of this assessment include:

- Web portal logins increased considerably (from an average of 323 per week to 360 per week) after the launch of the rewards platform;
- The click-to-open rates for Peak Event-related emails sent the day before and the day of a Peak Event increased by 18.4% and 9.2%, respectively; and,
- In a National Grid administered survey, the rewards platform received the highest satisfaction score compared to other portions of the portal (such as Peak Event content and energy-saving tips), with 83% of customers rating the rewards feature at least a 4 on a 5-point scale.

The results of this National Grid assessment suggest that the rewards platform was a significant driver of site traffic and engagement.

Figure 2-13. Excerpts on Rewards Platform from Smart Energy Solutions Mailers in June and August 2016



Save Energy. Earn Points. Receive Rewards.

To get insights, complete tips and redeem rewards, visit **www.WorcesterSmart.com**

Save Energy
Learn about your current energy usage and see how you compare to others.

Earn Points
Complete energy-saving tips and reduce your daily usage to earn points.

Receive Rewards
Redeem your reward points for gift cards to a variety of stores and restaurants.

Summertime and the Grillin's Easy

If you own a grill, consider cooking outside more often, especially in the summer. Using the oven in the heat of summer forces your AC to work harder, which raises your energy bill.

Earn
20
Points

Earn points for acknowledging this tip online.

Create your online profile and access more great tips at **www.WorcesterSmart.com**

Peak Events Have Moved Swiftly, Let's Raise the Multiplier to 50

Blue, Silver, White – Keep Up the Peak Events Might!
Worcester, great work on saving energy during Peak Events this summer. The season's not over yet, and Worcester's warm days in September will likely result in additional Peak Events. Keep up the spirit and the savings!

Need some encouragement to save?
We've got you covered with another increase to the Peak Event points multiplier. From here to the end of the season, your Peak Event savings will be multiplied by 50 to calculate the bonus points on top of your daily reward points total. Take advantage and earn rewards in no time!

See your Peak Event results at **www.Dashboard.WorcesterSmart.com**

Source: National Grid

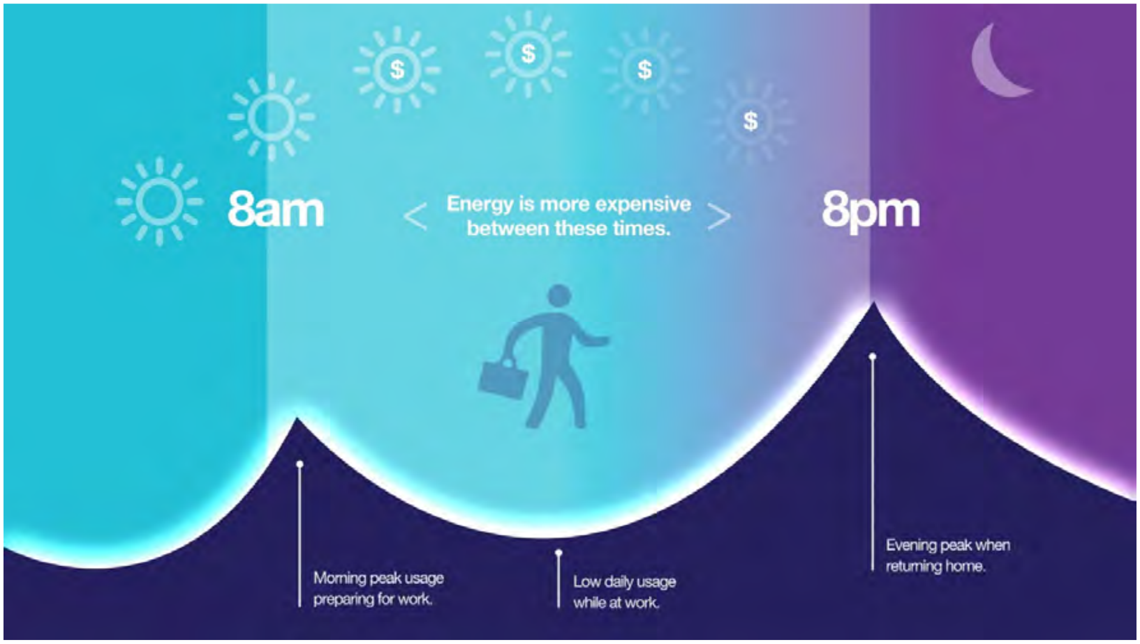
Energy Signatures were another new feature added to the Pilot in 2016. National Grid used customer data to create five common "energy signatures" or load profiles. Customers could self-identify with one of the signatures to receive personalized tips on how to conserve energy both during and outside of Peak

Events. The five signatures were:

- 9 to 5ers – These customers have a predictable, 9-5 work schedule. Their electricity use is characterized by a slight morning spike before work, low daily usage while at work, and a larger evening peak when they return home from work.
- The Late Nighters – These customers are awake late at night. Their electricity use is characterized by a morning increase before starting the day, low daily usage, and an extended increase in electricity use in the evening.
- The Even Keels – These customers have steadier electricity usage throughout the day than other signatures. Their electricity use is characterized by a very small increase in use in the morning and again in the evening, but is generally constant over the day.
- The Double Peakers – These customers are often families or group living situations. Their electricity use is characterized by a defined morning peak while everyone gets ready for the day, low daily usage while everyone is out, and a large evening peak when everyone returns home.
- Homebodies – These customers are at home during the day time hours and might work from home. Their electricity use looks like a bell shaped curve over the day – there is a steady morning increase that results in a midday peak and then decreases to low nighttime usage.

An example of the 9 to 5ers signature is shown in Figure 2-14.

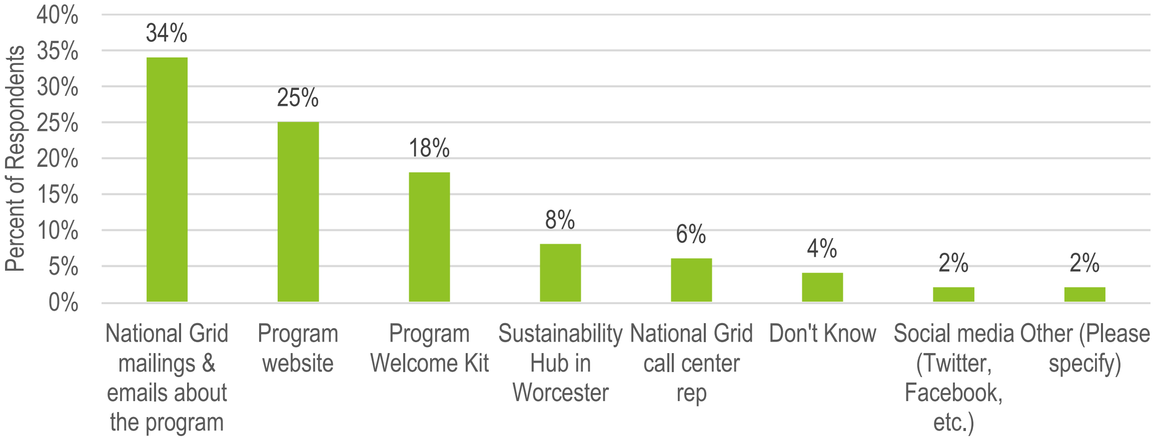
Figure 2-14. Energy Signatures



Source: National Grid

At the end of the Pilot, customers were asked which sources of information were the most useful to them in learning about the Pilot (Figure 2-15). The most frequently cited responses were the National Grid mailings and emails about the Pilot (34%), the program website (25%), and the program Welcome Kit (18%).

Figure 2-15. Most Useful Sources of Information about the Pilot



Source: Navigant analysis of end of pilot survey (N=600)

2.3.3 Customer Segmentation

National Grid defined eight overlapping customer segmentation subgroups based on demographic characteristics (demographic subgroups). With the exception of the renter data, the demographic data was purchased by National Grid from InfoGroup and Core Logic and matched to Pilot accounts by combinations of address, phone number, and/or customer name. The renter data was sourced from a combination of MA tax parcel records and the Company's customer database; customers were identified as likely renters if the name on the tax parcel did not match the name in the customer database.[55,56] The subgroups and their definitions are provided in Table 2-2.[57]

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[55] These customers were identified as "likely" renters because there was not sufficient information to determine whether the account holder was a renter or a family member, etc. Customers without data in the MA tax parcel records were not classified.

[56] Renters were not included as a demographic subgroup in National Grid's original smart grid pilot evaluation plan (D.P.U. 11-129 Exhibit EHW-3. December 22, 2011). National Grid and the evaluation team chose to add the group in 2016.

[57] In 2012, National Grid revised customer segment definitions. The Pilot area had fewer low-income customers than expected, and it was assumed that only 20% of customers would remain on the CPP rate. As a result, the number of low-income customers with medium usage decreased in the estimated customer segment. Reference: National Grid. D.P.U. 11-129: Response to Record Request AG-1. May 11, 2012.

Table 2-2. Demographic Subgroups

Demographic Subgroup	Definition
Low-income	Customers on R2 rate[58]
High Income	Customers on R1 rate with income greater than $100,000 based on demographic data
Low Use	Customers on R1 rate with low energy use
Medium Use	Customers on R1 rate with medium energy use
High Use	Customers on R1 rate with high energy use
Seniors	Customers 65 and older
Small Home	Customers with homes 1,000 sq. ft. or less
Large Home	Customers with homes over 2,500 sq. ft.
Renter	Account that likely belongs to a renter

Source: National Grid

Table 2-3 shows the demographic subgroup distribution in the Pilot as of October 4, 2016, except for the renter data which was identified as of February 2017.[59]

Table 2-3. Demographic Subgroup Distribution (as of October 4, 2016)

Pilot Participation By Treatment		All Residential Accounts	Non-Low-income Standard Residential Rate			Low-income Residential Rate (R-2)	Additional Population Segments				
			Low Use	Medium Use	High Use		High Income	Seniors	Small Home	Large Home	Renter
Level 1	CPP	8,942	2,338	4,611	870	923	1,459	1,710	5,014	175	2,740
	PTR	406	87	174	38	73	66	98	243	4	96
Level 2	CPP	634	105	387	76	62	155	95	276	13	104
	PTR	30	4	17	5	3	8	4	13	1	1
Level 3	CPP	28	4	21	3	0	10	8	12	1	4
	PTR	3	0	2	0	0	1	1	0	0	0
Level 4	CPP	235	25	160	43	7	101	35	85	17	13
	PTR	14	1	7	2	2	5	0	4	0	1
Total		**10,292**	**2,564**	**5,379**	**1,037**	**1,070**	**1,805**	**1,951**	**5,647**	**211**	**2,959**

Source: Navigant analysis

As previously mentioned, National Grid anticipated that 80% of customers would opt out of CPP and into

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[58] In many of the customer surveys, Navigant also collected self-reported data to capture customers whose income was at or below 200% of the federal poverty levels and 60% of the area median income. In 2015, Navigant found that the survey results did not vary based on which definition of low income was used; therefore, the R2 rate definition was used in the analyses throughout this report.

[59] October 4th, 2016 was chosen as these were the customers available to be surveyed for the end of pilot survey, the last major evaluation item included in this evaluation. This breakdown includes all active, residential customers who did not a) switch to a competitive supplier, or b) drop out of the Pilot.

PTR, but the data revealed that only 5% of customers had done so at the end of the two years of the Pilot. Further discussion of how the demographics changed across the two years of the Pilot and how the demographics of active and passive customers differed is included in Section 3.1.3.

Table 2-4 shows how the population of active customers changed across the two years of the Pilot. Each cell shows the percentage of customers in a given demographic group and technology/price group. Renters were left out of this analysis since that data was only collected for 2016. Level 1 for each price plan is split out, since there were both active and passive customers in that level, and then all active customers are shown (including active Level 1 customers and customers in Levels 2, 3, and 4). Compared to 2015, active customers in 2016 were:

- More likely to be low use (difference of +10% for all active customers)
- Less likely to be low-income (difference of -6% for all active customers)
- Less likely to be high income (difference of -4% for all active customers)
- More likely to have a small home (difference of +17% for all active customers)

As discussed in Section 3, the Pilot savings for active customers did not change significantly from the first to the second summer. This indicates that the demographic changes described in this section did not have much impact on the Pilot savings. Impacts by demographic group are discussed in Section 3.1.3, but most of the demographic groups were too small to examine. The changes in the quantity of some demographic groups across the two summers, along with the similarity in program impacts, lends anecdotal evidence to the idea that the demographic subgroups have similar savings.

Table 2-4. Demographics of Active Customers in 2015 versus 2016

Technology/Price Group	Year	Low Use	Medium Use	High Use	Low Income	High Income	Seniors	Small Home	Large Home
Level 1 CPP - Active	2015	25%	53%	12%	7%	18%	16%	40%	2%
	2016	27%	56%	10%	6%	17%	13%	55%	2%
Level 1 PTR - Active	2015	29%	53%	8%	10%	16%	10%	30%	0%
	2016	22%	55%	10%	8%	18%	17%	49%	0%
All Active Customers	2015	13%	59%	13%	13%	25%	17%	33%	2%
	2016	23%	59%	11%	7%	21%	14%	50%	2%

Source: Navigant analysis

Table 2-5 shows how the populations of active and passive customers differed in 2016. Each cell shows the percentage of customers in a given demographic group and technology/price group. Level 1 for each price plan is split out, since there are both active and passive customers in that level, and then all customers are shown. Compared to passive customers, active customers in 2016 were:

- Less likely to be low-income (difference of -4% for all customers)
- More likely to be medium use (difference of +10% for all customers)
- More likely to be high income (difference of +6% for all customers)
- Less likely to be seniors (difference of -6% for all customers)
- Less likely to have a small home (difference of -7% for all customers)

- Less likely to be renters (difference of -7% for all customers)

Since there were substantial efforts to drive customers to the web portal and convert them from passive to active status in the second year of the Pilot, looking at the groups that were less likely to be active customers in 2016 may shed light on groups that need special outreach. In particular, active customers were less likely to be low-income customers and they were less likely to be seniors; two groups which are often considered hard to reach. The focus groups also indicated that low-income customers may need focused outreach to gain as much as possible from the Pilot. Active customers were also less likely to be renters but the difference was smaller among Level 1 customers than in the Pilot population as a whole; this suggests renters were less likely to install technology packages but were almost as likely to visit the web portal. Renters had particular problems installing technologies due to the need for landlord permission and meter communication issues in multi-family housing.

Table 2-5. Demographics of Active versus Passive Customers in 2016

Technology/Price Group	Customer Type	Low Use	Medium Use	High Use	Low Income	High Income	Seniors	Small Home	Large Home	Renter
Level 1 CPP	Active	27%	56%	10%	6%	17%	13%	55%	2%	27%
	Passive	27%	49%	9%	11%	15%	19%	57%	2%	29%
Level 1 PTR	Active	22%	55%	10%	8%	18%	17%	49%	0%	23%
	Passive	21%	37%	10%	20%	16%	27%	63%	1%	26%
All Customers	Active	23%	59%	11%	7%	21%	14%	50%	2%	22%
	Passive	27%	49%	9%	11%	15%	20%	57%	2%	29%

Source: Navigant analysis

3. IMPACT ASSESSMENT

As laid out in National Grid's 2011 Evaluation Plan and in accordance with the *Common Evaluation Framework*, Navigant conducted impact analyses on four main topics:

1. **Peak Event Impacts**, which are demand savings (MW) during Peak Events called in the summer of 2015 and 2016;
2. **Energy Impacts**, which are energy savings (MWh) from the Pilot in 2015 and 2016; [60]
3. **Bill Impacts**, which are dollar savings on customer bills in 2015 and 2016; and
4. **Load Shifting** around Peak Events, including snapback and pre-cooling, and from peak to off-peak times in 2015 and 2016.[61]

This report covers impacts for the period from the start of the Pilot through the end of 2016. Impacts for each of the four analyses listed above were calculated for customer groups defined by technology level and price plan.[62] Where possible, Navigant also estimated impacts by demographic subgroup. The impact findings in this report are primarily focused on residential customers. Commercial customers made up less than 5% of the Pilot participants and outcomes were explored for them to the extent possible based on the constraints of the small sample. Detailed descriptions of the impact methodologies for each of the four topics above are included in APPENDIX A.

The Pilot was developed to meet the GCA goal of achieving peak and average load reductions of 5% or greater for those customers who actively participated in the Pilot.[63] In Navigant's analysis, peak load reduction was examined in the demand analysis and average load reduction in the energy analysis. Throughout this report, except in Section 3.1.2 where peak load reductions by Peak Event hour are discussed, the peak load reduction shown for a given Peak Event is the average load reduction across all the hours of that Peak Event. In both 2015 and 2016, active residential customers in the Pilot achieved an average of a 17% peak load reduction on Conservation Days. Active CPP participants[64] achieved an average load reduction of 4.3% in 2015 and 6.3% in 2016, which averaged to 5.4% over the whole Pilot. The demand savings may be slightly underestimated because hourly data from 2014 was used to estimate the baseline. In 2014, customers had access to usage information from the Pilot but the Pilot rates were not yet live, so they may have already been conserving as they were more aware of their

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[60] To a lesser extent, Navigant also examined savings from 2014 when the informational portion of the Pilot was in effect but the Pilot pricing had not yet gone into effect.

[61] Although load shifting impacts are not specifically identified in the *Common Evaluation Framework*, the team that developed National Grid's impact evaluation plan added this component to the evaluation scope of work.

[62] Impacts were not calculated in any of the analyses for Level 3 PTR customers as this group had only one customer in 2015 and two customers in 2016.

[63] As discussed previously, in the context of this opt-out Pilot, Navigant defined active customers as anyone who opted into one of the three higher technology packages (Levels 2-4) and anyone on the default technology package (Level 1) who logged into the web portal at least once. Customers in Level 1 who never logged into the web portal were considered passive participants in the Pilot.

[64] Energy savings or average load reductions were neither expected nor found for PTR customers as these customers were not on a TOU rate and thus did not have a monetary incentive to save energy outside of Peak Events.

electricity usage.[65] Navigant did find small energy savings from the Pilot in 2014. For the energy savings analysis, Navigant used 2013 as the pre-program year which was prior to any Pilot activities.

Table 3-1 shows total and percentage demand and energy savings and total bill savings for residential customers in each year of the Pilot. Total savings are the sum of savings across all residential customers in the program. For the Peak Event savings, the total savings are shown for the “average event”, which is the average across all Peak Event hours across all 20 Peak Events of each summer, and for the “maximum event”, which is the single Conservation Day with the highest average savings across the Peak Event hours. Percentage savings are the weighted average of savings across the residential technology/price plan groups. Peak Event savings stayed almost the same for active customers in 2015 versus 2016, but savings for passive customers increased considerably in 2016. Energy savings also increased in 2016 compared to 2015, driven primarily by a spike in savings in July 2016 (as discussed in Section 3.2.1). Total bill savings decreased in 2016 compared to 2015 (as discussed in Section 3.3).

Table 3-1. Total and Percentage Savings for Residential Customers

Impact Category		2015			2016		
		Total Savings	Percentage for Active Customers	Percentage for All Customers	Total Savings	Percentage for Active Customers	Percentage for All Customers
Peak Event Savings	Average Event*	0.55 MW	16.8%	3.9%	1.02 MW	16.8%	7.2%
	Maximum Event**	1.59 MW	29.0%	12.3%	2.28 MW	24.0%	14.3%
Energy Savings***		215 MWh	4.3%	0.2%	1,358 MWh†	6.3%	2.0%
Bill Savings‡		$997,621	-	-	$772,879	-	-

Source: Navigant analysis
* This is the total demand savings among all participants, averaged across all 20 events in the summer of each year.
** This is the total demand savings for 6/23/2015 and 7/25/2016, the Conservation Days with the highest savings for each summer.
*** This includes energy savings for CPP customers only, as energy savings were neither expected nor found for PTR customers.
† The considerable increase in energy savings in 2016 was driven primarily by a spike in savings in July, Navigant did not find any evidence suggesting this result was erroneous. This is discussed more fully in Section 3.2.1.
‡ This includes total bill savings for CPP customers and rebates for PTR customers.

Navigant also broke down the total Peak Event savings in 2016 to consider how much of the savings came from the pricing versus the technologies to address the question of how much of the savings could be achieved through price plans alone. To do this Navigant looked at what portion of the total savings came from customers in Level 1. Table 3-2 shows the portion of the total Peak Event savings that were achieved by passive customers in Level 1, which is similar to a program with just price plans, and by all customers in Level 1, which is similar to a program with price plans and a web portal. Seventy percent of the average total Peak Event savings in 2016 was achieved by all Level 1 customers (active and passive) and the remaining 30% of the savings came from customers who opted into one of the technology packages (although customers with technology accounted for only 10% of the customers in the Pilot). Passive customers in Level 1 made up 42% of the average total Peak Event savings in 2016, indicating this amount could have been achieved by the price plans alone.

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[65] Hourly data was not available prior to April 2014 when smart meters were installed.

Table 3-2. 2016 Peak Event Savings from Level 1 Customers

	Total Savings from All Customers	Total Savings from Passive Level 1 Customers	Portion of Savings from Passive Level 1 Customers	Total Savings from All Level 1 Customers	Portion of Savings from All Level 1 Customers
Average*	1.02 MW	0.43 MW	42%	0.72 MW	70%
Maximum**	2.28 MW	1.32 MW	58%	1.84 MW	81%

Source: Navigant analysis

Navigant did not find any statistically significant Peak Event impacts for commercial customers.[66] This finding matches the survey results for commercial customers, in which most businesses indicated that they were unable to adjust their usage during business hours when Peak Events were most likely to be called (see Section 4.2.8). This result should not be over interpreted to conclude that the Pilot was ineffective for commercial customers. The sample sizes for commercial customers on the PTR rate and in the higher technology levels were too small to draw any conclusions. It is possible that with the proper enabling technologies commercial customers were saving during Peak Events. It is also possible that subsets of commercial customers, for example those who were able to shift energy intensive activities to the evening or overnight, saved on the Pilot. There is not enough data for such possibilities to be explored.

3.1 Peak Event Impacts

Navigant estimated demand savings during each Peak Event by regression to predict fitted usage from 8 a.m. to 10 p.m. on each Conservation Day, controlling for temperature, humidity, day of the week, month, and a customer fixed effect that controlled for all observed and unobserved customer-specific variables that do not change through time. The evaluation team estimated savings for each technology/price group combination with the exception of the Level 3 PTR group, which only had one customer in 2015 and two customers in 2016. A detailed description of the methodology is included in APPENDIX A.

In both 2015 and 2016, active residential customers in the Pilot achieved an average 17% peak load reduction on Conservation Days. This means that the Pilot exceeded the GCA goal of achieving a 5% peak load reduction amongst active customers.

3.1.1 Average Peak Event Impact

Figure 3-1 shows the average percentage peak load reduction across all the events of each summer for each of the residential technology/price groups.[67] Whether on the CPP or PTR rate, customers achieved greater demand reduction with more advanced technology. For active customers at each technology level, CPP customers conserved more electricity than their PTR counterparts. Passive PTR customers

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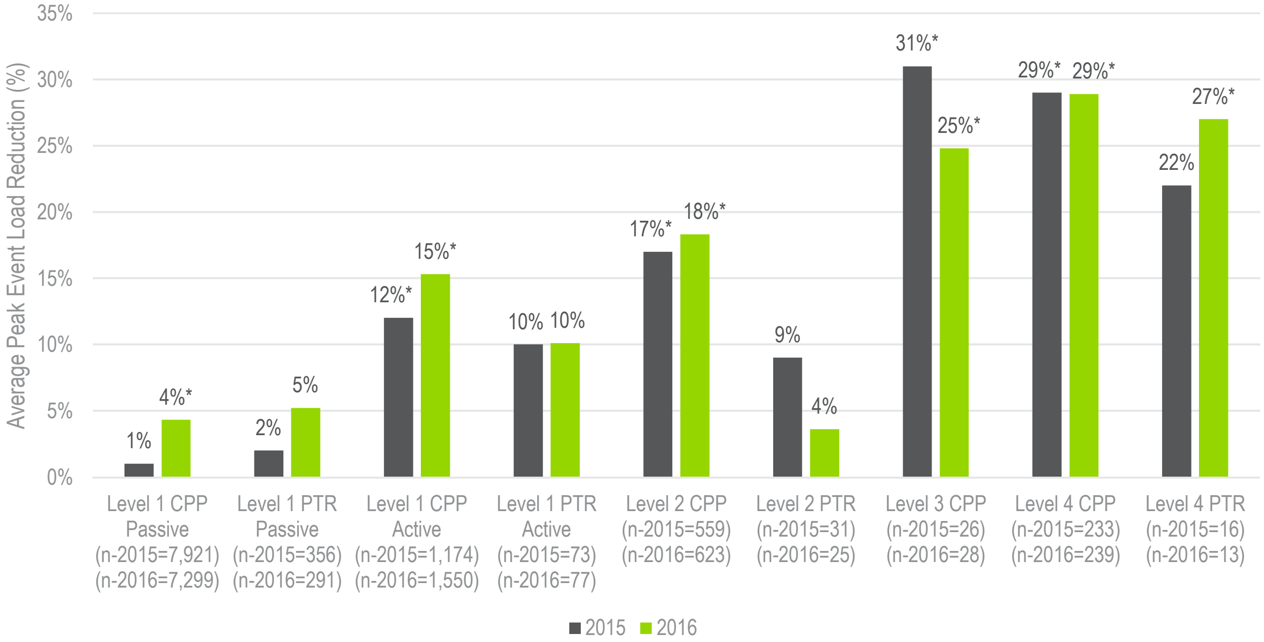
[66] Energy impacts for commercial customers were not analyzed as the group was too small to produce statistically significant results, and energy impacts were not expected because the group did not have any Peak Event impacts.

[67] This is the average across all 20 Peak Events for each summer averaged across all the hours of each individual Peak Event.

saved more than passive CPP customers, which could reflect that these customers have a higher level of engagement since they had to opt in to the PTR rate. Impacts for passive customers on both price plans increased considerably in 2016 compared to 2015. Impacts for most of the other groups stayed fairly consistent over the two years. Level 3 and 4 customers had very similar savings, suggesting that the smart thermostats received by customers in those two levels drove their savings.

Figure 3-1. Average Percent Peak Event Load Reductions by Residential Technology/Price Group



Source: Navigant analysis

Note: An asterisk (*) indicates that the majority of the event hours throughout the summer were statistically significant at the 90% confidence level for the indicated group. Additionally, n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

Table 3-3 shows the average absolute savings per customer across all the events of each summer for each technology/price group in each year.

Table 3-3. Average Absolute Peak Event Load Reductions per Customer by Residential Technology/Price Group

Technology/Price Group	2015 Absolute Savings (kW)	2016 Absolute Savings (kW)
Level 1 CPP Passive	0.01	0.05
Level 1 PTR Passive	0.03	0.07
Level 1 CPP Active	0.13	0.17
Level 1 PTR Active	0.12	0.12
Level 2 CPP	0.20	0.21
Level 2 PTR	0.13	0.05
Level 3 CPP	0.53	0.49
Level 4 CPP	0.56	0.60
Level 4 PTR	0.50	0.60

Source: Navigant analysis

In percentage terms, the impacts for active residential customers in the Pilot were similar to those from other, primarily opt-in, programs.[68] Comparisons of the Pilot to several other programs around the country are shown in Figure 3-2. The comparisons include the average, maximum, and minimum impact when possible, or the average impact when the minimum and maximum could not be found. The comparisons are grouped by the Pilot's technology/price groups, and the comparison programs are matched to the Pilot groups based on the descriptions of the price plans and the enabling technologies in the comparison program's report. The comparisons for Level 1 are to other programs with no technology, comparisons for Level 2 are to programs with IHDs, and Levels 3 and 4 are grouped together and compared to other programs with PCTs. The Pilot groups are highlighted in gray for 2015 and green for 2016. A similar graph showing absolute comparisons is included in APPENDIX B.

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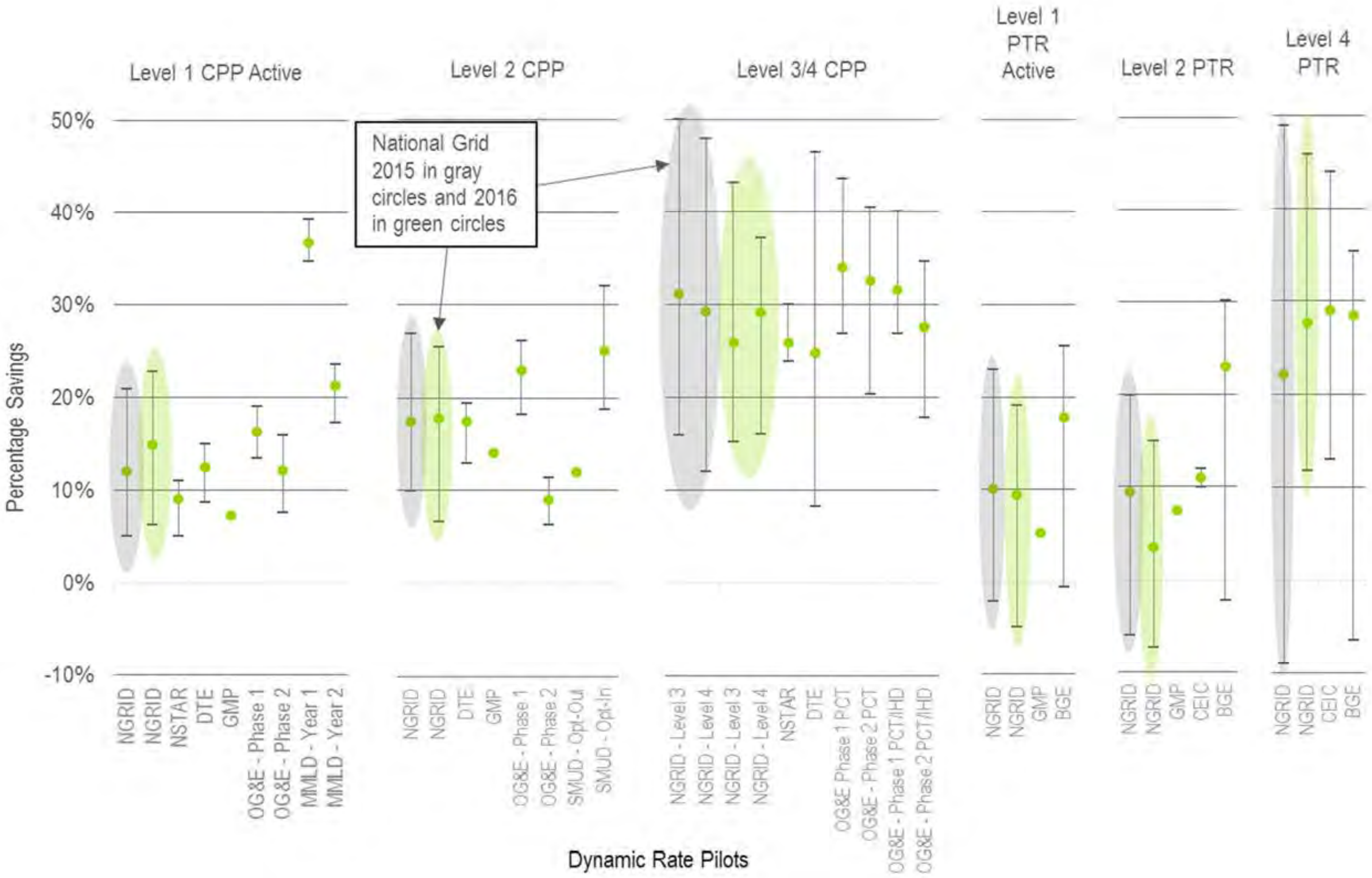
[68] Passive customers in Level 1 also had savings, but they are not shown in Figure 3-2 because all of the comparison programs are opt-in. Passive customers in an opt-out program are fundamentally different from customers in an opt-in program in terms of their motivation to participate in a program.

Figure 3-2. Residential Peak Event Impacts Percentage Comparison to Other Utilities

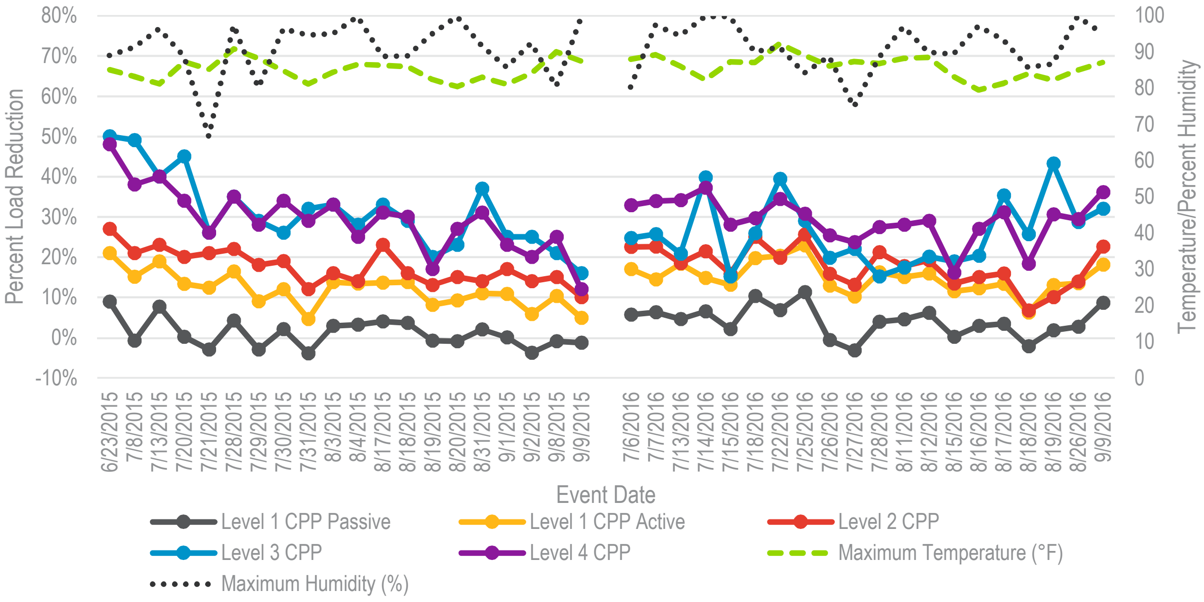


Source: Navigant analysis and the Smart Grid Investment Grant program

Note: NGRID = National Grid; NSTAR is now Eversource Energy; DTE = DTE Energy; GMP = Green Mountain Power; OG&E = Oklahoma Gas and Electric; MMLD = Marblehead Municipal Light Department; SMUD = Sacramento Municipal Utility District; BGE = Baltimore Gas and Electric; CEIC = Cleveland Electric Illuminating Company

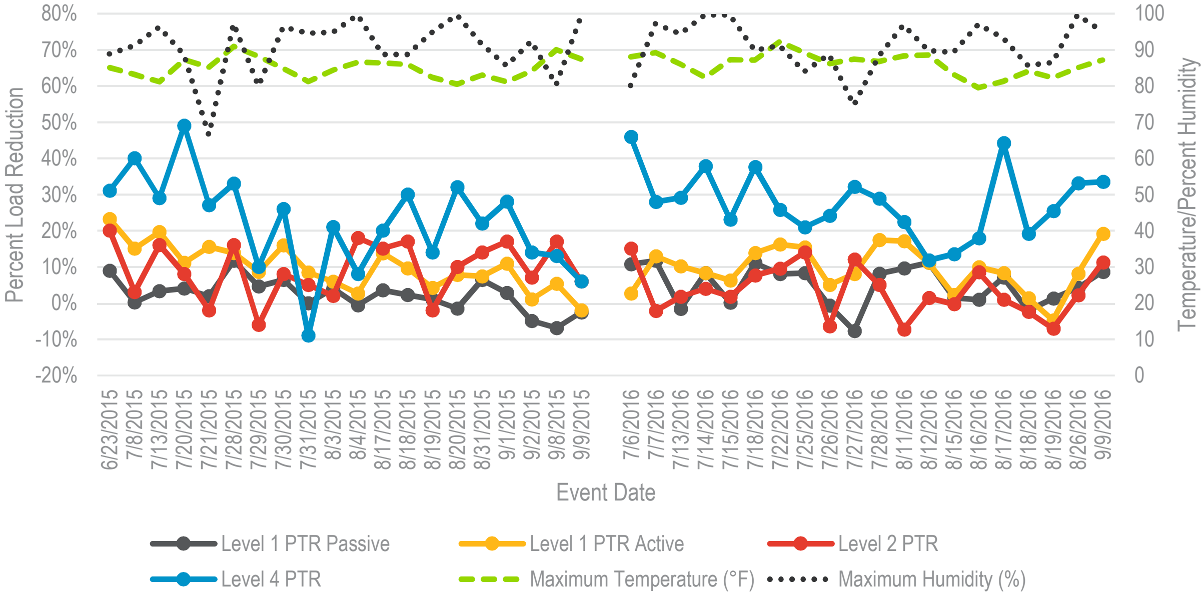
Figure 3-3 shows the average percentage impact for each event for the five residential CPP customer groups, and Figure 3-4 shows the average percentage impact for each event for the four residential PTR groups. For almost all of the technology/price groups, the impact was highest for the first Peak Event on June 23rd, 2015, and this may indicate initial excitement or novelty surrounding the first event. In 2015 for both price plans, Level 1 (active and passive) and Level 2 had relatively stable impacts throughout the summer, while Level 3 (CPP only) and Level 4 impacts declined throughout the summer. This matches with the survey data (Figure C-5), which showed that Level 3 and 4 customers were more likely to override their thermostats as the 2015 summer went on. In 2016 all of the technology/price groups had relatively stable impacts throughout the summer. This may indicate learning that occurred from the first summer to the second. Another reason for the difference may be that 2015 had more events in September than 2016 when many families are busy with back to school and change their behavior patterns compared to the rest of the summer. Another major difference from 2015 to 2016 was the increase in savings for passive customers in Level 1 which may be due to ramp-up similar to that seen in Home Energy Report programs wherein savings commonly increase from the first year into the second and sometimes even the third year of the program; examining savings for a third summer would shed further light on this trend. Similar graphs showing the absolute impact and tables showing the average percentage and absolute impact by event are in APPENDIX B.

Figure 3-3. Percentage Savings for CPP Customers



Source: Navigant analysis

Figure 3-4. Percentage Savings for PTR Customers



Source: Navigant analysis

Figure 3-5 shows the percentage savings during each Peak Event for customers with PCTs (Levels 3 and 4) and the degree setback on the thermostat for each Peak Event. National Grid remotely adjusted these customers' thermostats by the degree setback shown,[69] although customers had the option to opt-out of the event or override their thermostat at any time. Based on Figure 3-5 there do appear to be slightly higher savings associated with a higher degree setback, but the effect decays during back-to-back Peak Events. One might expect that a higher setback temperature would be correlated with a higher rate of opt-outs and overrides among thermostat customers; however, the data did not show this. A higher degree setback was slightly positively correlated with a higher percentage of customers with a thermostat opting out before the Peak Event started,[70] but it was negatively correlated with the percentage of customers overriding the thermostat during the Peak Event.[71] The rate of opt-outs and overrides was most strongly correlated with the length of the Peak Event; the longer the Peak Event the higher the percentage of customers choosing to opt out before or override during the Peak Event.[72] These trends are shown in Figure 3-6. The fact that opt-outs and overrides were more highly associated with the length of the Peak Event than the degree setback may indicate that customers noticed how long the Peak Event lasted more than they noticed how extreme the temperature shift was. This was further supported by the fact that opt-

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[69] Setback was relative to the setting on the thermostat when the Peak Event began, not to the programmed temperature for that time. Thus if a customer increased or decreased their thermostat prior to the event their temperature was still increased by the specified degrees. The setback was not reinstated if the customer changed their thermostat setting once the Peak Event had started.

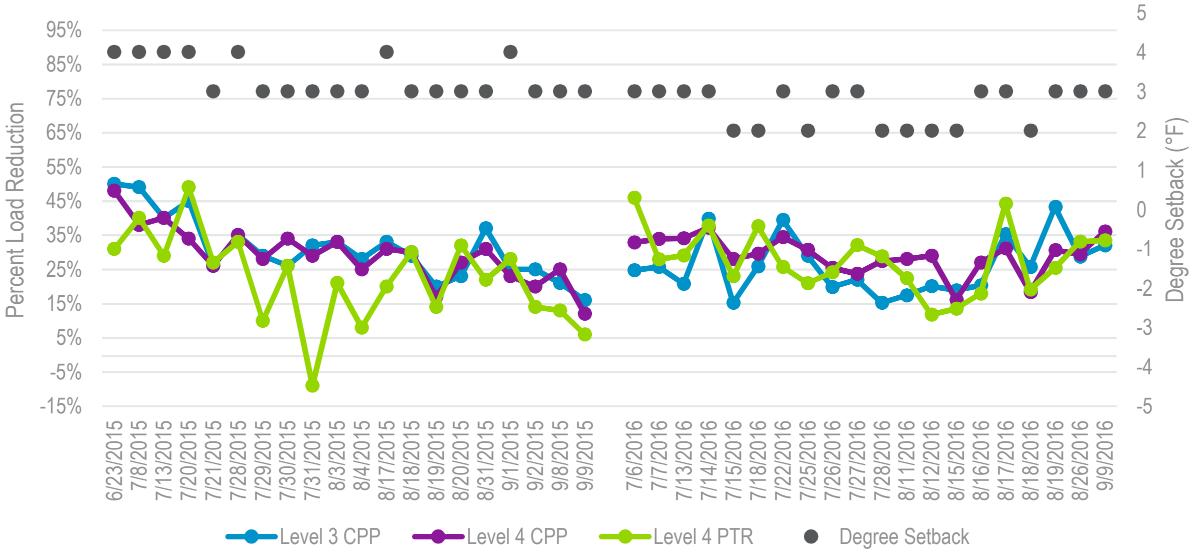
[70] Correlation coefficient of 0.30.

[71] Correlation coefficient of -0.27.

[72] The correlation coefficient between the length of the Peak Event and opt-outs and overrides was 0.30 and 0.54, respectively.

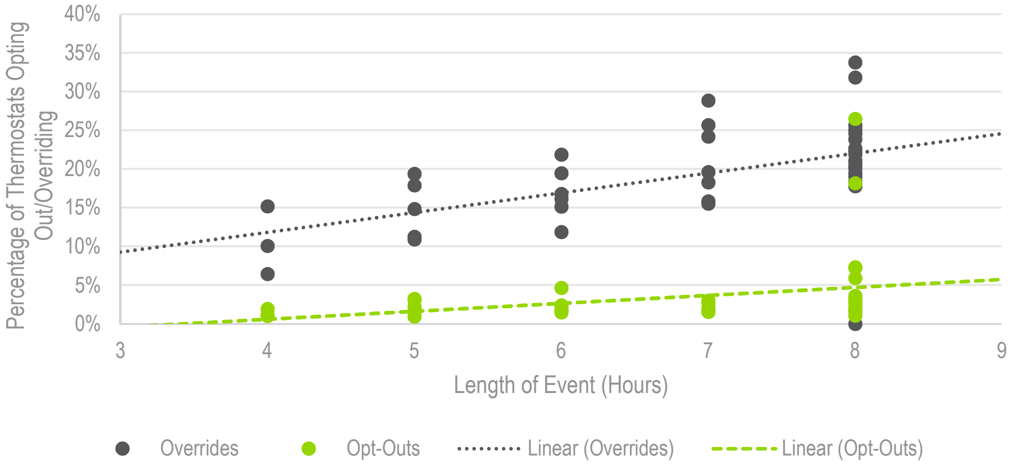
outs and overrides were also positively correlated with the end time of the Peak Event, meaning customers were more likely to opt-out/override the later into the evening a Peak Event went.[73]

Figure 3-5. Degree Setback and Percentage Savings for Customers with PCTs



Source: Navigant analysis

Figure 3-6. Length of the Peak Event and Percentage of Thermostat Customers Opting Out/Overriding



Source: Navigant analysis

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[73] The correlation coefficient between the end time of the Peak Event and opt-outs and overrides was 0.33 and 0.50, respectively.

Navigant looked at how the Peak Event load reductions differed over back-to-back events in 2016.[74] As shown in Table 3-4, the first day of a back-to-back event had average savings of 9% across all technology/price groups while subsequent days averaged 6%. The effect was slightly stronger for the lower technology groups as compared to the groups with PCTs (Level 3 and 4).

Table 3-4. Average Percentage Peak Event Load Reductions during Back-to-Back Peak Events

Technology/Price Group	Level 1 CPP Passive	Level 1 PTR Passive	Level 1 CPP Active	Level 1 PTR Active	Level 2 CPP	Level 2 PTR	Level 3 CPP	Level 4 CPP	Level 4 PTR	Weighted Average
First Day of a Back-to-Back Event	6%	7%	17%	12%	20%	6%	26%	30%	29%	9%
Subsequent Days (2-5) of a Back-to-Back Event	2%	3%	13%	8%	16%	1%	26%	28%	27%	6%

Source: Navigant analysis

3.1.2 Impacts by Event Hour

To assess the event impacts by hour, Navigant created graphs of average usage on each event day for each technology/price group. Figure 3-7 shows one such graph for Level 3 CPP for the first event on June 23rd, 2015. The x-axis plots the hours of the day, and the event period is highlighted in red. Usage is plotted on the primary y-axis with actual usage as the solid black line and fitted baseline usage as the dotted blue line. The 90% confidence interval on the adjusted fitted baseline during the event period and snapback period is shown in the lighter blue dot-dash lines. Temperature is plotted on the secondary y-axis as the dotted grey line. Similar graphs are available for each event for each technology and price plan group in the separately attached Appendix F for residential customers and Appendix G for commercial customers.

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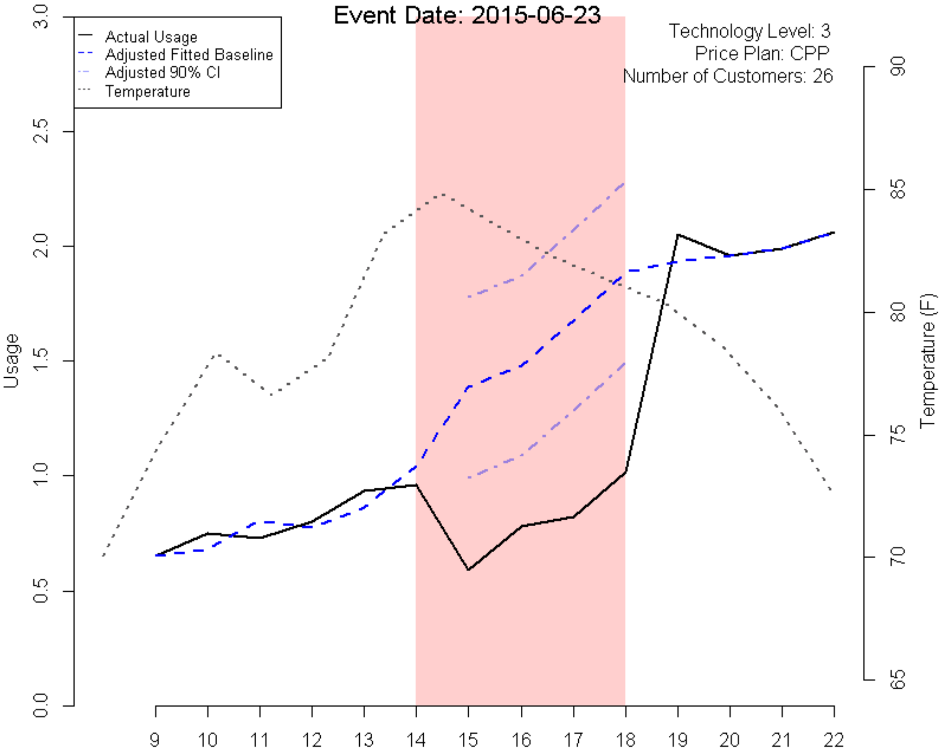
[74] Back-to-back events were defined as those where a Conservation Day occurred on two or more consecutive days. Conservation Days that spanned over a weekend, i.e., when a Peak Event was called on a Friday and the following Monday (the next day that was eligible for an event), were not counted as back-to-back.

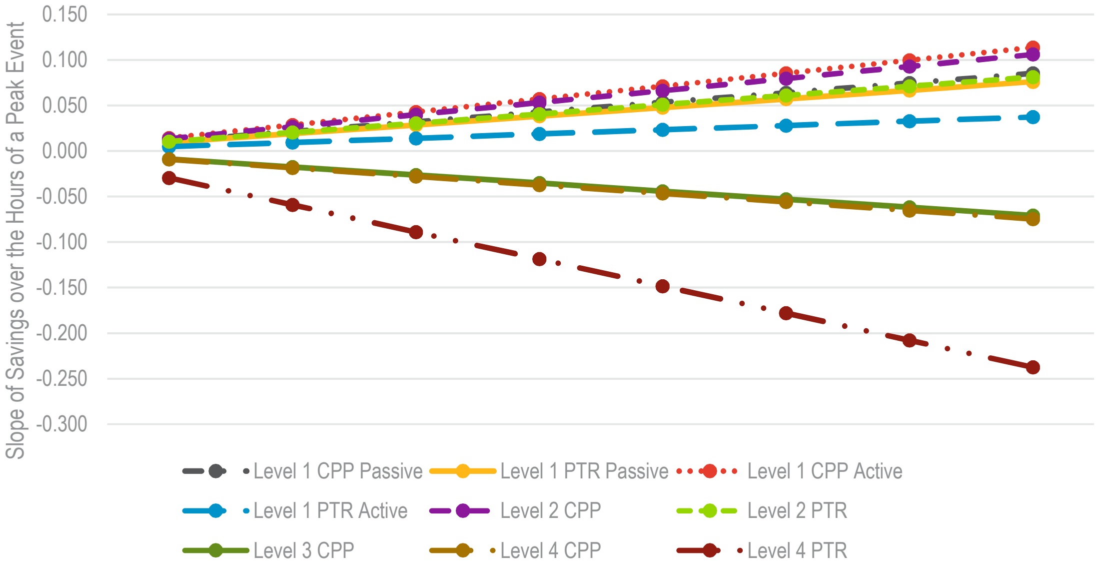
Figure 3-7. Level 3 CPP Actual and Baseline Usage on 2015-06-23



Source: Navigant analysis

To summarize how the load reductions changed through the hours of a Peak Event, Navigant calculated the average slope of the load reduction across the Peak Event hours for each technology/price group (i.e., the slope of the difference between the dotted blue line and the solid black line during Peak Events such as that shown in Figure 3-7). This analysis shows whether the impacts, on average across all the Peak Events, increased, decreased, or stayed the same throughout the hours of a Peak Event. Figure 3-8 shows lines with the same slope as the change in load reductions over the hours of a Peak Event for each technology/price group. The three groups with PCTs had slightly negative slopes, indicating that the impacts degraded a small amount over the hours of a Peak Event. All the other groups had slightly positive slopes indicating the impacts grew slightly over the hours of a Peak Event. Despite these trends by technology/price group, in general, across the groups, the slopes of the impacts were small indicating that savings only grew or fell a small amount over the hours of a Peak Event.

Figure 3-8. Savings Persistence Over the Course of a Peak Event



Source: Navigant analysis

3.1.3 Impacts by Demographic Subgroup

Impacts were estimated for 26 residential demographic subgroups as indicated by shading in Table 3-5.[75] Graphs similar to Figure 3-7 are provided in the separately attached Appendix H for each of the events for each demographic subgroup. A threshold of 100 customers was used to decide whether there was enough data to estimate results for a demographic subgroup.[76] Navigant made an exception to that threshold to estimate impacts for low-income customers in Level 1 CPP active and Level 2 CPP. Additionally, renter data was only collected in 2016 and so only one year of impacts was analyzed for those subgroups.[77]

Across all the subgroups only three had statistically significant differences in Peak Event impacts from the group as a whole: low-income customers in Level 2 CPP and renters in Level 1 CPP (both active and passive) had lower impacts than those technology/price groups as a whole. Impacts for low-income customers were also estimated for active and passive customers in Level 1 CPP, but for each of those groups no statistically significant difference was found between low-income customers and the group as a whole. Since 87% of all Pilot participants were in the Level 1 CPP groups we know that most of the low-income customers had the same impacts as other customers. Impacts for renters were also estimated for Level 2 CPP and while the differences were not statistically significant, impacts for renters were

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[75] Navigant did not estimate commercial customer impacts by demographic subgroup because the overall group size was too small to yield statistically significant results.

[76] A threshold of 100 was used to ensure a chance of statistical significance in the results.

[77] Renters were not included as a demographic subgroup in National Grid's original smart grid pilot evaluation plan (D.P.U. 11-129 Exhibit EHW-3. December 22, 2011). National Grid and the evaluation team chose to add this group in 2016.

consistently lower than for the group as a whole, as in Level 1.

Table 3-5. Peak Event Impact Estimation Groups in 2015/2016[78]

Technology/ Price Group		Non-Low Income			Low Income	High Income	Seniors	Small Home	Large Home	Renter
		Low Use	Medium Use	High Use						
Level 1: Web Portal Only	CPP - Active	297/438	640/905	142/154	88/101	212/269	189/202	481/889	24/28	427
	CPP - Passive	2,071/ 2,165	3,874/ 3,887	818/732	1,096/ 860	1,287/ 1,219	1,922/ 1,527	3,566/ 4,486	156/149	2,313
	PTR – Active	21/17	39/42	6/8	7/6	12/14	7/13	22/38	0/0	18
	PTR - Passive	110/61	146/110	33/30	65/60	37/47	85/80	122/186	3/4	78
Level 2: IHD	CPP	75/112	334/391	76/76	76/63	143/156	98/96	185/285	11/12	104
	PTR	3/1	16/15	7/5	5/3	4/8	6/3	11/10	1/1	1
Level 3: PCT	CPP	3/4	20/21	2/3	1/0	12/10	7/8	9/12	1/1	4
	PTR	0/0	1/1	0/0	0/0	1/1	0/0	0/0	0/0	0
Level 4: Tech Combos	CPP	25/26	151/164	44/42	13/9	91/103	37/34	68/87	20/18	13
	PTR	1/1	9/7	3/2	3/1	4/5	0/0	4/3	0/0	1

Source: Navigant analysis

Note: The first number in each box shows the sample size in 2015 while the second shows 2016, except for the renter demographic subgroup where data was only collected in 2016. Because of the change in the number of customers, impacts were only estimated for passive low use customers in Level 1 PTR in 2015 and for low use customers in Level 2 CPP in 2016; all other shaded demographic subgroups were estimated in both years.

Impacts for Low-Income Customers

Figure 3-9 shows the average percentage impact for each event for low-income customers and all customers in Level 2 CPP. In 2015, the impact for low-income customers averaged 10% compared to 17% for the group as a whole. The difference grew in 2016, with low-income customers averaging 7% compared to 18% for the group as a whole. For each event across both summers, low-income customers had lower savings than the group as a whole.

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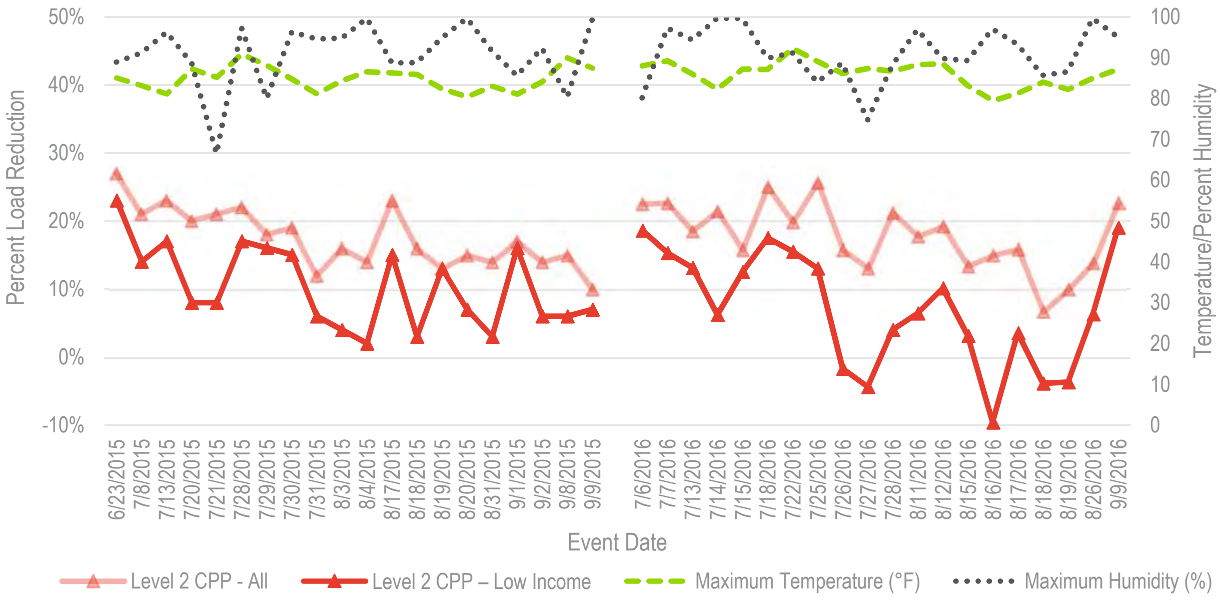
[78] The customer counts in this table differ slightly from the customers count in Table 2-3 due to small differences in the logic used to include customers in the impact analysis versus in the survey. For example, customers who went inactive during the summer of 2015 were not included in the survey sample but they were included in the impact analysis up until their account went inactive.

Figure 3-9. Event Savings for Low-Income Customers in Level 2 CPP



Source: Navigant analysis

There are several possible explanations for why low-income customers would save less than other customers:

1. Central air conditioning (CAC) penetration may be lower among low-income customers;
2. Low-income customers may have less discretionary energy usage and thus less energy to save;
3. Low-income customers may have been less able to shift their usage than other residential customers; or
4. The finding may be an anomaly, given that two of the three technology/price groups for which low-income customers were analyzed did not show statistically significant differences.

The next several paragraphs go through the first three hypotheses sequentially. For each hypothesis, we first explain it in more detail and then discuss what, if anything, we were able to do to assess its likelihood. The fourth explanation is not discussed in more detail since we cannot assess its likelihood.

Lower CAC penetration for the low-income customers: For example, low-income customers may be more likely to have window AC units rather than CAC. To further examine this possibility, Navigant identified customers likely to have CAC in Level 2 CPP as described in Section A.2 of APPENDIX A. Navigant then estimated the demand impacts during Peak Events for each summer for four income/CAC groups within Level 2 CPP: standard-income customers with CAC, low-income customers with CAC, standard-income customers without CAC, and low-income customers without CAC. For customers with and without CAC, the demand impacts were lower for low-income customers than standard-income customers in both percentage and absolute terms in 2015, as shown in Table 3-6. In 2016, the impacts for low-income customers without CAC rose substantially, and were higher than for standard-income customers, but the group of customers was quite small. This means that although CAC penetration may have been lower for low-income customers, it appeared that low-income customers had lower percentage demand savings regardless of the presence of CAC in 2015 but they may have done better than standard-income customers without CAC in 2016. The customers in Level 2 had IHDs but not PCTs; it is possible that with a PCT the disparity between low-income and other residential customer impacts would diminish.

Table 3-6. Demand Impacts for Level 2 CPP by Income and CAC

		2015			2016		
Income	CAC	Customer Count	Percentage Impacts	Absolute Impacts	Customer Count	Percentage Impacts	Absolute Impacts
Standard-Income	Y	284	20%	0.267	249	20%	0.286
Low-Income	Y	37	9%	0.143	23	6%	0.090
Standard-Income	N	164	18%	0.152	148	14%	0.126
Low-Income	N	35	11%	0.110	21	24%	0.235

Source: Navigant analysis

Low-income customers may have less discretionary energy usage and thus less energy to save: The lower impacts may be due to a tendency to have less discretionary energy usage and thus less energy to save, which is a common result found in evaluation.[79] Low-income customers are likely to already be conscious of their energy usage and its impact on their budget and thus may have been conserving more energy than other customers before the Pilot. Since they are already engaging in conservation behaviors, they have fewer improvements that they can make.

Low-income customers may have been less able to shift their usage than other residential customers: This was a concern when designing the Pilot and although, according to the pre-pilot and end of pilot surveys, low-income customers indicated that they could effectively shift their usage (see Figure 4-3 and Figure 4-4), it is possible that they over-estimated their ability to adjust their usage. Low-income customers may have had medical conditions that required them to run equipment throughout the day, such as HEPA air filters. They may also be more likely to live with children or elderly family members who were home during Peak Events and needed to stay comfortable, making them less able to adjust their AC usage.[80] As reported in the focus groups, some low-income customers may also have had shift work that caused them to be home during the day.

After exploring these possibilities, it seems unlikely that lower CAC penetration drove the lower savings for low-income customers. Low-income customers have lower energy usage overall than other customers which could mean they have less discretionary usage to cut but we do not have conclusive evidence of this. The focus group discussions lend anecdotal evidence to the possibility that low-income customers have more barriers to shifting usage than other customers, but the focus groups were not large enough to

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[79] See for example IEE Whitepaper (2010). *The Impact of Dynamic Pricing on Low Income Customers*.

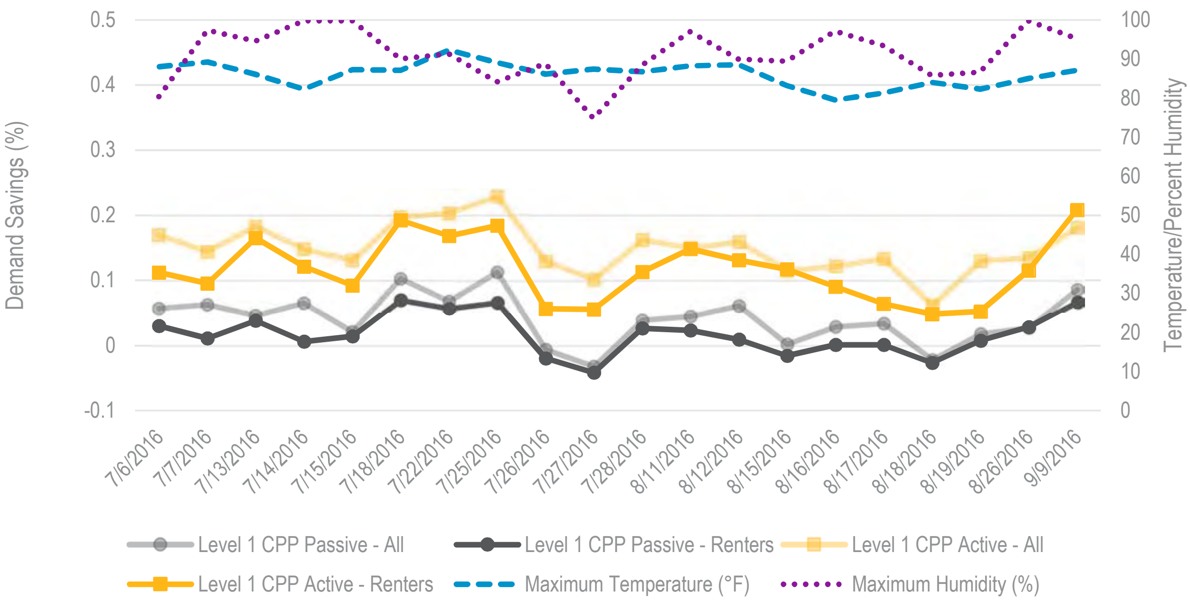
[80] The low-income focus groups suggested that some low-income customers experience these conditions but the sample sizes were not large enough to conclude that these conditions are more prevalent for low-income customers than for residential customers in general.

be considered conclusive. Finally, it is impossible to rule out the possibility that this result for Level 2 was simply an anomaly and that on the whole low-income customers in the Pilot are achieving results similar to other residential customers. This is supported by the finding that impacts for low-income customers were not statistically different from other customers in Level 1 CPP.

Impacts for Renters

Figure 3-10 shows the average percentage impact in each Peak Event for renters and all customers in Level 1 CPP, both active and passive, in 2016. Over all the events, the impact for passive renters averaged 2% compared to 4% for the group as a whole, and the impact for active renters averaged 12% compared to 15% for the group as a whole. For each event in each group, the average savings for renters were no more than for the group as a whole. Impacts for renters were also estimated for Level 2 CPP and while the differences in that group were not statistically significant, the same pattern was evident in that renters had lower impacts than the group as a whole. The lower savings for renters as compared to other customers likely stems from the particular challenges renters face in conserving electricity. For example, renters may or may not pay their own electric bill and they often have to get landlord permission for many conservation activities (such as buying new appliances).

Figure 3-10. Event Savings for Renters in Level 1 CPP



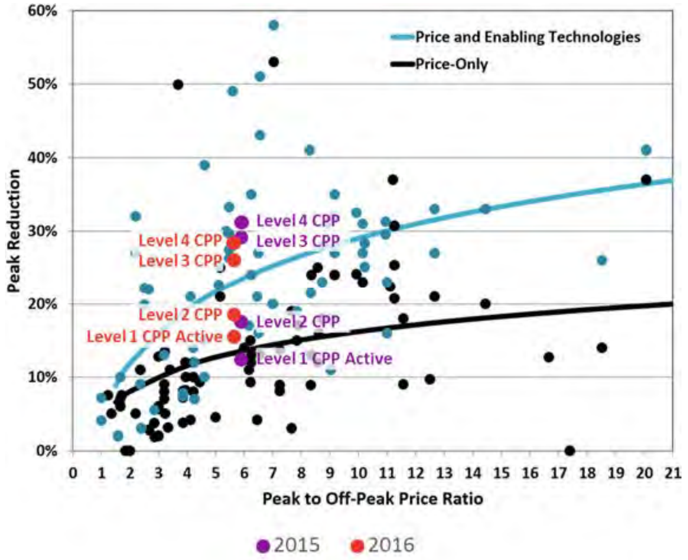
Source: Navigant analysis

3.1.4 Price Responsiveness

For the residential customers on the CPP price plan, Navigant was able to estimate the price responsiveness at each technology level. As shown in Figure 3-11, the level of price responsiveness for active customers was similar to that of other pricing programs. The figure shows Faruqui and Sergici's (2013) arc of price responsiveness, which is based on 137 pricing treatments in 34 programs worldwide; the Pilot price responsiveness is plotted in purple for 2015 and red for 2016 for each of the four active

CPP groups.[81] The arc plots the percentage peak reduction in electricity usage for various peak to off-peak price ratios for programs with and without enabling technologies. Although the off-peak and critical peak prices changed between the 2015 and 2016 summers, the peak to off-peak price ratio was approximately six in both years (note: 2016 is staggered just slightly to the left of 2015 for ease of viewing, but the ratio was actually the same in the two years).[82] The responsiveness for active customers in Level 1 was right at the average for price-only programs in 2015 and rose slightly in 2016. Level 2 was between the average for programs with and without enabling technologies in both years, which was expected given that an IHD is a relatively low-level enabling technology. Levels 3 and 4 were slightly above the average for programs with enabling technologies in both years, though slightly lower in 2016 than in 2015; both years fell well within the range seen at a peak to off-peak ratio of six.

Figure 3-11. Arc of Price Responsiveness for Active CPP Customers



Source: Faruqui and Sergici (2013) and Navigant analysis

Note: 2016 is staggered just slightly to the left of 2015 for ease of viewing, but the ratio was actually the same in the two years.

3.2 Energy Impacts

In order to calculate residential energy impacts, the evaluation team selected a group of matched control customers from a large pool of non-participant households that had similar patterns of energy usage in a 12-month period before the Pilot started to provide the counter-factual usage if the Smart Energy Solutions participants had not been in the Pilot.[83] The 12-month matching period went from September 2012 to August 2013, leaving a 4-month test period from September 2013 to December 2013 to ensure

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[81] Faruqui, Ahmad and Sergici, Sanem, Arcturus: International Evidence on Dynamic Pricing (July 1, 2013). Available at SSRN: http://ssrn.com/abstract=2288116.

[82] Prices for the Pilot rates and the Basic Rate are shown in Table A-1 and Table A-2 in APPENDIX A.

[83] To avoid the issue of control customers moving out, only controls who had billing data through the end of the 2016 were used.

that the matches were performing well (i.e., continued to have usage similar to the participants) outside of the matching period but before the program started. Regression analysis of monthly billing data using the participants and matched controls was then used to estimate the annual reduction in energy usage, controlling for weather, for 2014 and the reduction by month in 2015. A detailed description of the methodology, along with graphs showing the quality of the matches, is included in APPENDIX A.[84]

Overall, active CPP participants[85] achieved an average load reduction of 4.3% in 2015 and 6.3% in 2016, which averaged to 5.4% over the whole Pilot. This means the Pilot exceeded the GCA goal of achieving a 5% average load reduction for active customers.

3.2.1 2015 & 2016 Impacts

Figure 3-12 shows the average percentage energy impacts with 90% confidence intervals for CPP customers in different technology levels in 2015 and 2016. Navigant also examined energy savings for PTR customers but did not find any significant savings; PTR customers were not expected to achieve significant energy savings because they did not pay TOU rates. In both years, energy savings for active participants were highest for Level 2 customers (43 kWh per month in 2015 and 55 in 2016) and lowest for Level 4 customers (13 kWh per month in 2015 and 11 in 2016). Active Level 1 customers saved 24 kWh per month in 2015 and 39 in 2016, and Level 3 customers saved 39 kWh per month in 2015 and 10 in 2016. Although the point estimates of energy savings changed from 2015 to 2016, the changes were not statistically significant, indicating that the energy savings were similar across the two years of the Pilot. It is unclear why Level 4 customers saved less than Level 3 customers in 2015 since the two groups had similar technologies; however, the 90% confidence bounds for the two estimates overlap and the sample sizes are relatively small for monthly billing analysis, which may have contributed to the discrepancy. Additionally, the discrepancy disappeared in 2016 when the point estimate for Level 3 customers fell considerably. The estimates of energy savings for passive customers in Level 1 were very small and not statistically significant in either year.

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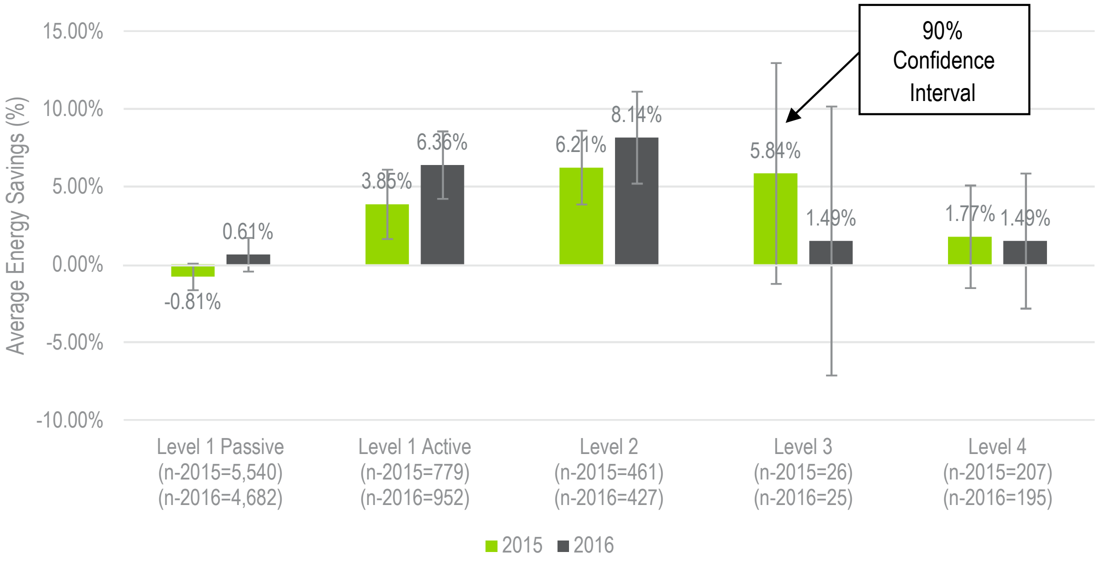
[84] Navigant did not estimate energy impacts by demographic subgroup because there was not enough data to do billing analysis on these smaller groups. Given that there were few differences in demand savings across the demographic subgroups it is unlikely that there were differences in energy savings.

[85] Energy savings, or average load reductions, were neither expected nor found for PTR customers as these customers were not on a TOU rate and thus did not have a financial incentive to save energy outside of Peak Events.

Figure 3-12. Average Energy Impacts for CPP Customers by Technology Level

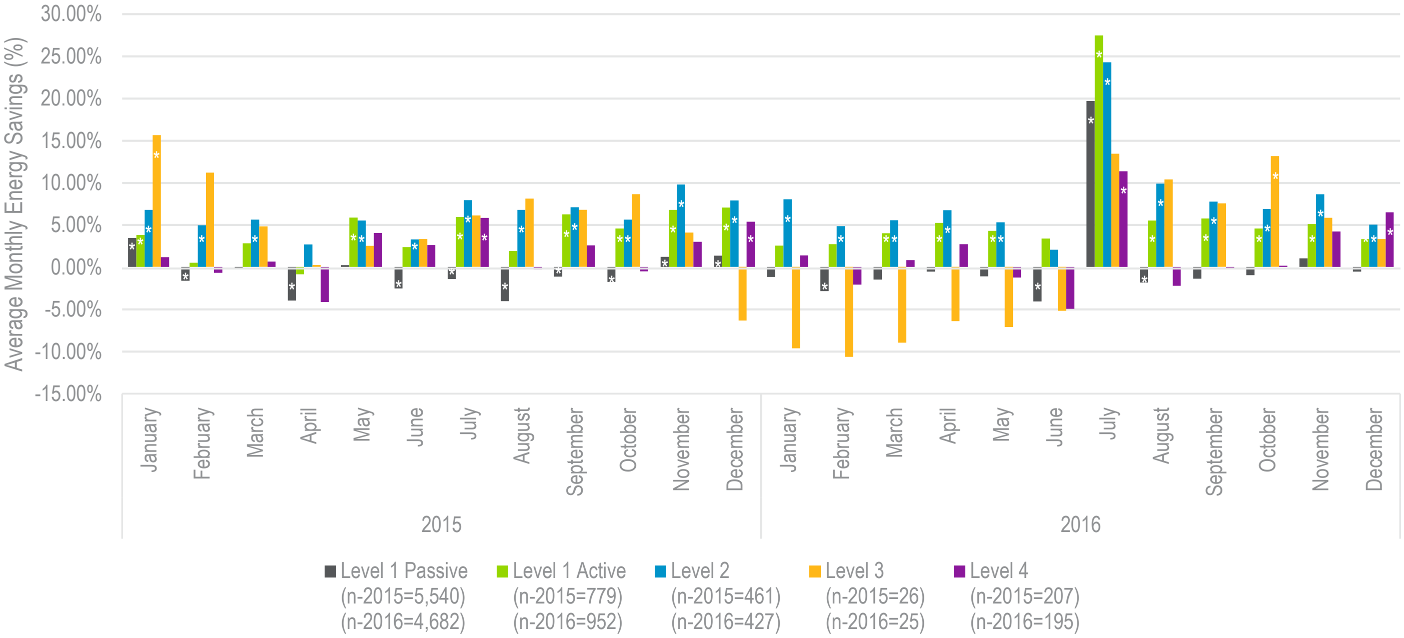


Source: Navigant analysis

Note: n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

Energy savings by month and year for each technology level are shown in Figure 3-13. This shows that for most of the groups there were energy savings in almost every month. Level 3 customers showed negative savings in the first half of 2016, but this group was very small (only 25 customers) and these estimates were not statistically significant. Notably July, August, and September of both years, which cover the period when the summer Peak Events were being called, showed energy savings for almost all of the active customers (and the few negative estimates were not statistically significant). Energy savings for all of the groups spiked considerably in July 2016, which may have occurred because that month had 11 events (8 events was the next highest in a single month, occurring in both August 2016 and July 2015). Active customers in Level 1 and Level 2 had significant savings in most of the months of the Pilot. There were not obvious seasonal patterns in energy savings across the five CPP customer groups.

Figure 3-13. Average Monthly Energy Impacts for CPP Customers by Technology Level



Source: Navigant analysis
Note: White asterisks (*) indicate statistical significance at the 90% confidence level. n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

Navigant examined the billing data from July 2016 thoroughly to ensure that the spike in savings in that month was not driven by an error in the data. Navigant did find that participant usage dipped in that month compared to the matched controls' usage. However, there was no evidence suggesting that the dip was due to erroneous data as opposed to an actual drop in usage, i.e. energy savings.[86]

Navigant attempted to break down the energy impacts by demographic subgroups but the sample sizes were simply too small to draw any conclusions.

3.2.2 2014 Impacts

Figure 3-14 shows the energy savings from the Pilot in 2014 with 90% confidence intervals. In 2014, only the information portion of the Pilot was in effect—i.e., customers knew the Pilot was coming and technologies were available for those who wanted them. However, there were no price changes or Peak Events. Energy savings were statistically significant at the 90% level for Level 2 CPP customers, who saved 3.00%. Savings were positive, but statistically insignificant, for active and passive Level 1

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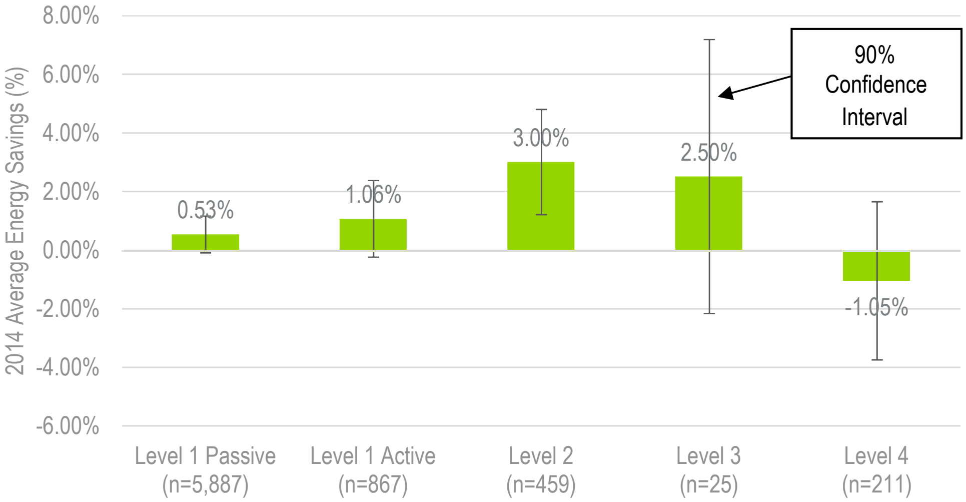
[86] There was not a drop in the number of customers or observations recorded in this month. Additionally, there was not an increase in observations of zero or negative usage for participants, nor was there a spike in high outliers for matched controls. Finally, usage was not outside the bounds of recorded usage: from 2014 to 2016 average monthly usage ranged from 16 to 26 kWh per day, usage for participants in July 2016 was 18 kWh per day while usage for matched controls was 22 kWh per day.

customers and for Level 3 customers, and negative, but statistically insignificant for Level 4 customers. For passive customers in Level 1 the savings were too small to see a statistically significant effect, and for the other three groups the relatively small sample sizes for billing analysis contributed to the statistical insignificance of the effects.

Figure 3-14. Energy Savings in 2014 by Technology/Price Group



Source: Navigant analysis
Note: n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

3.3 Bill Savings

Navigant calculated bill savings separately for Pilot participants on the CPP and PTR rates. To estimate the monthly bill impacts of the Pilot for CPP customers, Navigant calculated the bill amount using actual usage under the Smart Rewards TOU pricing rates and the counter-factual bill amount in absence of the Pilot using counter-factual usage under the Basic Rate. Counter-factual usage accounted for the energy savings estimated in Navigant's analysis. For PTR customers, the bill savings were due to the rebates paid by National Grid during Peak Events since these customers were not on the TOU rate. The rebate was calculated by subtracting the actual electricity consumed during Peak Events from the counter-factual consumption during Peak Events (defined as average usage during the ten prior non-holiday, non-Conservation Day weekdays after accounting for a day-of adjustment to capture weather differences, time of event, pre-cooling, etc.) and multiplying by the rebate amount in cents per kWh. These methods are detailed in APPENDIX A.

Table 3-7 shows savings for CPP and PTR customers in both years of the Pilot with the Peak Event hours that were actually called (135 in 2015 and 139 in 2016) and if the maximum of 175 Peak Event hours had been called (based on the average savings per event hour). Considering the actual number of Peak Events called, customers on both rates saved less in 2016 than in 2015 but the drop was more pronounced for CPP customers. The reduction in 2016 compared to 2015 occurred despite the increase in energy savings for CPP customers. Increases in energy savings do not necessarily produce increases in bill savings because of the high price during Peak Events. For example, the highest energy savings occurred in July 2016, but that did not produce high bill savings in that month because eleven Peak Events were called, increasing bills for many customers. If 175 Peak Event hours had been called, PTR customers would have earned more savings in rebates but CPP customers would have had slightly lower bill savings as their bills would increase due to more hours being charged at the higher Peak Event period rate.

Table 3-7. Bill Savings by Price Plan

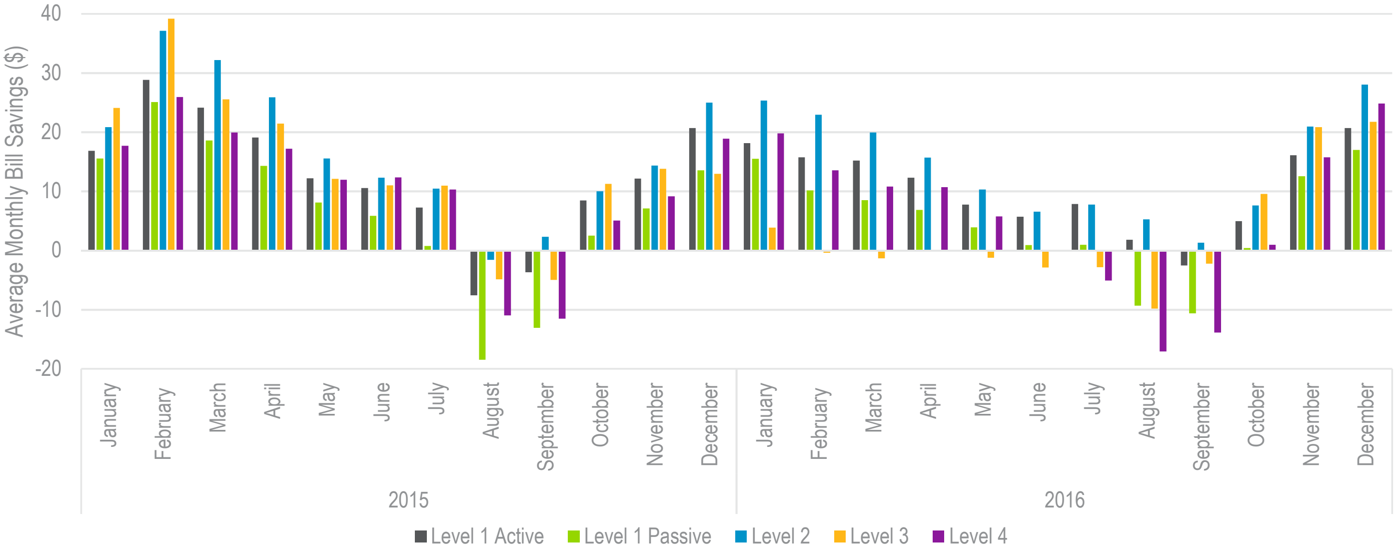
	2015		2016	
	With 135 Peak Event Hours	With 175 Peak Event Hours	With 139 Peak Event Hours	With 175 Peak Event Hours
CPP	$146	$142	$90	$87
PTR	$20	$26	$19	$25

Source: Navigant analysis

3.3.1 CPP Customers

Figure 3-15 shows the average bill savings by month and year for CPP customers. The month of each bill is defined as the last day of the billing period. This means that on average bills in each month contain an equal number of days in the current month and the previous month, for example bills in May reflect usage in the second half of April and the first half of May. On average across technologies, bill savings were highest in February 2015, which reflects January and February 2015 usage, when customers were still adjusting to the new TOU rate. Customers' bills went up in August and September of each year, reflecting usage in July, August, and September, which is expected since July and August were when the majority of the Peak Events were called in each year. Savings followed a similar pattern in both years, peaking in winter (through December, January, and February) and bottoming out during the summer months with Peak Events.

Figure 3-15. Average Bill Savings for CPP Customers



Source: Navigant analysis

Average per-customer bill savings are shown by year in Table 3-8. Savings were lower for each group in 2016 than in 2015. This occurred partially because the difference between the Basic Rate and the CPP rates fell in 2016 compared to 2015. In the summer of 2015 the CPP peak period rate was 0.40¢ less than the Basic Rate and the off-peak rate was 1.94¢ less, whereas in the summer of 2016 the peak period rate was 0.34¢ less than the Basic Rate and the off-peak rate was 1.66¢ less. The price during Peak Events fell from 34.29¢ more than the Basic Rate in 2015 to 29.33¢ more in 2016.

Table 3-8. Bill Savings for CPP Customers by Technology Group

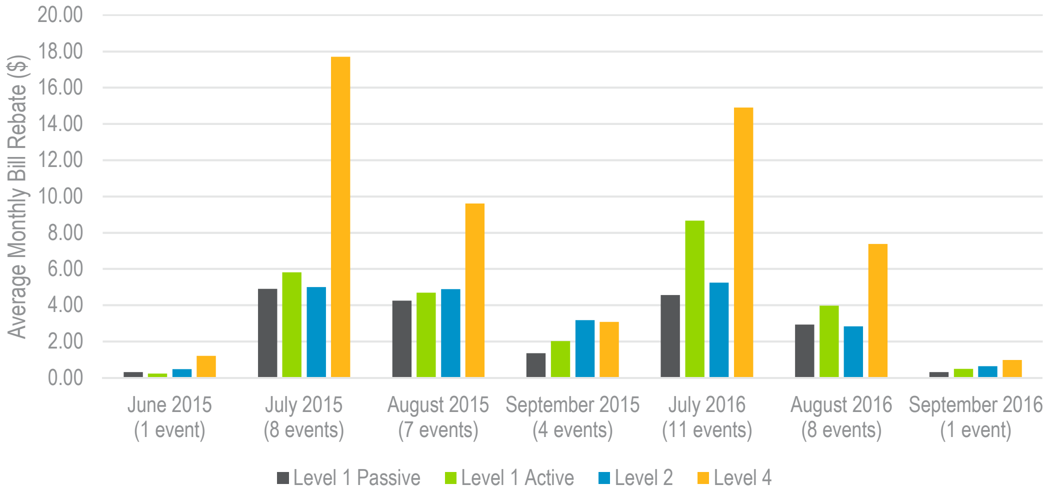
	2015	2016
Level 1 Passive	$79	$56
Level 1 Active	$148	$123
Level 2	$204	$171
Level 3	$172	$35
Level 4	$125	$66

Source: Navigant analysis

3.3.2 PTR Customers

The bill savings for PTR customers came from the monthly rebates earned during Peak Events.[87] Figure 3-16 shows the average bill rebates by month and year for PTR customers. The average total rebate for events called during the summer of 2015 was $10.80 and the average for 2016 was lower at $7.80. Table 3-9 shows the average savings per event in each year.

Figure 3-16. Average Bill Rebates for PTR Customers



Source: Navigant analysis

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[87] Energy savings were neither expected nor found for PTR customers and thus changes in usage outside of Peak Events do not enter into our calculations of bill savings.

Table 3-9. Rebate Paid per Event for PTR Customers by Technology Group

	2015	2016
Level 1 Passive	$0.54	$0.39
Level 1 Active	$0.64	$0.66
Level 2	$0.68	$0.44
Level 4	$1.58	$1.16

Source: Navigant analysis

3.3.3 Arrearage Analysis

As a complement to the bill savings analysis, the evaluation team calculated credit and collection results for Pilot participants and other customers in Worcester. Comparisons between the two groups included the following metrics:

- End of Pilot arrears balances and customer counts for 30/60/90+ day periods;
- End of Pilot arrears balances and customer counts for accounts flagged as medical or life support, and therefore not subject to disconnections;
- Disconnection service history before and during the Pilot; and,
- Uncollectible account history before and during the Pilot.

Navigant found that the Pilot did not have a large impact on any of these four metrics. Overall compared to Worcester customers not in the Pilot, a smaller portion of the Pilot participants had disconnections or uncollectible balances. However, this was true in 2014, before the Pilot began, as well as during the Pilot in 2015 and 2016. A similar percentage of customers within and outside of the Pilot had arrears balances. The average dollar amounts per customer with arrears, disconnects, or uncollectible balances were also similar for Pilot and non-Pilot customers. Tables showing analysis of each of these metrics are presented in APPENDIX B.

3.4 Load Shifting

The regressions from which Navigant estimated Peak Event impacts, which covered June to September of each year, also included coefficients to estimate three types of load shifting:

1. **Load shifting around Peak Events,** including pre-cooling, wherein customers change their energy usage before a Peak Event, and snapback, wherein customers change their energy usage after a Peak Event. In 2015, evidence of pre-cooling in the Pilot was not found and thus pre-cooling was left out of the final regression specification. However, some customers did report using pre-cooling as a strategy to save energy in the surveys, especially in 2016 (see Figure 4-17).
2. **Load-shifting from weekdays to weekends**.
3. **Non-event peak impacts,** in which customers shift usage on weekdays that are not Conservation Days from peak to off-peak hours.

Snapback was estimated for each Peak Event while the other two types of load shifting ware estimated on average for each summer.

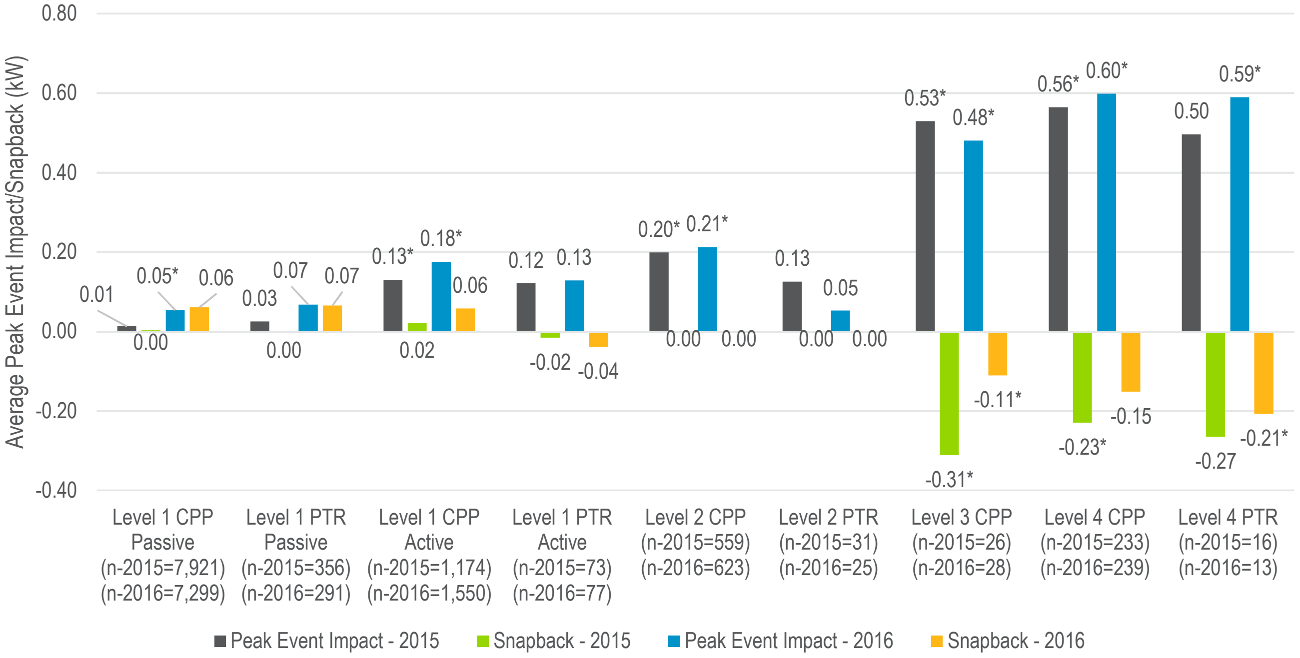
CPP customers were expected to exhibit all three types of load shifting as they were on a TOU rate and thus had an incentive to be price-conscious and shift usage to lower-cost times of the day and week, i.e. off-peak hours and weekends. Load shifting contributed to bill savings for CPP customers. PTR customers may exhibit load shifting around Peak Events as they could earn money back if they reduce usage during Peak Events hours, but they did not have a strong incentive to shift loads from weekdays to weekends or from peak to off-peak hours on days that were not Conservation Days as they were not charged a TOU rate. Overall, Navigant found that each type of load shifting was: (1) small compared to the Peak Event impact, (2) mostly larger for CPP than PTR customers as expected, and (3) mostly larger for customers with higher levels of technology.

Statistically significant load shifting effects were not found for commercial customers in any of the three categories, thus the following subsections focus on residential customer impacts.

3.4.1 Snapback

Figure 3-17 shows the average Peak Event impact and snapback for each residential technology/price group. The overall result is that for this Pilot snapback was not very prominent.

Figure 3-17. Snapback Compared to Peak Event Impacts



Source: Navigant analysis

Note: Negative values for snapback in this graph indicate an increase in usage in the hours after peak events. An asterisk (*) indicates that the majority of the event or snapback hours throughout the summer were statistically significant for the indicated group. Also, n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

For Level 1 and 2 customers in both price groups there was hardly any snapback in either year. In fact, for Level 2 customers in both price groups there was no snapback found for any of the Peak Events. For Level 1 customers, Navigant actually found that customers continued to save electricity even after the Peak Event had ended. This may be evidence that these customers, who have no enabling technologies, were making changes during events that they did not stop immediately at the end of the event. This phenomenon can be seen in the graphs provided in Appendix F.

Snapback was more prominent for Level 3 and Level 4 customers. For these groups, snapback was slightly lower in 2016 than in 2015 which could be due to increased awareness of and familiarity with the Pilot in the second year. The disparity in snapback across the different technology levels was almost certainly driven by PCTs which Level 3 and 4 customers had, but Level 1 and 2 customers did not. The smart thermostats were adjusted remotely by National Grid during Peak Event hours and then returned to the user-defined temperature once the Peak Event ended. The snapback observed for customers with these thermostats was likely from the HVAC system working hard to cool the home after running less than usual during Peak Event hours.

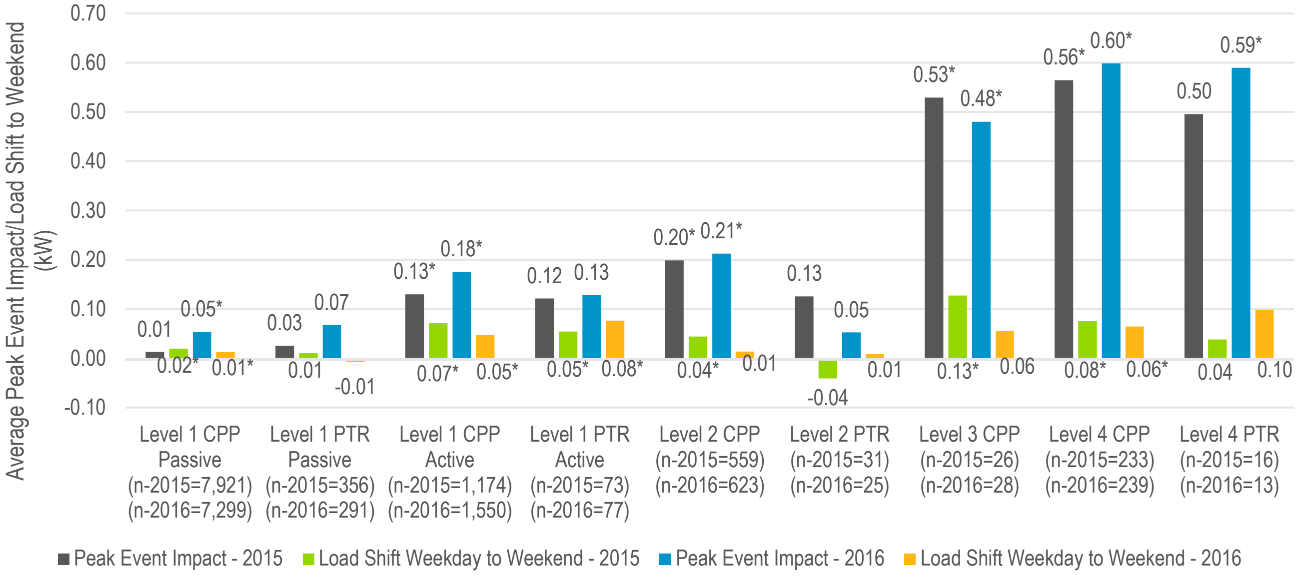
Even for Level 3 and 4 customers where significant snapback was observed it was relatively small in magnitude and short in length. On average for Level 3 and 4 customers, the snapback was about half the magnitude of the Peak Event impact. Additionally, snapback generally lasted less than two hours, which is fairly short, especially given the long length of the Peak Events. Tables with snapback for each Peak Event are provided in APPENDIX B.

3.4.2 Weekday to Weekend Load Shifting

CPP customers had an incentive to shift their usage from weekdays to weekends in order to avoid paying the higher peak time rate that ran from 8 a.m. to 8 p.m. on weekdays. PTR customers may have had an incentive to shift usage to weekends when Peak Events were being run during the week, but the incentive was much smaller as they were not charged the TOU rate. Additionally, the Pilot may have caused them to form habits which involved shifting their energy intensive activities to times when Peak Events would definitely not be called.

Figure 3-18 shows the average Peak Event impact and the average shift of usage from weekdays to weekends for each residential technology/price group in each summer (June to September) of the Pilot. For CPP customers some load shifting to weekends was observed for each technology level. The magnitude of the shifting was relatively similar across the two years of the Pilot. PTR customers did not exhibit a statistically significant load shift at any technology level. The disparity in weekday to weekend load shifting between the two rates is not surprising given the different incentives for customers on each rate discussed in the previous paragraph.

Figure 3-18. Weekday to Weekend Load Shifting Compared to Peak Event Impacts



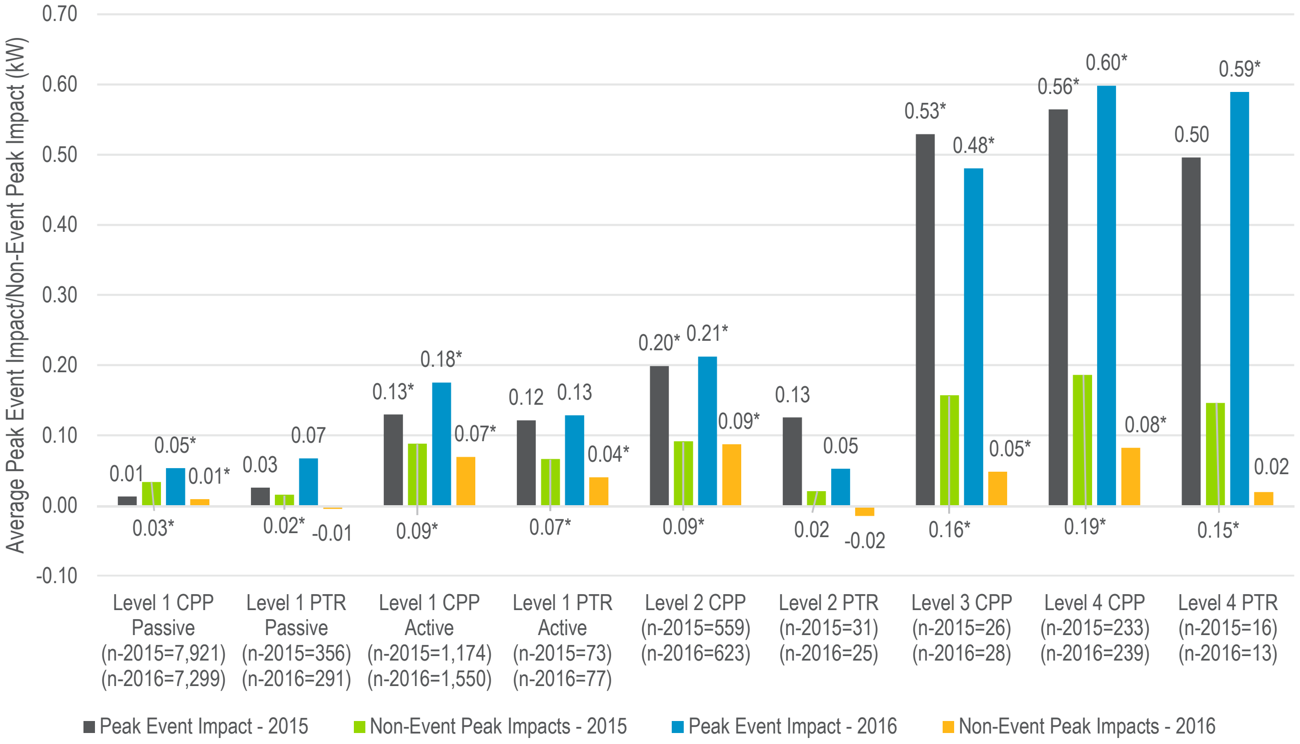
Source: Navigant analysis
Note: Positive numbers for load shift in this graph indicate a decrease in weekday usage and an increase in weekend usage. An asterisk (*) indicates that the majority of the hours throughout the summer were statistically significant for the indicated group. Also, n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

3.4.3 Non-Event Peak Impacts

CPP customers had an incentive to shift their usage from peak hours to off-peak hours, even in the absence of a Conservation Day, since electricity was cheaper for them during off-peak (8 pm to 8 am) hours. PTR customers had no monetary incentive to shift usage to off-peak hours on days that were not Conservation Days, but the Pilot may have caused them to form habits which involved shifting their energy intensive activities to times when Peak Events would definitely not be called.

Figure 3-19 shows the average Peak Event impacts and the average non-event peak impacts for each residential technology/price group for each year. For CPP customers there were non-event peak impacts at each technology level in both years, although they were generally smaller in 2016 than in 2015. Level 4 customers on the PTR rate showed non-event peak impacts of practical significance in 2015, but the effect dissipated in 2016.

Figure 3-19. Non-Event Peak Impacts Compared to Peak Event Impacts



Source: Navigant analysis
Note: Positive numbers for non-event peak impacts indicate savings during peak hours that were not also Peak Events. An asterisk (*) indicates that the majority of the event hours throughout the summer were statistically significant for the indicated group. Also, n refers to the number of customers used in this particular analysis, not the total number of customers in each technology/price group.

For CPP customers the non-event peak impacts were almost always smaller than the Peak Event impacts. In particular, for the three groups with PCTs the magnitude of the non-event peak impacts was small compared to the Peak Event impacts; the non-event peak impacts for these groups were always less than one-third of the Peak Event impacts.

4. CUSTOMER EXPERIENCE ASSESSMENT

National Grid based its Smart Energy Solutions evaluation plan for customer experience on the *Common Evaluation Framework's* research questions. The customer experience evaluation focused on these key areas:

- How well did customers understand the Pilot's purpose and its impact on their electric use and bills?
- How did customers interact with the technologies? Were the technologies informative? Did they lead to taking conserving and efficiency actions?
- How well did customers understand the rate choices and 12-month bill protection?
- Why did customers stay in or opt out of the program? What were the critical factors in those decisions?
- What age, income, or other demographic characteristics were important to understanding customer reaction to and participation in the Pilot?[88]

In order to assess customer experience, Navigant relied upon a combination of customer surveys, interviews, and focus groups, as noted in Section 1.2. Although entry into the program was on an opt-out basis, Smart Energy Solutions actually contained a number of opt-out and opt-in decision/action points, as described in Section 1.2.2. Thus, marketing, education, satisfaction, and lessons learned were assessed for each program aspect. APPENDIX C contains a detailed discussion of each customer experience evaluation activity.

4.1 Participation Drivers

Before and throughout the Pilot, National Grid provided information to customers in the Pilot area that emphasized the pricing and no-cost technology options available to them.

4.1.1 Most Customers Accepted the AMI Meter

The first customer decision point occurred when National Grid installed smart meters. While customers had the option to decline the meter, 95% of meters were installed; only about 5% of the eligible 15,000 customers in the Pilot program area declined the meter. According to the meter opt-out survey, most of the customers who declined the meter appeared to do so because they had no interest in participating in the Pilot. Customers who declined the smart meter expressed a variety of reasons, primarily confusion, indifference, health and safety issues, concerns about electricity costs, and data security and privacy concerns, as shown in Figure 4-1. Twenty-two customers provided "generic" reasons for declining the meter, which were divided between 13 saying they "don't think I will benefit from this" and 9 simply saying

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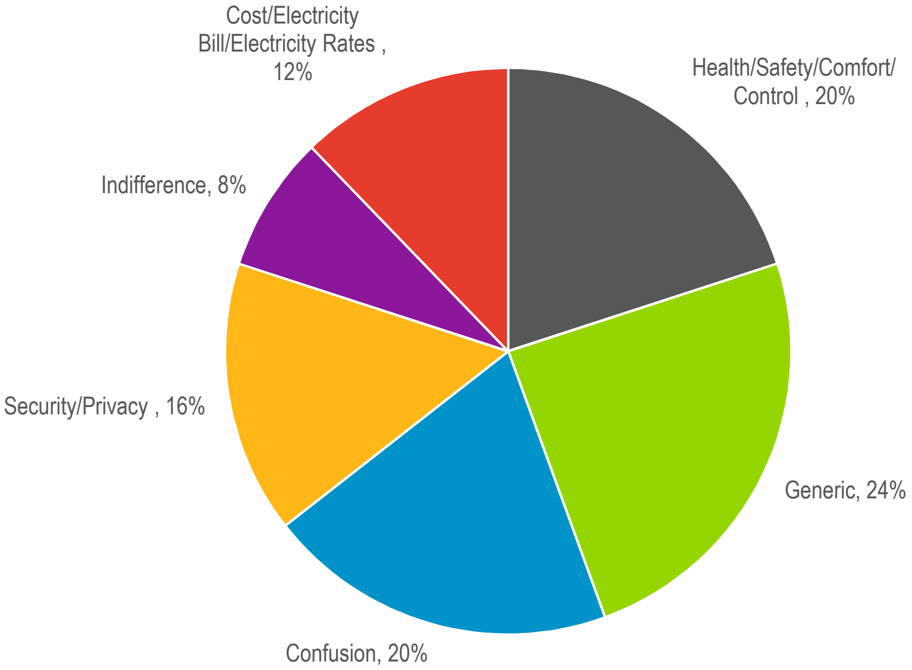
[88] Navigant identified low-income customers using the R2 rate. Many of the surveys also collected self-reported data to capture customers whose income was at or below 200% of the federal poverty levels and 60% of the area median income. In 2015, Navigant found that the survey results did not vary based on which definition of low income was used; therefore, the R2 rate definition was used in the analyses throughout this report.

"I don't want this."

Figure 4-1. Categorical Reasons for Declining a Meter

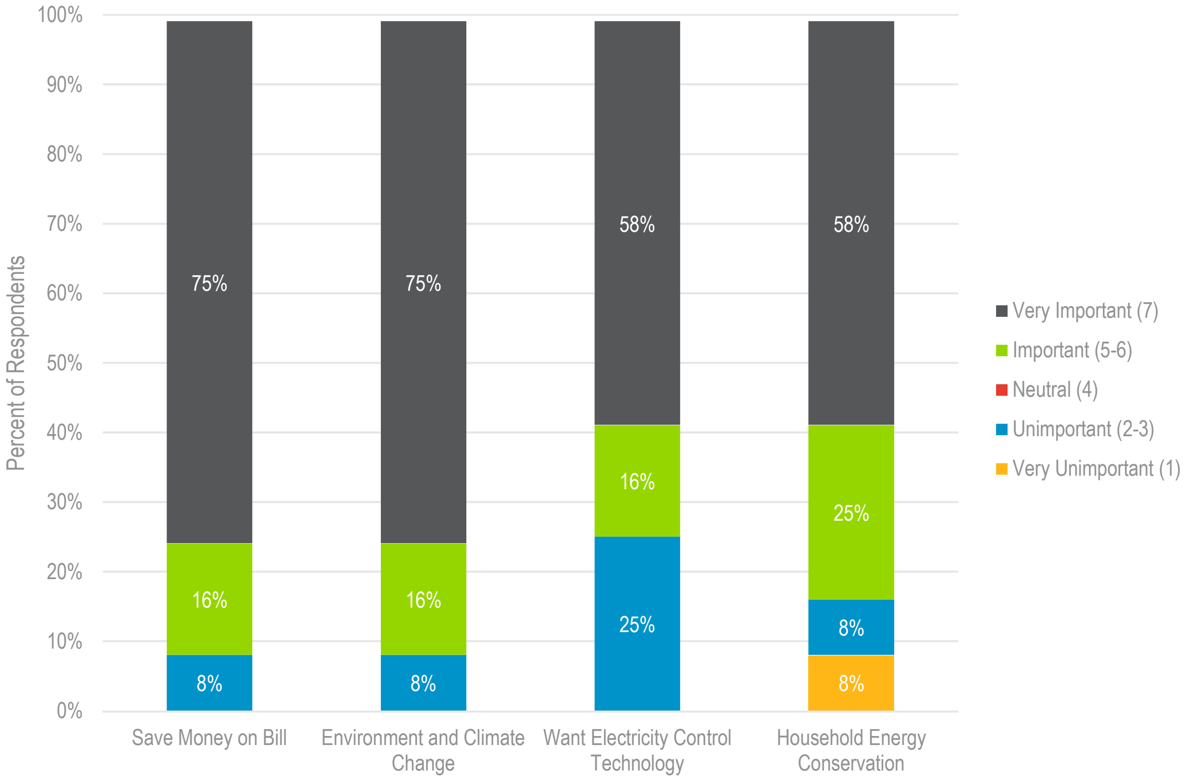


Source: Navigant analysis of meter decline survey (N=70)

4.1.2 Motives for Pilot Participation

In the pre-pilot survey, customers were asked to rate the importance of the following motives to participate in the Pilot: saving money on their electricity bills, the environment and climate change, receiving control technologies, and household energy conservation. As summarized in Figure 4-2, participants most often rated saving money on their electricity bill and protecting the environment as "very important" reasons for participating in the Pilot (75% for both motivations).

Figure 4-2. Customer Motivations for Pilot Participation, as Expressed in the Pre-Pilot Survey



Source: Navigant analysis of pre-pilot survey (N=1,478)
Note: No survey participants provided a neutral response.

4.1.3 Low-Income Customers' Perceived Ability to Adjust Electricity Usage was High

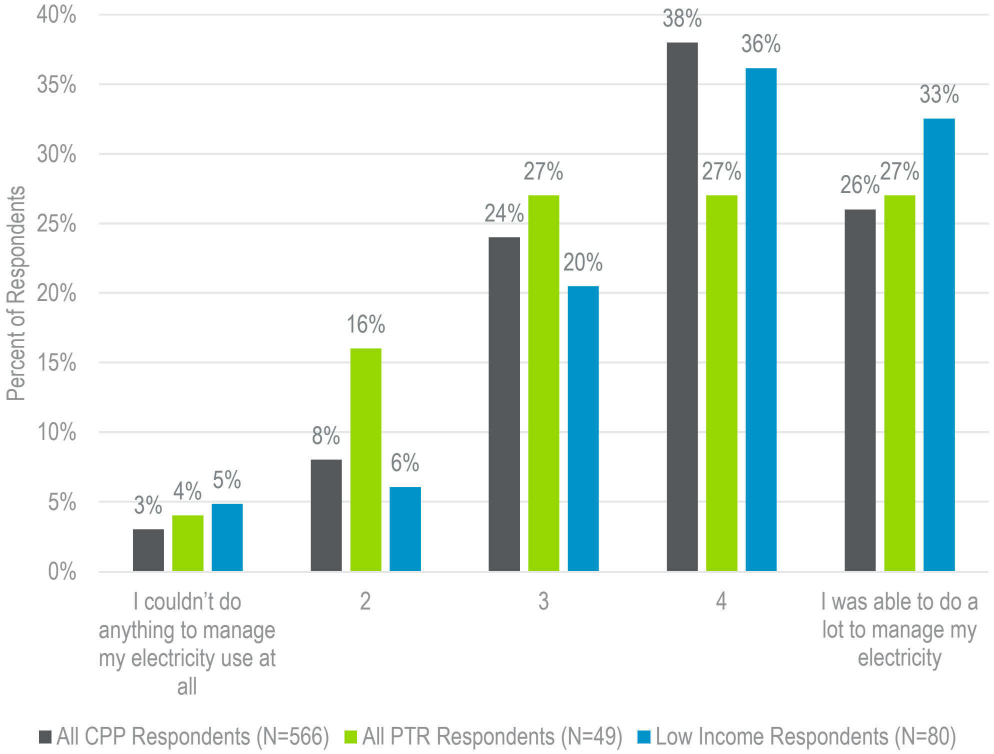
There was concern, before the Pilot started, that low-income participants would not be able to shift their usage to take advantage of lower rates in non-peak hours. However, when asked about their expectations, more of these participants expected that they would be "highly effective" at shifting usage than other participants did (Figure 4-3).

Figure 4-3. Pre-Pilot Perceived Ability of Low-Income Participants to Adjust Energy Usage

Source: Navigant analysis of pre-pilot survey (N=1,470)

As shown in Figure 4-4, when surveyed at the end of the Pilot, low-income customers again rated their ability to manage their electricity higher than all respondents on either the CPP or PTR price plan. However, within the focus groups (as discussed further in Section 4.2.7) low-income customers sometimes indicated taking extreme actions to save energy during events, such as shutting off their room AC entirely, and said that their actual options for controlling electricity use during events were often quite limited. Overall, PTR respondents rated their ability to manage their electricity usage slightly lower than CPP respondents, which makes sense as customers with a low ability to manage electricity would be more likely to switch to the PTR rate to avoid the high Peak Event rate on the CPP plan.

Figure 4-4. Reported Ability of Low-Income Customers to Manage Electricity Use at End of Pilot



Source: Navigant analysis of end of pilot survey (N=615)

4.2 Participant Awareness, Engagement, Satisfaction

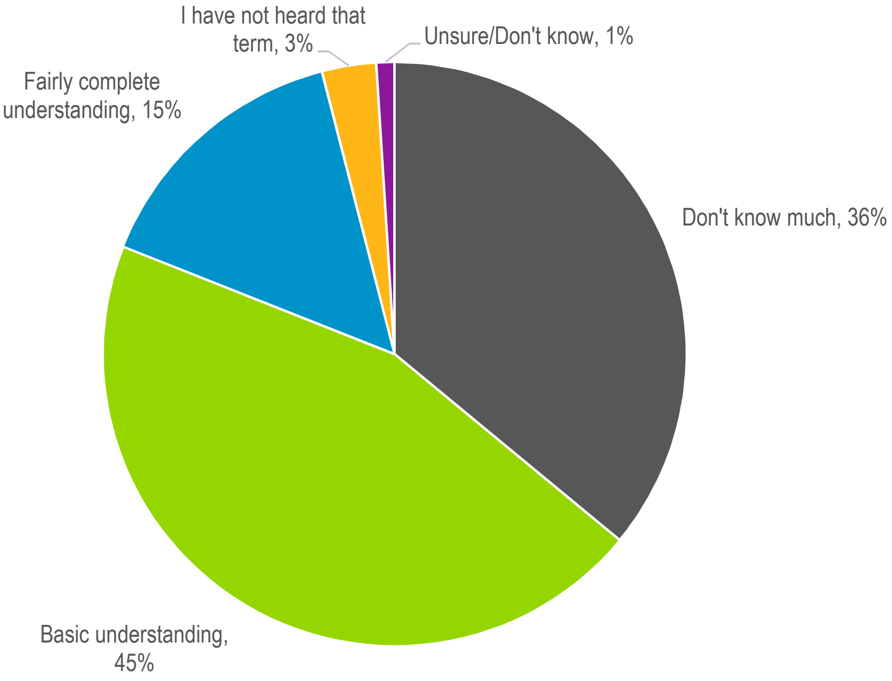
National Grid provided extensive information to customers about the program, rates, technologies, and bill protection before and during the Pilot, as shown in Chapter 2. During the pre-pilot survey, customers expressed motivation to save money and confidence that they could shift their electricity usage. In the surveys of all residential customers and focus groups with low-income customers conducted throughout the Pilot, many customers in all demographic segments indicated a desire for more information about the rates and technologies, personalized conservation tips, additional means of communication about the events, and more insights into savings. After the first summer, National Grid adapted the Pilot based on feedback from customers; for example, National Grid expanded and highlighted the options to personalize event notifications in 2016 compared to 2015 based on customer complaints about the timing and channel of the notifications. The Company also continued to send regular mailings and emails throughout the Pilot to keep customers informed and motivated.

4.2.1 Rate Awareness and Understanding Increased over Time

Participant knowledge and understanding of the program rates was an important aspect of the Pilot. National Grid offered both CPP and PTR options to customers in order to provide flexibility in the program. At face value, customers might prefer the PTR rate over the CPP rate as the CPP rate charges customers a higher rate during Peak Events. The utility industry typically perceives that the advantage of PTR over CPP for customers is that it provides a rebate due to conservation during Peak Events but does not increase the rate, such that a customer's bill decreases in the short run.[89] However, due to National Grid's CPP rate design, which charged a lower rate than the Basic Rate for at least 335 days (the utility could hold up to 30 Peak Events per year), if customers shifted their usage they would most likely save more money annually on the CPP rate than on the PTR rate. Additionally, customers on the CPP rate were offered bill protection in which they were given a credit at the end of the year if their expenditures exceeded what they would have spent if they had been on the Basic Rate, thus mitigating the risk of the CPP rate. Most customers remained on CPP and did not actively elect either plan. The majority of National Grid customers who contacted the utility to select a rate chose the CPP rate over the PTR rate.

In the initial pre-pilot survey conducted in 2014, 8% of customers said that they had heard of the CPP rate. Of the customers who had heard of the rate, 15% of them "ha[d] a fairly complete understanding of what it means" and 46% "ha[d] a basic understanding of what it means", as shown in Figure 4-5. A few customers may have been confused about the rate, as 3% of these customers said they had never heard of the new rate, when asked how well they understood it.

Figure 4-5. Customer Pre-Pilot Knowledge of the CPP Rate



Source: Navigant analysis of pre-pilot survey (N=118)

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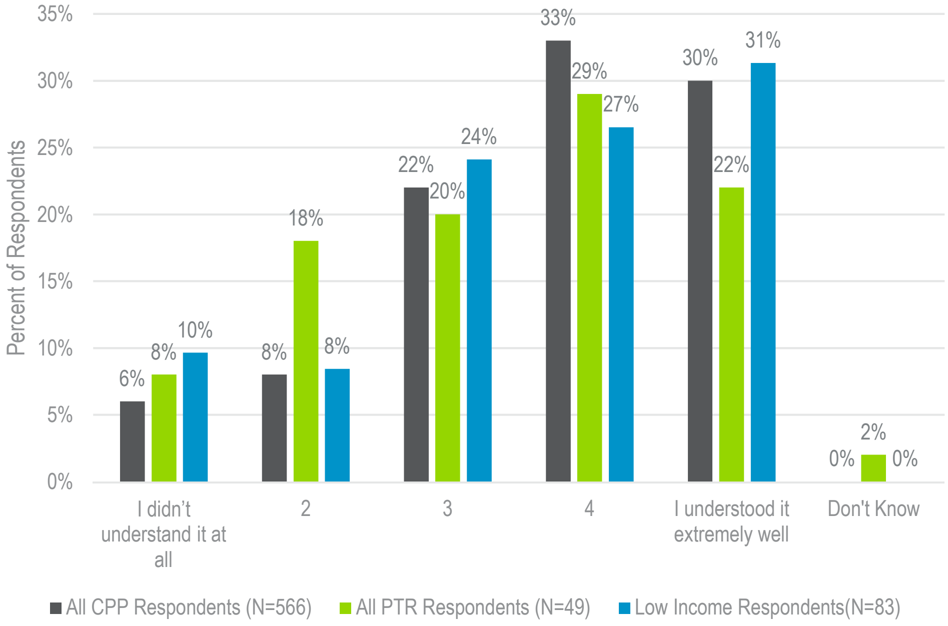
[89] The Regulatory Assistance Project. *Time-Varying and Dynamic Rate Design.* July 2012.

By the time the end of pilot survey was administered (October 2016), almost all customers (97%) were aware of the Pilot and the rate they were on. Additionally, the majority of customers on both price plans, including those with low incomes, indicated that they had a good understanding of their pricing plan (rating their understanding as a 4 or 5 on a 5-point scale), as shown in Figure 4-6.

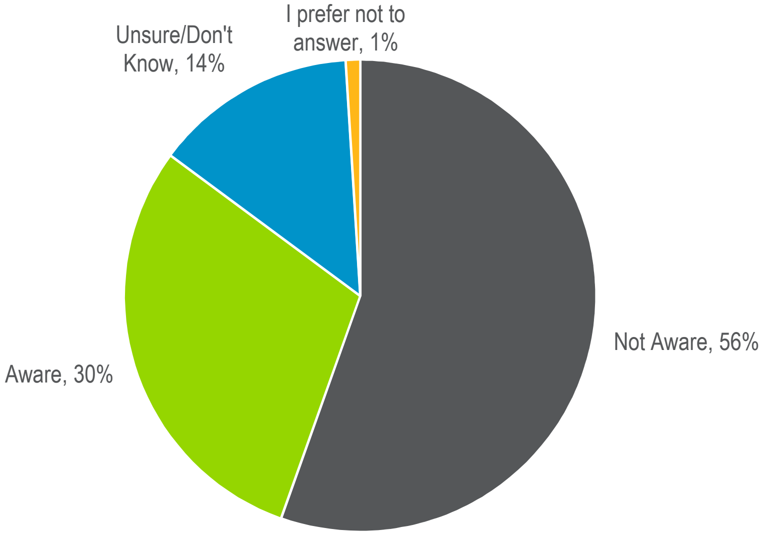
Figure 4-6. Customer Understanding of the Pilot Pricing Plan



Source: Navigant analysis of 2016 end of pilot survey (N=615)

Although customers understood the rate that they were on, most (56%) were not aware they had the option to switch pricing plans (see Figure 4-7). This lack of awareness may have contributed to the higher than expected retention of customers on the Pilot's default CPP rate. The lack of awareness occurred despite the fact that National Grid provided a lot of information about both rates, starting with an official welcome kit. National Grid provided examples of participant bills to customers to illustrate the differences between the two rates. The Company continued to provide information to explain that there were many variables determining the impact of use on cost, particularly during Peak Events, throughout the Pilot.

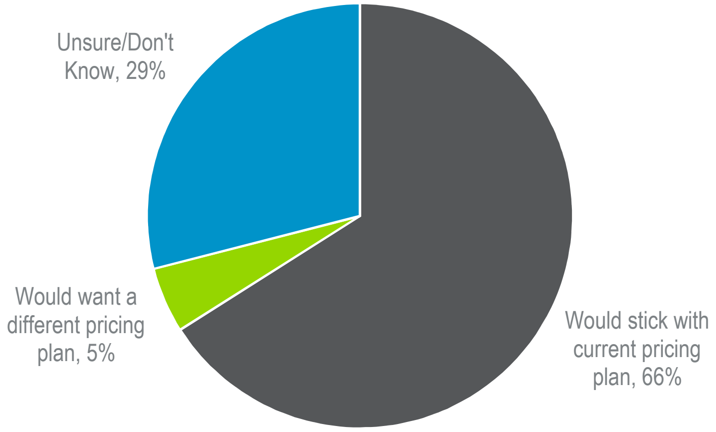
Figure 4-7. Customer Awareness of Ability to Switch Pricing Plans



Source: Navigant analysis of 2016 end of pilot survey (N=615)

Despite not realizing that they could switch price plans, most customers (66%) indicated that they would want to continue with their current price plan if they continued to be enrolled in the Pilot (Figure 4-8). Additionally, only 5% of customers said that they would want to switch to a different pricing plan. This indicates that customers were generally happy with the rate they were on and may not have been seeking options to switch, contributing to the low awareness of switching.

Figure 4-8. Customers' Interest in Continuing with Current Pricing Plan



Source: Navigant analysis of 2016 end of pilot survey (N=615)

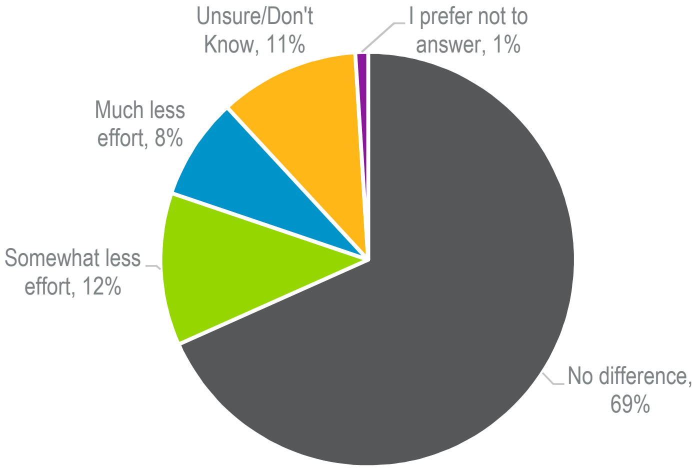
4.2.2 Customers Exhibited Mixed Awareness and Understanding of Program Features

At the end of the Pilot, customers were surveyed about their awareness and understanding of various features of the program. Survey questions focused on the bill protection available on the CPP rate, the technology packages, and the rewards platform that was added in 2016.

Bill Protection

At the end of the Pilot, almost half of the customers on the CPP rate (40%) said that they were aware of the bill protection feature. However, over two-thirds of those who knew about it said that the feature made no difference in their efforts to manage their electricity use. This means that most CPP customers likely did not reduce their energy savings behaviors because they knew they would get bill protection at the end of the year anyway. Approximately 20% of the CPP participants did say that knowing about bill protection led them to put "somewhat less" or "much less" effort into saving energy. To explore this further Navigant matched the survey results to the usage data and examined the Peak Event impacts for active customers in Level 1 CPP who said they were aware or unaware of the bill protection feature.[90] This analysis did not reveal statistically significant differences in impacts and neither group had consistently higher or lower impacts than the other, supporting the conclusion that bill protection awareness did not influence customers' actions in the Pilot.

Figure 4-9. Effect of Bill Protection on Customers' Efforts to Manage Electricity



Source: Navigant analysis of 2016 end of pilot survey (N=229)

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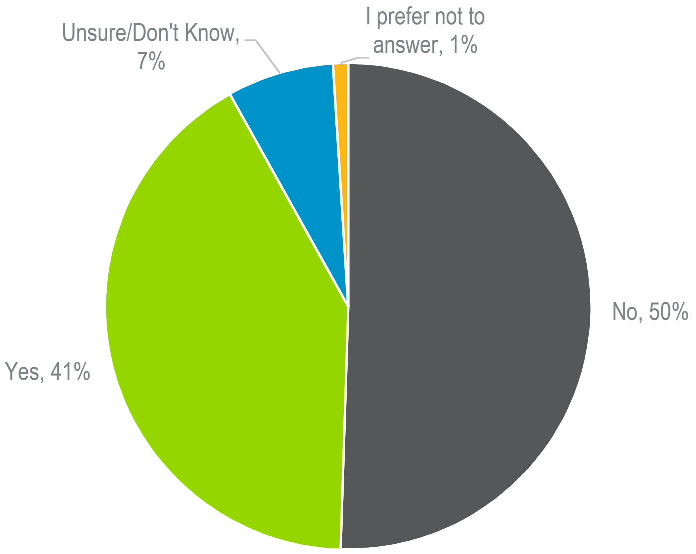
[90] We examined active customers in Level 1 CPP because this group contained the largest number of customers who answered this question. In this group, there were 71 customers who were aware of bill protection and 101 who were unaware.

Technology

Approximately 40% of the customers in Level 1, i.e., those who did not opt to receive the free Pilot technologies, were aware that the technologies were available (see Figure 4-10); the relatively low awareness occurred despite heavy promotion of the technologies. Many of those who were aware of the technology offerings chose not to opt into the technologies for reasons that indicated they did not see the benefit of the technology to them and thus expressed a lack of interest in it.[91] Additionally, several customers mentioned they could not install the technology as they were not the homeowner. This complication for renters was also reflected in the reasons reported by customers who wanted one of the technology packages but had to cancel their install (see Figure 2-10).

Figure 4-10. Customer Awareness of Free In-Home Technologies



Source: Navigant analysis of 2016 end of pilot survey (N=379)

Rewards Platform

By the time of the End of Pilot survey (October 2016), 67% of customers reported awareness of the rewards platform launched in February 2016. As demonstrated in Figure 4-11, the rewards platform seemed to have varied influence on customers' efforts to save electricity. About half reported that the rewards platform had considerable influence on their efforts, while half reported little to moderate influence. There was an increase in the number of active participants in Level 1 in 2016 compared to 2015 and the increase may be partially attributable to increased traffic to the web portal because of the rewards platform. In 2016, 1,042 customers redeemed points in the rewards platform to receive 2,219 gift cards.

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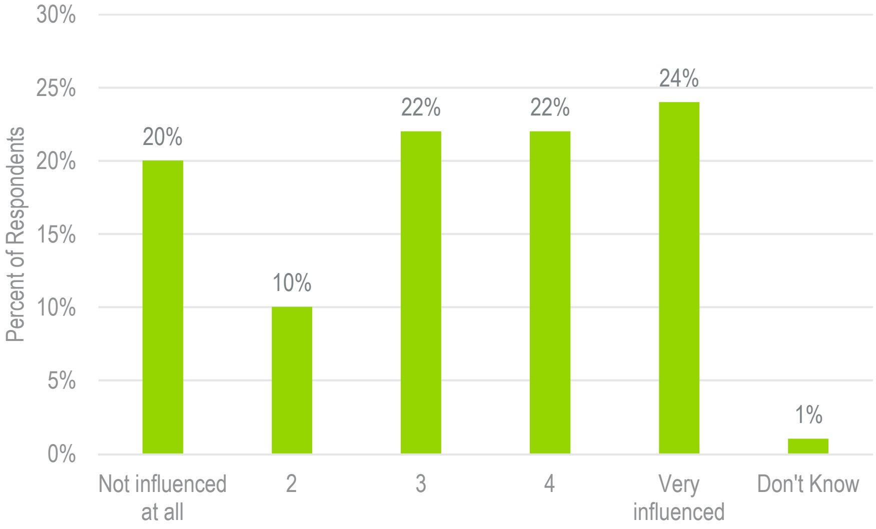
[91] Response options included "Too much bother", "I didn't think about it", "I wasn't sure what it would do", and "I didn't think it would help."

Figure 4-11. Reported Influence of Rewards Platform on Energy Efficient Actions



Source: Navigant analysis of 2016 end of pilot survey (N=428)

4.2.3 Rate Enrollment and Retention Rates On Par with Opt-Out Recruitment Methods

The majority of time-based rate pilots around the country are based on an opt-in recruitment model, in which customers volunteer to participate. By definition, opt-in customers are motivated to participate in a dynamic rate pilot. Customers who participate in opt-in programs tend to be enthusiastic early adopters and not likely to drop out of a program they signed up for.

Smart Energy Solutions is unusual because it is an opt-out program, which requires customers to contact the utility to opt out of the pricing program. Opt-out program design is a relatively new industry concept. Opt-out programs capture all customers, many of whom may follow “default bias”, which means that they tend towards the default offering rather than accepting alternative offerings. Industry understanding at this time is that retention rates are similar for opt-in and opt-out programs.[92]

The CPP and PTR rates went live in January 2015 and had been in effect for two years at the end of 2016. As shown in Figure 4-12, National Grid’s residential enrollment rates were high compared to opt-in recruitment rates and were on par with typical opt-out recruitment rates. Customer enrollment is the percentage of customers, as of January 2015 when the Pilot rates went live, in the Pilot area who had a meter and had not yet opted out. Over time, customer retention reflects how many customers remain in the Pilot rather than dropping out.[93] As shown in Figure 4-13, National Grid’s retention rates for residential

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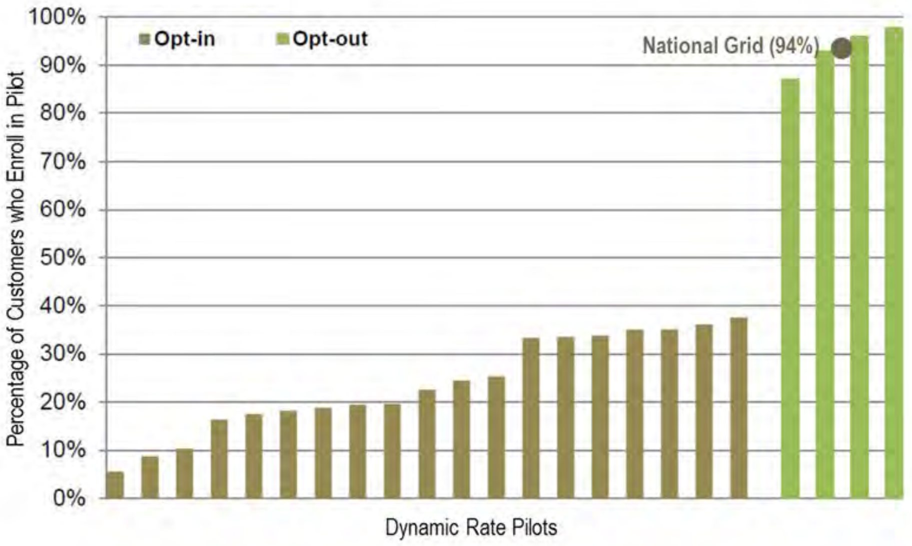
[92] Cappers, P., H. Liesel, R. Scheer. *American Recovery and Reinvestment Act of 2009: Interim report on customer acceptance, retention, and response to time-based rates from the consumer behavior studies*. LBNL-183029. June 2015.

[93] The retention rate considers only those customers who actually dropped out of the Pilot and excludes those who moved or switched to a competitive supplier, which could have happened for any number of reasons unrelated to the Pilot.

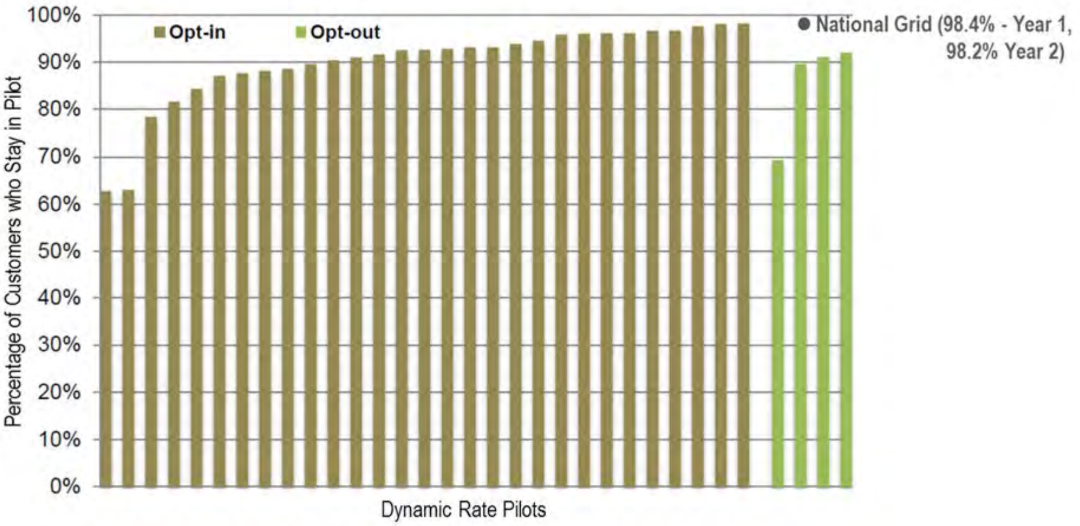
customers were higher than one-year retention rates for other opt-out rate pilot programs, even after two years of the Pilot. In fact, the Pilot had hardly any drop outs from the first year to the second year, making the first and second year retention rates virtually identical.

Figure 4-12. Customer Enrollment Rates Based on Opt-In vs. Opt-Out Recruitment



Source: Lawrence Berkeley National Laboratory and Navigant analysis
Note: Each bar represents a utility that has offered a dynamic rate to its customers.

Figure 4-13. Customer Retention Rate Based on Whether the Utility Used Opt-In or Opt-Out Recruitment

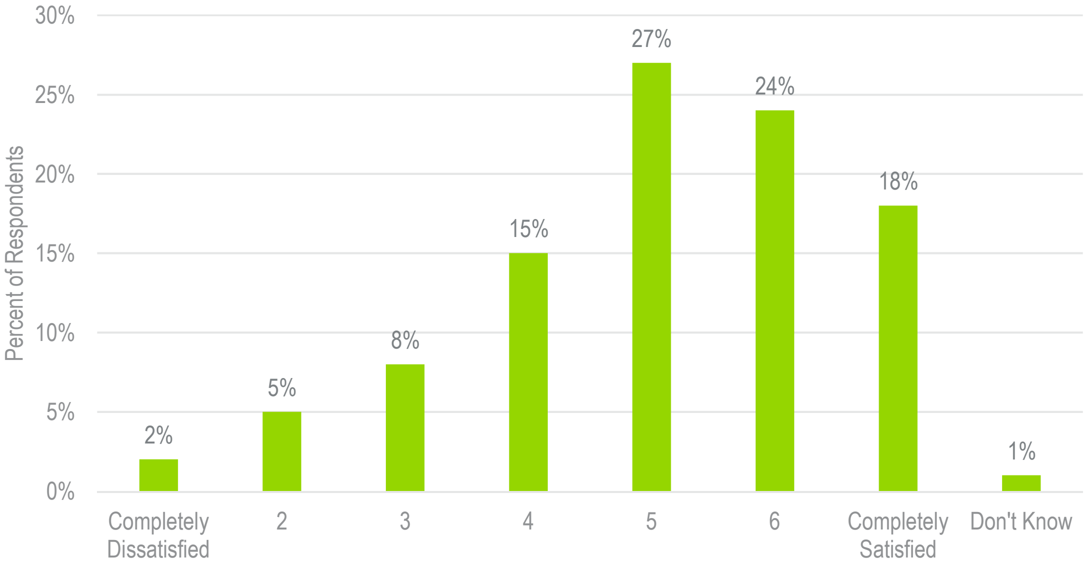


Source: Lawrence Berkeley National Laboratory and Navigant analysis
Note: Each bar represents a utility that has offered a dynamic rate to its customers.

4.2.4 Strong Customer Satisfaction with Program

At the end of the Pilot, as shown in Figure 4-14, 69% of customers indicated a strong level of satisfaction with the Pilot (rating it at least a 5 on a 7-point scale). The weighted average satisfaction rating was 5.06. This was similar to satisfaction after the first year in the Pilot when 72% of customers reported being "very satisfied" or "somewhat satisfied" with the Pilot on a 3-category scale.[94]

Figure 4-14. Participant Overall Satisfaction with Smart Energy Solutions



Source: Navigant analysis of 2016 end of pilot survey (N=615)

As described in the next several paragraphs, the Pilot's satisfaction rating was in line with the satisfaction achieved by several similar demand response pilots implemented by other utilities. In comparing satisfaction with Smart Energy Solutions to similar demand response programs, it is worth reiterating that Smart Energy Solutions is an opt-out program while the comparison programs are opt-in. Participants in opt-in programs chose to enroll and are thus expected to have a higher level of satisfaction than opt-out participants who are enrolled automatically. Satisfaction that is similar to opt-in programs in an opt-out program is commendable.

The Pilot's satisfaction rating was similar to customer feedback to NSTAR's[95] 2012-2013 pilot, undertaken in compliance with Section 85 of the GCA. NSTAR pilot customers were asked to rate the program on a 5-point scale (5 = very positive, 1=very negative, and 3 is neutral); the average rating was 4.0.[96] When translated to the 7-point Smart Energy Solutions scale, NSTAR's satisfaction would have been 5.6 out of 7, which is comparable to the 5.06 out of 7 for Smart Energy Solutions.

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[94] The scale was changed from the first to the second year of the Pilot to better align with DPU requirements.

[95] NSTAR is now called Eversource Energy.

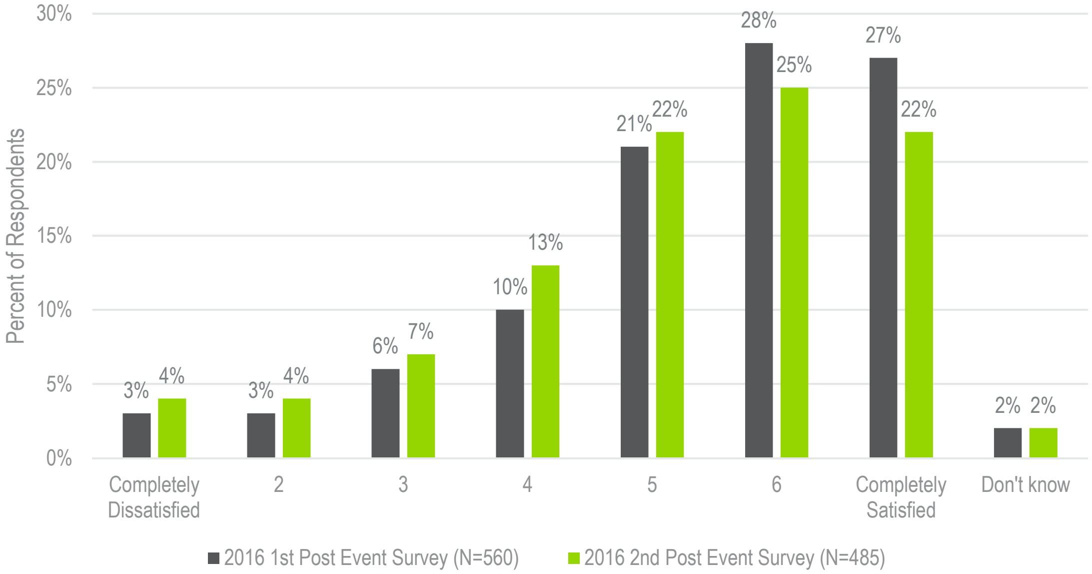
[96] Navigant. *NSTAR Smart Grid Pilot Final Technical Report: AMR Based Dynamic Pricing*. DE-OE0000292. Prepared for U.S. Department of Energy on behalf of NSTAR Gas and Electric Corporation. August 2014.

DTE conducted an opt-in pricing pilot that had a TOU/CPP price plan and included technology offerings very similar to Smart Energy Solutions'. By the end of DTE's pilot, 86% of customers rated their pilot at least a 6 on a 10-point scale.[97] Translated to the 7-point Smart Energy Solutions scale, 86% of customers rated the program at least a 4.2 out of 7 which is comparable to the 84% of Smart Energy Solutions customers that rated the Pilot at least a 4 out of 7.

MN Power held an opt-in demand response pilot that used a TOU/CPP rate but did not include technologies. The satisfaction for MN Power's program averaged 5.6 – 6.1 out of 10 across the three customer groups included.[98] When translated to a 7-point scale, the average satisfaction ranged from 3.9 – 4.3 out of 7. This is slightly lower than the average satisfaction for Level 1 customers in Smart Energy Solutions (who also had no in-home technology) at the end of the Pilot, which was 4.94 out of 7.

Satisfaction with Smart Energy Solutions was also measured in each post event survey. In 2016, the first post event survey occurred on July 7th, which was the second event in a two-day series, and the second post event survey occurred on July 28th, which was the fourth event in a four-day series. The satisfaction across these two surveys did not change significantly as shown in Figure 4-15.[99] In the first survey, 76% of customers rated the Pilot at least a 5 and in the second, 69% did the same. Since the second post event survey was done after a long series of back-to-back Peak Events, these results indicate that satisfaction did not suffer significantly due to the consecutive day Peak Events.

Figure 4-15. Participant Satisfaction with Smart Energy Solutions in 2016 Post Event Surveys



Source: Navigant analysis of 2016 post event surveys (N=560, N=485)

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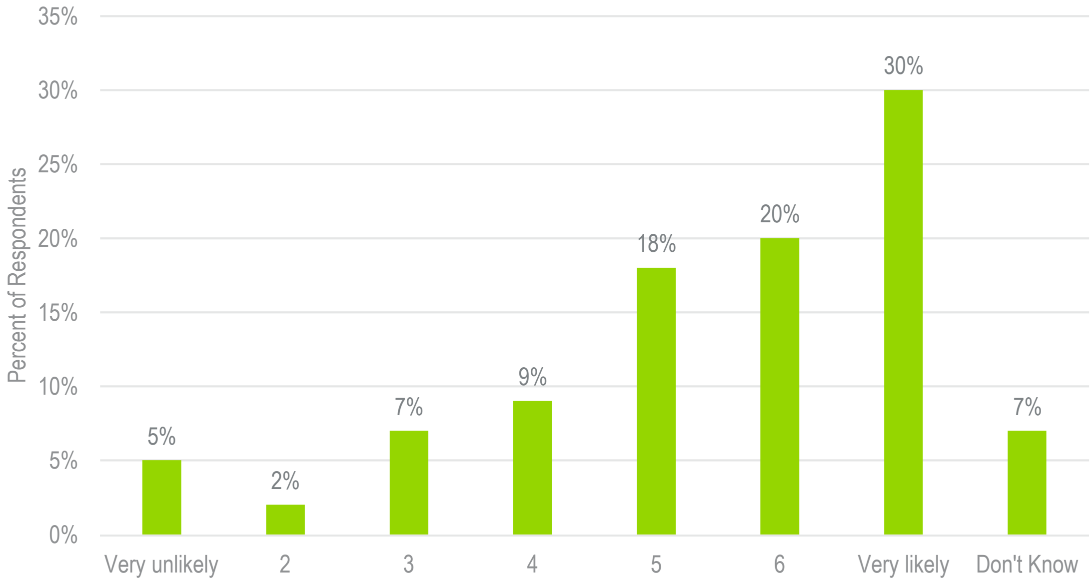
[97] See Cappers, P., H. Liesel, R. Scheer. 2015.

[98] Ibid.

[99] Comparisons to the 2015 post event surveys are not included because the satisfaction questions were changed from a 3 to a 7-point scale to better align with DPU requirements.

Further confirming the strong satisfaction results, over two-thirds of respondents indicated that they would like to continue with the Pilot if it were extended with the same conditions (Figure 4-16). Almost one-third of the customers (30%) indicated that their likelihood of continuing was a 7 on a 7-point scale.

Figure 4-16. Customer's Likelihood to Continue with Smart Energy Solutions

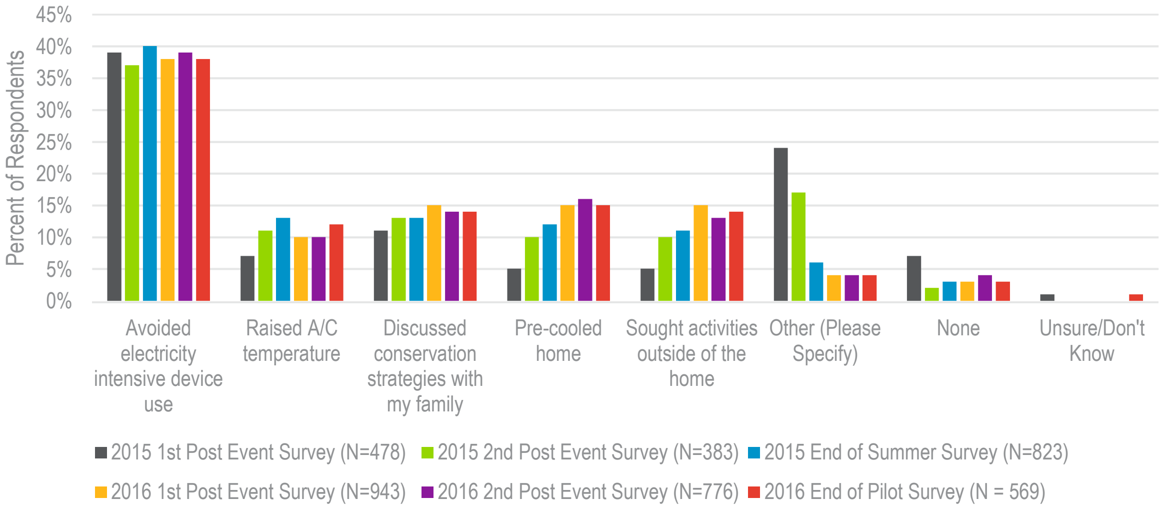


Source: Navigant analysis of 2016 end of pilot survey (N=615)

4.2.5 Customers Changed Electricity Usage and Behavior

Throughout the Pilot, as shown in Figure 4-17, many customers reported that they took actions to change their electricity usage during Peak Events. The most frequent reported action taken, across all the surveys, was to reduce the usage of electricity-intensive devices. Customers also reduced their AC usage, discussed conservation strategies with their families, pre-cooled their homes, and sought activities outside the home during Peak Events. Family discussions, pre-cooling, and leaving home all increased in frequency from the first summer of the Pilot to the second. The number of customers who took actions to reduce their electricity usage during Peak Events increased throughout the Pilot's first summer, reflecting customers' behavioral change and learning. The increased level seen at the end of 2015 was maintained through the Pilot's second summer.

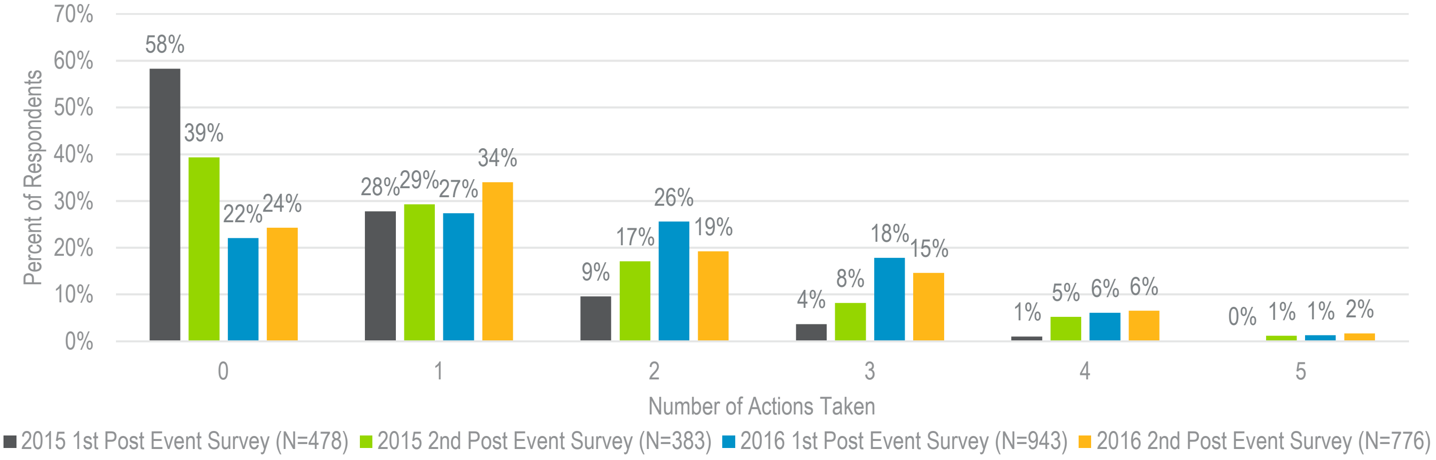
Figure 4-17. Actions Customers Took to Reduce Electricity Usage on Conservation Days



Source: Navigant analysis of post event surveys (N=527, N=270, N=943, N=776), 2015 end of summer survey (N=406), and 2016 end of pilot survey (N=569)

Navigant aggregated the number of actions customers indicated taking in the post event surveys to look at the intensity of actions across the two summers of the Pilot. The number of actions was counted from the survey, so certain actions were aggregated together. For example, "Avoided electricity intensive device use" was counted as one action, although customers may have changed their usage of several distinct devices. As shown in Figure 4-18, compared to the first summer of the Pilot, in the second summer fewer individuals took no actions to reduce their electricity usage during a Conservation Day and the average number of actions taken increased from 2.25 to 3.72.

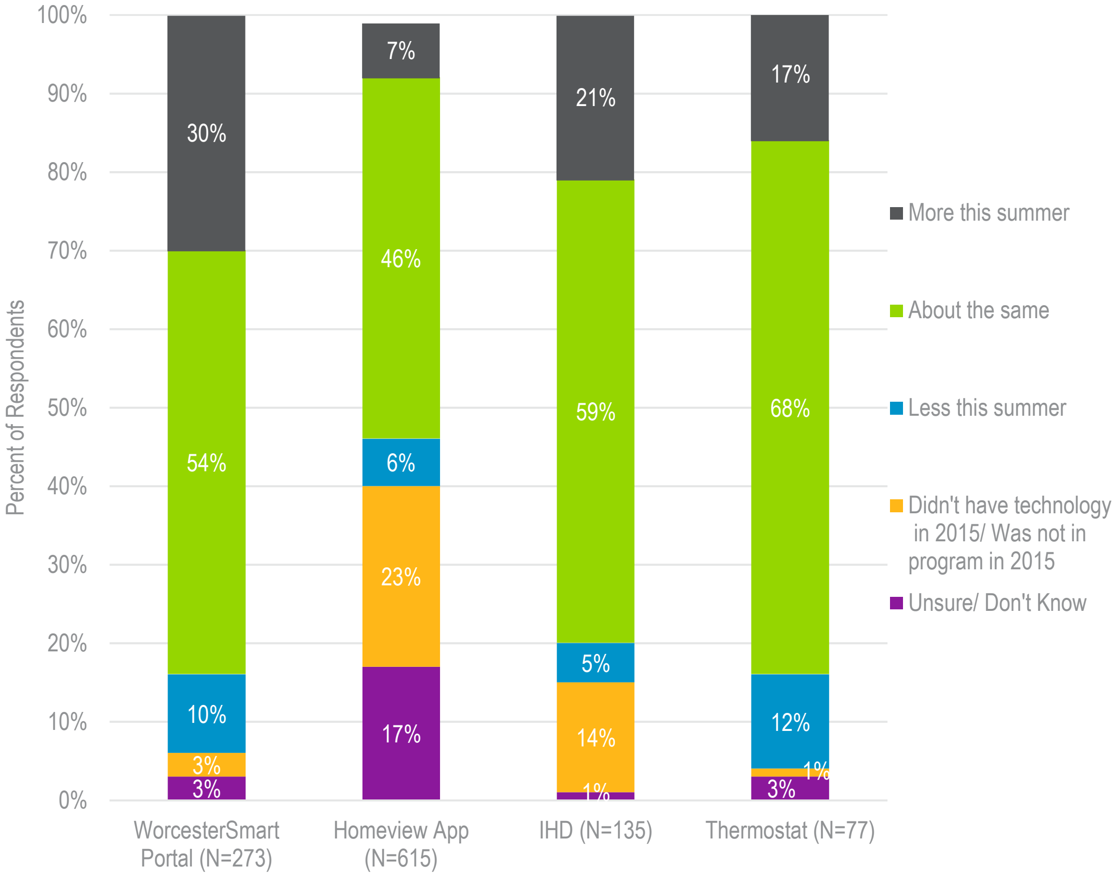
Figure 4-18. Reported Number of Actions Taken during Peak Events



Source: Navigant analysis of post event surveys (N=527, N=270, N=943, N=776)

As shown in Figure 4-19, most customers did not change the frequency with which they viewed the WorcesterSmart web portal (54%), the Homeview App (46%), their IHD (59%), or their smart thermostat (68%) through the two summers of the Pilot. The IHD and the web portal were the two technologies that had the largest increase in usage from 2015 to 2016; 21% of customers reported viewing their IHD more frequently and 30% reported viewing the web portal more frequently in 2016 than 2015. Very few customers reported viewing each technology less in 2016 than in 2015. These results suggest that the value of these technologies remained steady throughout the duration of the Pilot.

Figure 4-19. Change in Customer Viewing of Technology in the Second Summer Compared to the First

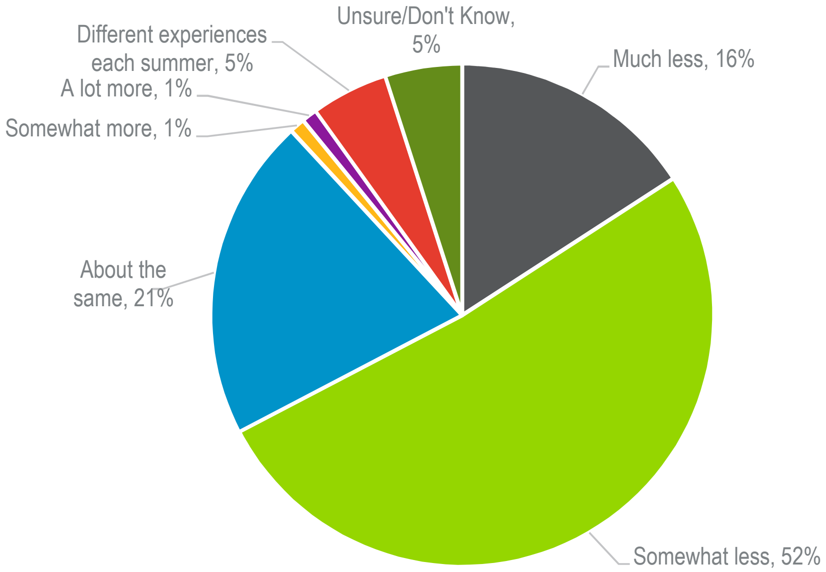


Source: Navigant analysis of 2016 end of pilot survey (N=615)

4.2.6 Customers Believed they Reduced Summer Electricity Usage and Noticed Summer Bill Increase

As discussed in Section 4.1.2, two of the major motivations of customers who enrolled in Smart Energy Solutions were to explore technologies that could help them reduce electricity usage and to save money on their electricity bills. Customers provided insight into their perceived savings and conservation in the end of pilot survey. Most customers perceived a change in their electricity usage during the two years of the Pilot compared to a normal summer. The majority of customers (68%) believed they reduced their electricity usage at least “somewhat” (see Figure 4-20).

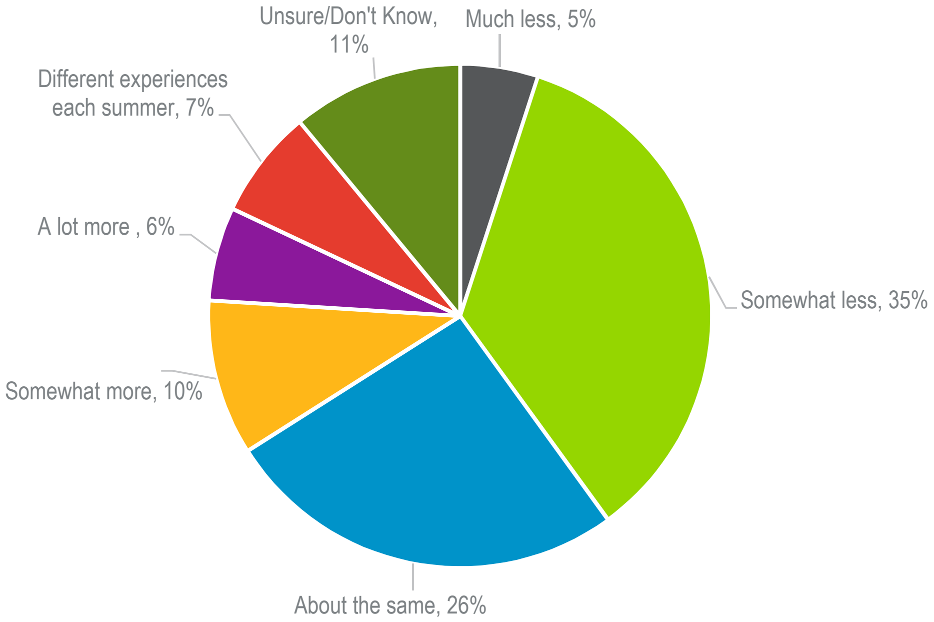
Figure 4-20. Customer Perceived Change in Summer 2015 & 2016 Electricity Usage Compared to a Normal Summer



Source: Navigant analysis of 2016 end of pilot survey (N=615)

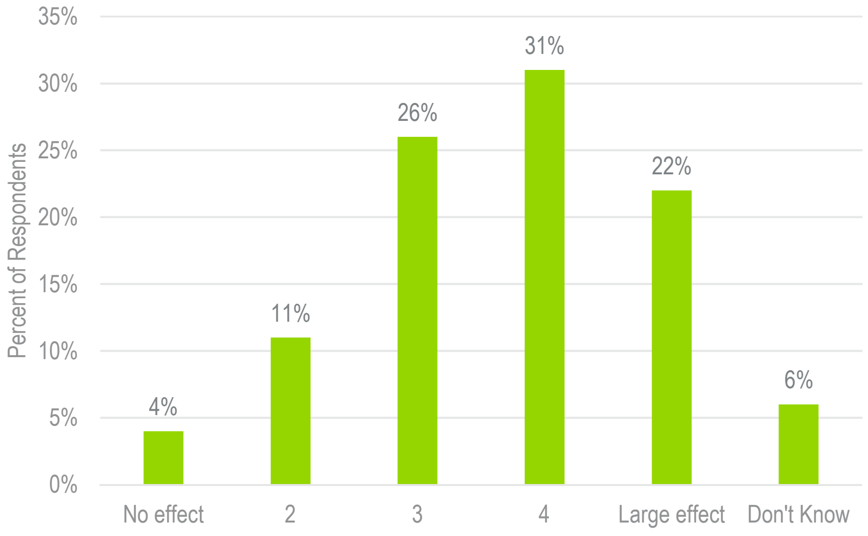
Forty percent of customers believed their summer bills decreased during the Pilot, 26% said they stayed the same, and 16% believed their summer bills increased during the Pilot (see Figure 4-21). Seven percent of customers felt they had different experiences with their bills each summer of the Pilot. As demonstrated in Figure 4-22, the majority of customers (53%) believed that Smart Energy Solutions was largely responsible for the changes in their electric bill, rating the effect of the Pilot at least a 4 on a 5-point scale. The finding that many customers said their summer bills increased was not surprising, as the CPP rate was designed to save customers money over the course of the year to balance out possible increases in summer months due to Peak Events. The Peak Event rates were in effect for over 130 hours in each summer, so the average customer spent more on electricity during summer months than in pre-pilot summers. Customers noticed this increase. However, they saved during the rest of the year because the Pilot rates were lower than the Basic Rate on non-Conservation Days. It is actually surprising that 40% said their bills decreased when the bill savings analysis clearly shows bill increases in the summer months (see Figure 3-15).

Figure 4-21. Customer-Perceived Change in Summer 2015 & 2016 Electric Bill Compared to a Normal Summer



Source: Navigant analysis of 2016 end of pilot survey (N=615)

Figure 4-22. Customer Perception of Effect of Pilot on Bill



Source: Navigant analysis of 2016 end of pilot survey (N=385)

4.2.7 Low-Income Customers were Positive about the Pilot but Need Targeted Outreach

Low-income customers who participated in focus groups were not significantly different from other customers in their behaviors. They were quite aware of events and they were knowledgeable about the WorcesterSmart portal and the rewards platform. They took care to educate household members about reducing their energy use during events, found activities outside their homes, and limited air conditioning usage (which was primarily window AC). However, we learned from the focus groups that knowledge about the most effective energy conserving behaviors was sometimes limited. These customers were not aware of energy efficiency programs offered by National Grid or available through organizations such as Worcester Community Action. They understood how the CPP rate worked but often didn't know they had the option to switch to the PTR rate, which may have suited some of them better. They felt their options to conserve further were constrained either because they had already taken all the measures they could think of for their daily use or had elderly, ill or limited mobility household members or pets who needed cooled environments. Finally, in response to the back-to-back events that occurred in 2016, some participants said they essentially 'gave up' trying to conserve by the third day.

Even though focus group participants felt there were challenges, their overall reaction to the program was positive. Participants liked the ability to take more control of their electricity use and were very interested in the program technologies, though very few were aware of the technology options before the focus group. The findings suggest three areas for National Grid to tailor outreach for low-income participants:

- Outreach and education about the program rates, perhaps including a template to help participants decide which rate makes the most sense for their particular living situation;
- Outreach and education about the available technologies and how to get the most impact from them; and,
- Outreach on applicable energy efficiency programs that provide assistance with home improvements such as air sealing, insulation, appliances, and heating and cooling equipment.

4.2.8 Commercial Customers were Difficult to Identify and Engage

Small commercial customers are a 'difficult to serve' group in energy efficiency programs, and that was found to be the case in Smart Energy Solutions as well. Commercial customers were included in the Pilot area and were identified by their rates (G1 and G2). In attempting to recruit small commercial customers for evaluation activities, Navigant found that in many cases the customer account was limited to common area lighting or similar uses in rental buildings, making true small commercial accounts difficult to identify.

Most commercial customers were unresponsive to attempts to recruit them to focus groups and interviews. Navigant was able to complete five pre-pilot interviews in the spring of 2014 and four in-person or telephone interviews at the end of the 2015 summer. Almost every small commercial customer interviewed had only a general knowledge of and little interest in the Pilot and said they paid very little attention to it. The typical response was that they needed to run their businesses and did not see how they could adjust electricity usage without having some negative impact on their business. The single exception was a retail food service business customer who was both knowledgeable and enthusiastic about the program. He said he actively adjusted his usage during Peak Event hours and believed he benefitted substantially.

Given the responses, further work with small business customers would greatly benefit from active outreach tailored to their needs, possibly through a well-informed customer like the one cited above and/or through local business organizations, stressing the benefits and techniques of actively managing electricity use under either the CPP or PTR rate.

4.2.9 Customers Provided Feedback Throughout the Pilot to Improve Smart Energy Solutions

According to all of Navigant's customer engagement research, participants were aware of Conservation Days. They also acknowledged the multiple communications that they received about Conservation Days and Peak Events. Customers had the option to select their notification preferences for events. They could be notified of events by National Grid one day prior to, and/or the day of, a Peak Event via a combination of telephone, email, text, notification on IHDs, and the web portal.

As part of the Company's "listen, test, learn" approach, customer feedback was sought out and National Grid took actions to improve the customer experience based upon the feedback they received. Some customer feedback in 2015 demonstrated that customers lacked understanding about the program, and in 2016 National Grid increased information and education to meet customers' needs. As shown in Figure 4-23, which summarizes feedback from across the surveys, participants were aware that efforts should be made to conserve electricity during critical Peak Event hours and most participants were diligent in adjusting their energy use and practices to minimize usage. Based on feedback provided via the surveys and focus groups, customers wanted personalized conservation tips, transparency in bill calculations, additional information about the pricing plans to aid them in making the right rate choice, and information about technologies that could help them further reduce electricity usage (Figure 4-23). National Grid responded to this feedback in various ways, such as by creating the Energy Signatures and rewards platform in 2016 (see Section 2.3.2). Customers also desired more advance notice about Peak Events, which implies not having a clear understanding of how far in advance National Grid can confirm an event will be called.

Figure 4-23. Additional Information Customers Would Like About Smart Energy Solutions

Energy Usage, Tips and Suggestions

"A breakdown of where the energy is being used."

"I would say charting my usage during non peak day against the people in my community during that non peak day. I would be able to see if I was doing better against the other people in the community."

"I've been running around my house unplugging stuff all summer and hanging out in the dark. One more step and I'll be Amish."

"Bullet suggestions of ways to save energy."

"If they could figure out why my electricity use is higher than everyone else's in my neighborhood when I am at work all the time and have a very small apartment. Makes no sense and no one wants to help ."

Pricing Program Information

"A flat rate would be nice."

"Comparison vs. regular rates on bill."

"More rebates or discounted items."

Technology Information or Upgrades

"Could tell me how to get some free stuff like light bulbs, new stove. If I could get information on how to get free stuff that would be cool."

"It would be nice if the there was a cutoff on the smart energy thermostat. During the first few days, I had raised my thermostat 4 degrees before I left home. And then during the peak hours, National Grid raised it another 4 degrees, so my house was extremely warm when I got home."

Conservation Day Notification

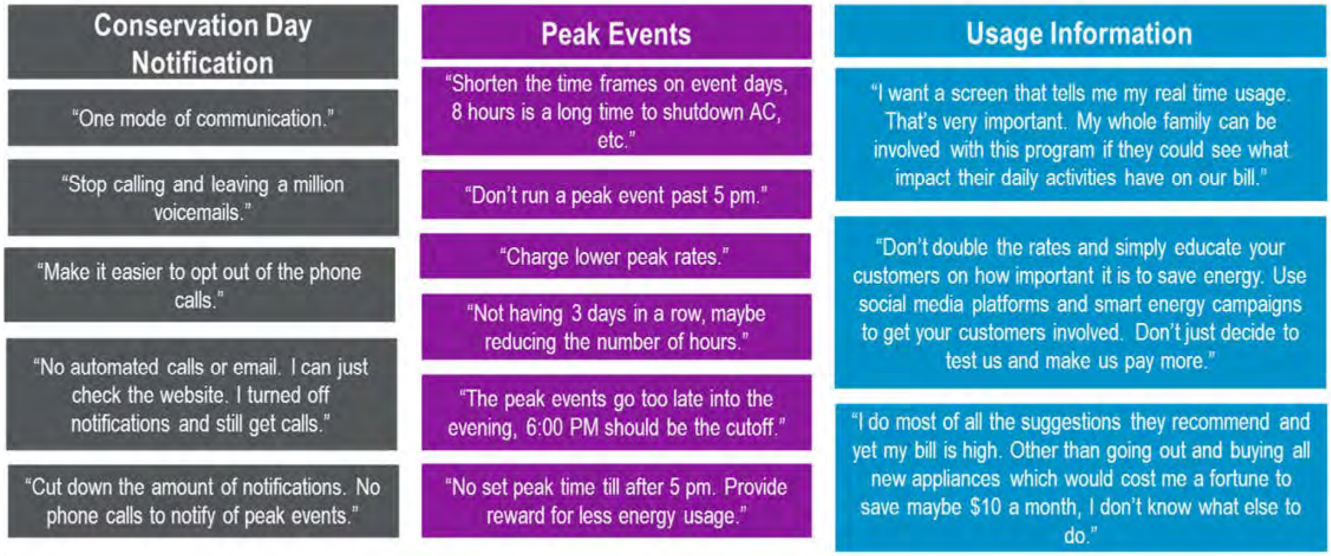
"Give us more than 20 hours advance notice that an event is going to happen... Only finding out about them in the middle of the afternoon the day before was not enough lead time. Also, if you're going to have 4 or 5 in a row, can you just notify us all at once? For each single event, I get a phone call and an email the day before, then a phone call and an email the day of. Now think about getting that 4 or 5 days in a row. It obnoxious!"

"I think the program is wonderful and I'm glad to participate but I felt bombarded with notifications of peak events – emails, calls, messages. It was all too much! An email would have sufficed."

Source: Navigant analysis of 2015 end of summer survey, 2016 post event surveys, and 2016 end of pilot survey

In addition to wanting more specific information about the program, customers had several requests for National Grid to improve Smart Energy Solutions in both 2015 and 2016. As shown in Figure 4-24, customers wanted lower rates, shorter Peak Event timeframes, fewer Peak Events, and additional information about their usage. In 2015, customers stated their preference for text or email notifications over phone calls and voicemails and National Grid made adjustments. While these comments were critical, they show that customers were aware of and engaged with the Pilot. As discussed in Section 4.2.4, 69% of customers rated their satisfaction at least a 5 on a 7-point scale. Feedback is part of National Grid's "listen, test, learn" approach, and serves as the basis for adjustments to the Pilot that will improve customer experience.

Figure 4-24. Customer Recommendations to Improve Smart Energy Solutions



Conservation Day Notification

- "One mode of communication."
- "Stop calling and leaving a million voicemails."
- "Make it easier to opt out of the phone calls."
- "No automated calls or email. I can just check the website. I turned off notifications and still get calls."
- "Cut down the amount of notifications. No phone calls to notify of peak events."

Peak Events

- "Shorten the time frames on event days, 8 hours is a long time to shutdown AC, etc."
- "Don't run a peak event past 5 pm."
- "Charge lower peak rates."
- "Not having 3 days in a row, maybe reducing the number of hours."
- "The peak events go too late into the evening, 6:00 PM should be the cutoff."
- "No set peak time till after 5 pm. Provide reward for less energy usage."

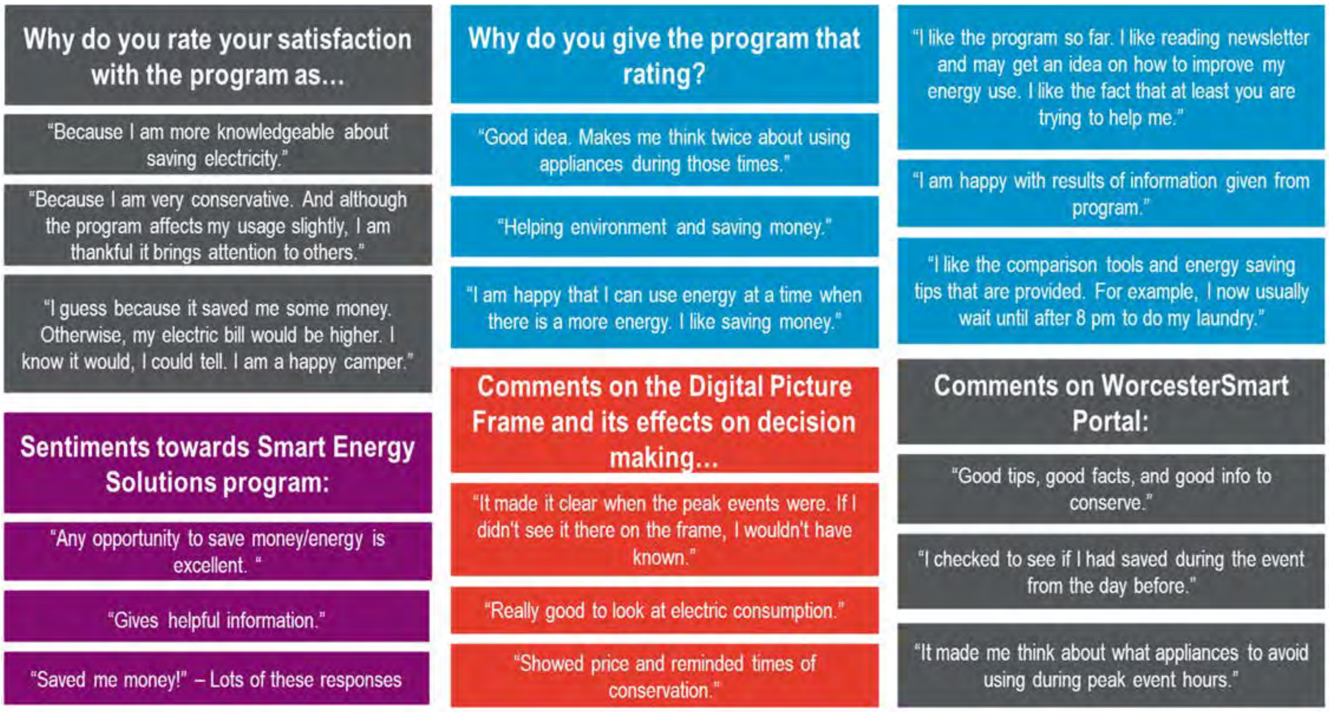
Usage Information

- "I want a screen that tells me my real time usage. That's very important. My whole family can be involved with this program if they could see what impact their daily activities have on our bill."
- "Don't double the rates and simply educate your customers on how important it is to save energy. Use social media platforms and smart energy campaigns to get your customers involved. Don't just decide to test us and make us pay more."
- "I do most of all the suggestions they recommend and yet my bill is high. Other than going out and buying all new appliances which would cost me a fortune to save maybe $10 a month, I don't know what else to do."

Source: Navigant analysis of 2015 end of summer survey and 2016 end of pilot survey

As shown in Figure 4-25, customers also expressed positive feedback over the course of the Pilot emphasizing that they appreciated that the Pilot helped save them money and electricity and was an avenue for them to help the environment. Customers liked that the WorcesterSmart portal provided them with information that allowed them to conserve electricity, such as tips on which appliances to avoid using during Peak Events and how much electricity they were able to save on past Conservations Days. Customers with the IHD mentioned that the frame was useful in reminding them of conservation hours and informing them of their real-time electricity usage and real time prices.

Figure 4-25. Customer's Positive Feedback on Smart Energy Solutions



Why do you rate your satisfaction with the program as…

"Because I am more knowledgeable about saving electricity."

"Because I am very conservative. And although the program affects my usage slightly, I am thankful it brings attention to others."

"I guess because it saved me some money. Otherwise, my electric bill would be higher. I know it would, I could tell. I am a happy camper."

Sentiments towards Smart Energy Solutions program:

"Any opportunity to save money/energy is excellent. "

"Gives helpful information."

"Saved me money!" – Lots of these responses

Why do you give the program that rating?

"Good idea. Makes me think twice about using appliances during those times."

"Helping environment and saving money."

"I am happy that I can use energy at a time when there is a more energy. I like saving money."

Comments on the Digital Picture Frame and its effects on decision making…

"It made it clear when the peak events were. If I didn't see it there on the frame, I wouldn't have known."

"Really good to look at electric consumption."

"Showed price and reminded times of conservation."

"I like the program so far. I like reading newsletter and may get an idea on how to improve my energy use. I like the fact that at least you are trying to help me."

"I am happy with results of information given from program."

"I like the comparison tools and energy saving tips that are provided. For example, I now usually wait until after 8 pm to do my laundry."

Comments on WorcesterSmart Portal:

"Good tips, good facts, and good info to conserve."

"I checked to see if I had saved during the event from the day before."

"It made me think about what appliances to avoid using during peak event hours."

Source: Navigant analysis of 2015 & 2016 post event surveys, 2015 end of summer survey, and 2016 end of pilot survey

5. LESSONS LEARNED FROM PROGRAM IMPLEMENTATION STAFF

National Grid identified lessons learned from the Pilot through meetings with members of National Grid's implementation team. This process captured key learnings, including aspects that worked well and also opportunities identified during Pilot implementation. Lessons learned that are relevant to the customer-facing evaluation discussed in this report were identified in the following areas:

- Advanced Metering Infrastructure (AMI)
- Billing
- Outreach and Education
- Customer Service
- Peak Events
- In-Home Technology Installation

5.1 Advanced Metering Infrastructure

National Grid found that the opt-out approach to the Pilot was instrumental in simplifying the planning, scheduling, communication, and initial technology successes, including the Early Field Trial. The opt-out model allowed National Grid to plan the solution around the idea that most customers would stay in the program. This allowed the design of the RF Mesh solution (a wireless mesh network) to include all meter locations, facilitating a hybrid and integrated environment using a combination of RF Mesh and a small population of cellular meters. National Grid enabled a mixture of data collection time frames in an effort to identify the optimal frequency (e.g., 5- or 15-minute intervals) to support customer desires or deliver advanced analytics and asset management value.

National Grid identified the need to perform a more thorough business process impact and analysis effort to ensure the myriad of customer scenarios can be supported by any chosen solution. Some of the business processes that needed to be examined included meter installations and exchanges, billing, bill presentation, presentation of data on the web, and integration of new suppliers into the process.

5.2 Billing

National Grid was able to successfully support a wide variety of billing scenarios, under both current tariffs and Smart Grid tariffs, using AMI meter data. National Grid delivered a solution that leveraged existing customer billing capabilities and incorporated changes to support the new billing process using energy intervals and a tiered pricing structure based on time of use. This required minimal changes to the existing bill format. National Grid has been delivering the new billing capabilities since January 2015.

The approach used for bill presentation would have benefited from a more flexible and innovative bill design. Representing the energy and bill savings as well as the TOU pricing aspects on the customer bill each month would have created greater transparency and understanding for the customer, as well as promoting awareness of the value and benefits that many customers realized through participating in the Pilot. Revision of the bill presentation was not pursued because of the complexity of changing the bill format in National Grid's customer billing system and the Pilot timeline. In lieu of presenting savings on the bill itself, customers' savings were communicated from time to time in the monthly reports.

5.3 Outreach and Education

Extensive outreach and education were critical to creating awareness and interest among customers and motivating them to participate actively in the Pilot. National Grid was highly focused on achieving a positive customer experience while meeting all the pilot requirements and delivering on National Grid's Outreach and Education (O&E) Plan. From the beginning, National Grid found that carefully planned outreach and education efforts and application of the "listen, test and learn" approach created synergistic value. For example, the Green to Growth Summit informed National Grid's O&E Plan and how it sought to connect with customers. National Grid and leaders from the City of Worcester worked closely on all aspects of the Pilot and sought to properly address concerns raised in the various public forums. As the Pilot moved into the implementation phase, the opt-out design simplified communications and outreach and allowed National Grid to remain focused within the Pilot area. By delivering information and capabilities to customers in a phased manner, National Grid was able to build awareness and understanding in a focused and well-articulated manner, which supported a more positive customer experience.

Several aspects of the O&E efforts stood out as supporting the success of the Pilot in meeting its goals. The Sustainability Hub grew from a concept created by the stakeholders participating in the Green to Growth Summit. With well over 8,000 visitors since it opened, the Hub has been a place where customers, the community and interested stakeholders can learn about the program and how a smarter grid will deliver greater choice, control, and convenience. As demonstrated by this evaluation, the WorcesterSmart web portal was more successful than expected in driving peak demand reductions. National Grid would continue to highlight a web portal or similar information-provision resource in future efforts as a key tool enabling customers to learn and take action. The findings that most customers understand their pricing plan at least reasonably well, and that most would choose to stay on the CPP rate if the program were to continue (see Figure 4-6 and Figure 4-8), support that the outreach and education efforts have been successful in helping customers to embrace these changes in the ways they use and value energy.

National Grid identified a need for more personalized information and insights for Pilot customers. The monthly paper reports sent to all customers included comparative information, but providing customers with more specific and tangible advice and suggestions on how they can save within the Pilot would add considerable value. Towards this end, National Grid has been developing "Energy Signatures" that can help customers identify their patterns of daily energy use and ways to save based upon those patterns (see Section 2.3.2).

5.4 Customer Service

Providing access to dedicated support services and the Sustainability Hub allowed customers to receive quick access to information and resolution of issues. The use of dedicated personnel to support customers was critical to helping customers with any questions or concerns that arose. These dedicated personnel were well-versed in the fine details of the program, and this made it easier for the customer to access timely assistance. This group consisted of dedicated call center representatives, tier 2 support through the project team, and vendor support, including one-on-one training provided as part of the in-home technology installation process. Personalized support and instruction were also provided to Pilot participants who visited the Sustainability Hub. As of the end of 2016, over 8,200 customers had visited the Sustainability Hub and it was mentioned by many customers as a useful source of information alongside direct mail, the Smart Energy Solutions website, and National Grid's Customer Contact Center (see Figure 2-15). A survey administered by the Sustainability Hub also found that customers ranked the Hub highly as a source of information (see APPENDIX C).

Improving access to the web portal would have enhanced customers' access to online customer support resources. The process of signing up for the web portal could have been faster, more intuitive and streamlined. In addition, having the web portal available when meters were installed would have helped to maintain interest and engagement with the Pilot in the time before technologies were installed and pricing plans went into effect. In the future, a better design and flow for all customer web-based transactions and interactions, in concert with standard controls and security concerns, would support higher levels of customer engagement.

5.5 Peak Events

Optimizing peak event communications by providing and promoting communication options, and customizing peak event characteristics to make participation easier for customers, supported the achievement of higher participation and savings levels in the second year. The demand response program was successful in Year 1, and Year 2 saw improvements in impacts and customer engagement. In Year 1, National Grid organized a test Peak Event prior to the summer to engage customers in the process and refresh their memory, so they would be prepared for the first real Peak Event. Upon hearing from some customers that the Conservation Day communications were excessive, National Grid adjusted the default notification process and also promoted the availability of communication personalization options to participants. Calling or logging in to the web portal in order to log their communication preferences provided an opportunity for customers to become engaged in the process. National Grid also responded to customer feedback in Year 2 by making adjustments to Peak Event start and end times and thermostat offsets in order to facilitate participation.

Additional customer education could contribute to further improvement in Peak Events. Survey results indicated that some customers did not understand why and how Peak Events were called, and additional education could help customers understand, for example, why Peak Events could not be called several days in advance and why they tended to occur on the hottest days. In addition, the evaluation determined that customers with in-home technology saved more than those without any technologies apart from web portal access. Promoting the savings opportunities created by embracing technologies could help more customers take the step of signing up for technologies and increasing their participation in the program.

5.6 In-Home Technology Installation

The installation and customer education process received positive feedback from customers. National Grid received very positive feedback from customers about the process of installing home energy management technologies in their homes. The training provided in relation to operation of the technologies was also very well received. Trial installations in the homes of early adopters and "friendly" installs were valuable in National Grid's efforts to design the process, to validate the amount of time required for installation, and to identify some potential issues that might be encountered.

National Grid observed, however, that a number of customers seemed to lose interest in installing in-home technologies after they had completed the initial online or paper-based technology enrollment process. In order to address this phenomenon, more detailed information about the actual installation process could be provided to customers. For example, customers who rent their home should receive the information needed to understand that they are responsible for obtaining the landlord’s permission before a visit can be scheduled. Similarly, customers should understand that the installation process requires that a technician enter the home, rather than performing the work outdoors or in a basement. Clearly stating the available installation times is also important. Finally, the education process should inform customers that there may be additional obstacles to installation that can only be identified when the installer is on site, such as construction, the location of the AMI meter relative to the in–home technologies, and meter vaults.

6. KEY FINDINGS AND LEARNINGS

6.1 Key Evaluation Findings

National Grid's Pilot was an innovative smart grid pilot combining deployment of advanced meters, customer-facing technologies, and TOU rates that ran through the end of 2016. National Grid filed for a two-year extension of the Pilot in 2016 and the DPU approved an interim extension that extends the Pilot until a final decision is reached in 2017. The Pilot also includes advanced distribution grid-side technologies which are the subject of a separate report.[100] This evaluation, conducted by Navigant, covers Pilot activities through the end of 2016. Key findings from this evaluation are shown in Figure 6-1.

Figure 6-1. Key Findings from Evaluation of Smart Energy Solutions

Energy and Demand Savings for Active Customers	• Load reductions from 4% to 31% (0.12 to 0.60 kW) during Conservation Day Peak Events depending on the combination of rate and technology • 5.4% (approximately 35 kWh per month) weighted average energy savings across the technology groups for CPP customers over the two years of the Pilot
Enabling Technologies Increased Demand Savings for Active Customers	• Customers with programmable communicating thermostats had the highest load reductions (25%-31% on CPP and 22%-29% on PTR) • Customers with in-home displays were next (17%-18% on CPP and 4%-9% on PTR), followed by customers with only Web Portal access (12%-15% on CPP and 10% on PTR)
Bill Savings	• Average per customer bill savings of $236 over the two years of the Pilot for customers on CPP • Average total rebates of almost $30 for Conservation Day Peak Events across both summers for customers on PTR
High Retention Rate	• 98% retention rate of customers in the Pilot at the end of 2016 after rates went live on January 1, 2015
Strong Customer Satisfaction	• 69% of customers rated their satisfaction with Smart Energy Solutions at least a 5 on a 7-point scale

Source: Navigant analysis

Note: CPP refers to Critical Peak Pricing and PTR refers to Peak Time Rebate.

6.2 Key Learnings from Smart Energy Solutions

Before and throughout the Pilot, National Grid implemented a "listen, test, learn" approach that is based on "on the ground" conversations and reflections on the Pilot. This feedback, combined with learning,

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[100] National Grid. *Interim Grid-Facing Evaluation Report*, March 31, 2016.

leads to continuous improvement. National Grid conducted extensive program marketing in the lead-up to initiating meter installations, the first phase of the program. These activities included convening a public summit to discuss the proposed program, development of brochures explaining the program, and establishment of the staffed, physical Sustainability Hub within the Pilot program area. National Grid also partnered with local schools to offer Energy Ambassador internships at the Sustainability Hub. Clark University offered annual internships, and Worcester Polytechnic Institute created a student Sustainability Ambassador program. Ambassadors host Sustainability Hub tours and attend outreach events to educate customers throughout the community. Presenting the personal side of the Company is the backbone of "listen, test, learn", and is the inspiration for sending National Grid employees and Ambassadors into the community. It is also the basis for hosting visitors at the Sustainability Hub for the dual purpose of educating customers and listening to their concerns and feedback.

Several broad themes emerged regarding customer response to the Pilot design and implementation: Impacts for active customers (17% peak load reduction and 5.4% average load reduction over the two years of the Pilot) met the goals established through Section 85 of the GCA, and the majority of customers were satisfied with the Pilot. Figure 6-2 summarizes key learnings from the two years of Smart Energy Solutions.

Figure 6-2. Key Learnings from Smart Energy Solutions

Smart Energy Solutions shows the viability of opt-out design.

- The program enrolled ~11,000 participants, which is many more than could have been recruited in an opt-in design.
- The retention rate after two years was 98%, which is higher than many comparable opt-in programs.
- Program satisfaction was strong, with 69% of participants rating the Pilot at least a 5 on a 7-point scale.

It is important to choose the default options in an opt-out program carefully.

- Smart Energy Solutions defaulted customers onto the CPP rate and web portal, with no additional in-home technology.
- Approximately 95% of customers were still on the default price plan and 90% on the default technology level after the two years of the Pilot.
- Although satisfaction was strong, "default bias" is likely to be a factor in customers staying on the default enrollment options in the opt-out design.

Long Peak Events and Peak Events called on consecutive days did not significantly affect savings or satisfaction.

- Despite calling more Peak Events (including on consecutive days) and longer Peak Events than similar programs, Smart Energy Solutions acheived similar satisfaction and savings.
- However, some customers did express a desire for shorter events ending earlier in the evening.

In-home devices increased demand savings, but much of the total savings were acheived with just a web portal.

- Customers with in-home devices had significantly higher demand savings (up to 31%) than those without any technology (up to 15%).
- Customers without technology who visited the program web portal saved approximately twice as much in the second year of the Pilot as those who did not visit the web portal (this may be attributable to differences in motivation as well as to the web portal itself).
- Customers without technology made up 90% of the participants in the Pilot and approximately 70% of the total Peak Event savings.
- Customers with IHDs saved the most energy, followed by those with web portal access only. Those with PCTs had higher demand savings but lower energy savings.

Customers on the CPP rate saved more than those on the PTR rate.

- At each technology level, active customers on the CPP rate saved more than those on the PTR rate.
- Passive customers saved more on the PTR rate, but that could be due to a slightly higher level of engagement since they had to opt in to the PTR rate.
- The motivations to save on the CPP rate are greater than for the PTR rate, as on the CPP rate customers face higher bills if they don't save.

The PTR rate may be more appropriate than the CPP rate for those on fixed budgets or with health issues.

- Although the CPP rate saves money over the course of the year, bills do increase for many customers in the summer, potentially making the PTR rate a better choice for customers on a fixed or limited income.
- Additionally for those who have a limited ability to reduce their energy usage (because of elderly, ill, or limited mobility household members, pets who need cooler temperatures, electric medical equipment, etc.) the PTR rate may be more appropriate.

Information needs to be provided multiple times via multiple channels.

- Despite a plethora of communication from National Grid, half of customers without technology did not know it was available, and of the 40% who knew it was available, many did not understand the benefits.
- Additionally, many customers (56%) did not realize they had the option to switch price plans.
- Based on the focus groups, low-income customers had low awareness of the rates and technologies despite the high potential benefits to this group.

Customers want options to personalize notifications.

- Customers cited issues with the amount and methods of Conservation Day notifications in 2015, and responded well to additional promotion and simplification of personalization options in 2016.

Source: Navigant analysis

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APPENDIX A. IMPACT ASSESSMENT METHODOLOGY

Navigant evaluated energy, demand, and bill impacts from the Pilot using regression analysis of monthly bills and hourly customer loads, respectively, using anonymized customer data from National Grid. Energy and demand impacts were estimated by technology/price group. On the residential side, a single regression was estimated for each group when the number of customers in the group was large enough, or combined regressions with dummies were used to separate the effect for each group individually if there were too few customers. Navigant also estimated impacts by demographic subgroup as the data allowed, i.e., when there were enough customers in a given subgroup to estimate savings via regression analysis. On the commercial side, a pooled regression was run for G1 commercial customers on the CPP rate in Level 1 and single customer regressions were run for all other commercial customers.

A.1 Peak Event Impacts

Navigant used an *ex-post* model to estimate demand impacts, which included variables to control for temperature, humidity, intra-seasonal, intra-weekly and intra-daily (i.e., hourly) seasonality, and the build-up of heat in the home over 4- and 24-hour periods.[101] The model included additional controls for the way that the relationship between demand and temperature can vary by month and for the possibly non-linear manner in which heat build-up may affect household demand.

The impacts and snapback were estimated using a battery of dummy variables that were specific to each unique Conservation Day, hour of day combination. In effect, the model ascribes all event- and snapback hour variation in demand from the baseline to the event (or the snapback). Navigant also explored the possibility of pre-cooling but did not find significant evidence of its existence, and therefore pre-cooling was left out of the final model specification.

For each technology/price group over the period from 8 a.m. to 10 p.m. from June through September of 2014 and the year being estimated (either 2015 or 2016) the regression model in Equation A-1 was estimated. This equation shows the exact model used in 2015 and a very similar model was used in 2016. In 2015, Navigant estimated the model using quarter-hourly data and then aggregated impacts to the hourly level. In 2016, Navigant aggregated the data to the hourly level first and then ran the regression at that level, thus the quarter-hour dummies were changed to hour dummies (which was the only change for the 2016 regression model). This aggregation to the hourly level was made to simplify the calculation of standard errors and was not expected to impact the savings estimates. Navigant tested both methods in 2016 and, as expected, found that the change did not have a statistically significant impact on the coefficient estimates.

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[101] In the original scope of work, Navigant proposed matching from the load research customers to construct the baseline usage, as opposed to the within subject method that was ultimately used. However, the load research group only consisted of about 200 customers and thus was not large enough to match from.

Equation A-1. *Ex-post* Regression Model to Estimate Demand Savings

$$
\begin{aligned}
y_{k,t} = {} & \alpha_k + \sum_{i=1}^{55} \beta_i^h \cdot qh_{i,t} + \sum_{s=1}^{S=22} \sum_{i=1}^{55} \beta_{i,s}^e \cdot qh_{i,t} \cdot e_{\mathrm{s},t} + \sum_{s=1}^{S=22} \sum_{r=1}^{R=20} \beta_{\mathrm{s},r}^s \cdot qh_{i,t} \cdot s_{\mathrm{s},r,t} + \sum_{i=1}^{55} \beta_i^{CDH} \cdot qh_{i,t} \cdot CDH65_t + \sum_{i=1}^{55} \beta_i^{HDH} \cdot qh_{i,t} \cdot HDH65_t \\
& + \sum_{i=1}^{55} \beta_i^{THI} \cdot qh_{i,t} \cdot THI_t + \sum_{i=1}^{55} \beta_i^{THI_{15}} \cdot qh_{i,t} \cdot THI\_lag15_t + \sum_{i=1}^{55} \beta_i^{THI_{30}} \cdot qh_{i,t} \cdot THI\_lag30_t + \sum_{i=1}^{55} \beta_i^{THI_{45}} \cdot qh_{i,t} \cdot THI\_lag45_t \\
& + \sum_{i=1}^{55} \beta_i^{THI_{60}} \cdot qh_{i,t} \cdot THI\_lag60_t + \sum_{i=1}^{55} \beta_i^{CDTH} \cdot qh_{i,t} \cdot CDH65_t \cdot THI_t + \sum_{i=1}^{55} \beta_i^{MA24CD} \cdot qh_{i,t} \cdot MA24\_CDH65_t \\
& + \sum_{i=1}^{55} \beta_i^{MA24CDTH} \cdot qh_{i,t} \cdot MA24\_CDH65_t \cdot THI_t + \sum_{i=1}^{55} \beta_i^{MA4CD} \cdot qh_{i,t} \cdot MA4\_CDH65_t \\
& + \sum_{i=1}^{55} \beta_i^{MA4CDTH} \cdot qh_{i,t} \cdot MA4\_CDH65_t \cdot THI_t + \sum_{i=1}^{55} \beta_i^{RH} \cdot qh_{i,t} \cdot RH_t + \sum_{i=1}^{55} \sum_{d=1}^{7} \beta_d^{DoW} \cdot qh_{i,t} \cdot DoW_{d,t} \\
& + \sum_{i=1}^{55} \sum_{m=6}^{M=9} \beta_m^{Month} \cdot qh_{i,t} \cdot Month_{m,t} + \sum_{i=1}^{55} \sum_{m=6}^{M=9} \beta_m^{MonthCDH} \cdot qh_{i,t} \cdot Month_{m,t} \cdot CDH_t \\
& + \sum_{i=1}^{55} \sum_{m=6}^{M=9} \beta_m^{MonthTHI} \cdot qh_{i,t} \cdot Month_{m,t} \cdot THI_t + \sum_{i=1}^{55} \beta_i^{pmMA24CD2} \cdot pm_{i,t} \cdot MA24\_CDH65_t^{\,2} \\
& + \sum_{i=1}^{55} \beta_i^{pmMA24CD2TH} \cdot pm_{i,t} \cdot MA24\_CDH65_t^{\,2} \cdot THI_t + \sum_{i=1}^{55} \beta_i^{pmMA4CD2} \cdot pm_{i,t} \cdot MA4\_CDH65_t^{\,2} \\
& + \sum_{i=1}^{55} \beta_i^{pmMA4CD2TH} \cdot pm_{i,t} \cdot MA4\_CDH65_t^{\,2} \cdot THI_t + \sum_{i=1}^{55} \beta_i^{peak} qh_{i,t} \cdot peakhour\_evtyr_t + \sum_{i=1}^{55} \sum_{d=1}^{7} \beta_d^{weekend} qh_{i,t} \cdot weekend\_evtyr_{d,t} \\
& + \varepsilon_t
\end{aligned}
$$

Where:

$y_{k,t}$ = The average kWh usage of household *k* in quarter-hour *t*.

$qh_{i,t}$ = A dummy variable equal to one if *i* is equal to the quarter-hour defined by *t*. For example, if quarter-hour *t* were 12-12:15 p.m. then $h_{17,t}$ would equal one and $h_{1,t}$ to $h_{16,t}$ and $h_{18,t}$ to $h_{55,t}$ would all be equal to zero.[102]

$e_{s,t}$ = A dummy variable equal to one if there is a Peak Event taking place in quarter-hour *t* on event day *s* (one of the 40 Peak Event days) and zero otherwise.

$s_{s,r,t}$ = A dummy variable intended to capture the effect of snapback in the period following the end of the event period. The *r*-th dummy is equal to one if period *t* is the *r*-th period following the end of a Peak Event and the event in quarter-hour *t* corresponds to event *s*. Note that snapback is modeled only within the same day as the event, thus the highest value attained by *R* was 20 (for the events ending at 5 p.m.), and the lowest was 8 (for the events that ended at 8 p.m.).

$CDH65_t$ = Cooling degree hours observed in quarter-hour *t* – base is 65°F.

$HDH65_t$ = Heating degree hours observed in quarter-hour *t* – base is 65°F.

THI_t = Temperature humidity index in quarter-hour *t*.

$MA24\_CDH65_t$ = Cooling degree hours calculated based on a 24-hour moving average of temperatures leading up to quarter-hour *t*. This variable helps capture the effect

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[102] Recall that only hours between 8 a.m. and 10 p.m. were included in the regression.

on demand of heat build-up during periods of extended high temperatures.

$MA4\_CDH65_t$ = Cooling degree hours calculated based on a 4-hour moving average of temperatures leading up to quarter-hour *t*. This variable helps capture the effect on demand of heat build-up during short periods of high temperatures followed by precipitous drops in temperature such as during a storm.

$MA4\_THI_t$ = Temperature humidity index calculated based on a 24-hour moving average of the temperature humidity index leading up to quarter-hour *t*. This variable helps capture the effect on demand of heat build-up during short periods of high temperatures followed by precipitous drops in temperature such as during a storm.

RH_t = Relative humidity of quarter-hour *t*.

$DoW_{d,t}$ = A dummy variable equal to one if quarter-hour *t* falls in the day of the week indicated by subscript *d*. A value of *d* of 1 indicates a Sunday, and a value of 7 indicates a Saturday.

$Month_{m,t}$ = A dummy variable equal to one if quarter-hour *t* falls in month *m*, and zero otherwise. Note that only the months of June through September are included in the estimation sample.

$CDD65_t$ = Cooling degree days observed on the day in which quarter-hour *t* falls – base is 65°F.

$pm_{it,}$ = A dummy variable equal to one if quarter-hour *t* falls between noon and 9 p.m.

$peakhour\_evtyr_t$ = A dummy variable equal to one if quarter-hour *t* falls during a peak hour, 8 a.m. to 8 p.m., in the event year (2015 or 2016). This variable captures the effect of the Smart Rewards Pricing on usage during non-event peak hours.

$weekend\_evtyr_{d,t}$ = A dummy variable equal to one if quarter-hour *t* falls on a weekend in the event year (2015 or 2016). This variable captures the effect of the pricing scheme and the Peak Events on weekend usage, for example, weekend usage might go up if customers shift loads to the weekend to avoid the higher weekend day and Peak Event pricing.

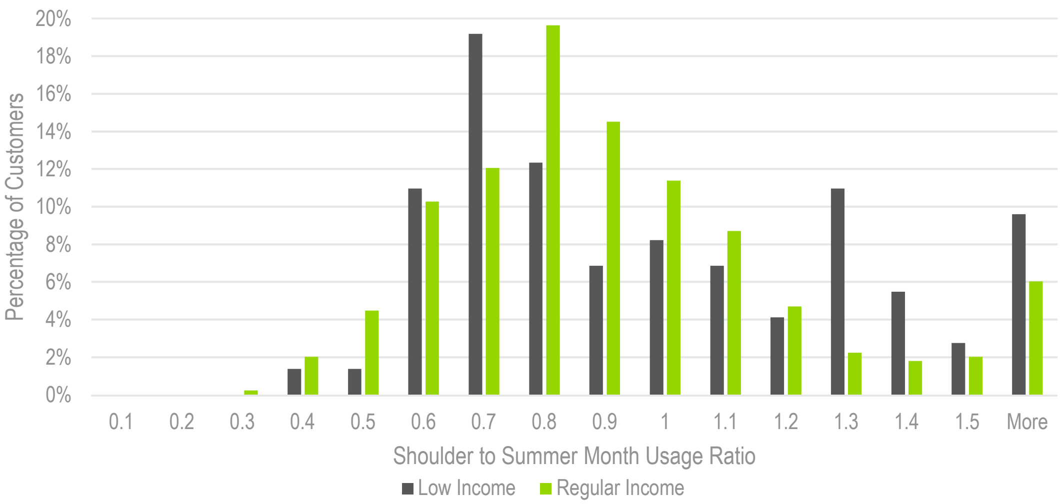
Each regression creates an estimated fitted average per-participant baseline for every day included in the regression. In 2015, the regression in Equation A-1 was estimated using energy usage (kWh) over 15 minute periods which was then aggregated to the hour to get demand (kW) impacts. In 2016, hourly demand data (kW) was used directly in the regression.

In 2015, the evaluation team estimated a day-of adjustment for each event day by subtracting actual usage from the fitted usage for the time from 8 a.m. until the start of the event. The day-of adjustment was subtracted from fitted usage for the entire day to create an adjusted fitted baseline. Demand savings were calculated by subtracting actual usage from the adjusted fitted baseline in each time period of the event. In 2016, the day-of adjustment was removed to simplify the calculation of standard errors. Navigant found that the day-of adjustment was minimal and did not have a statistically significant effect on the savings estimate.

A.2 CAC Penetration

Using 2015 data, Navigant identified customers likely to have CAC in Level 2 CPP by examining the ratio of shoulder to summer month usage.[103] A customer with CAC is likely to have considerably higher usage in the summer than in the shoulder months; therefore, a lower shoulder to summer month usage ratio indicates a higher likelihood of having CAC. Figure A-1 shows the distribution of the shoulder to summer month usage ratio for low-income and standard-income customers in Level 2 CPP. The percentage of customers with a ratio below 0.9 is 52% for low-income customers and 63% for standard-income customers. This suggests that there may be lower CAC penetration for low-income customers, as a lower percentage of them have a low shoulder to summer month usage ratio.

Figure A-1. Shoulder to Summer Month Usage Ratio for Level 2 CPP Customers by Income Level



Source: Navigant analysis

A.3 Energy Impacts

Navigant estimated the reduction in energy use for 2014, when only the informational portion of the program was in effect, and for 2015 and 2016 when the Pilot's Smart Rewards Pricing was in effect and Peak Events were called during the summer. In order to estimate energy impacts via regression analysis, Navigant drew matched controls from a large pool of non-participant households in ZIP codes near the Worcester area where the Pilot took place.[104] The basic logic of matching is to balance the participant and non-participant samples by matching on the exogenous covariates known to have a high correlation with the outcome variable. Doing so increases the efficiency of the estimate and reduces the potential for model specification bias. Formally, the argument is that if the outcome variable Y is independently distributed conditional on X and D (conditional independence assumption), where X is a set of exogenous variables and D is the program variable, then the analyst can gain some power in the estimate of savings

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[103] Navigant chose to use July and August as the summer months and May and October as the shoulder months.

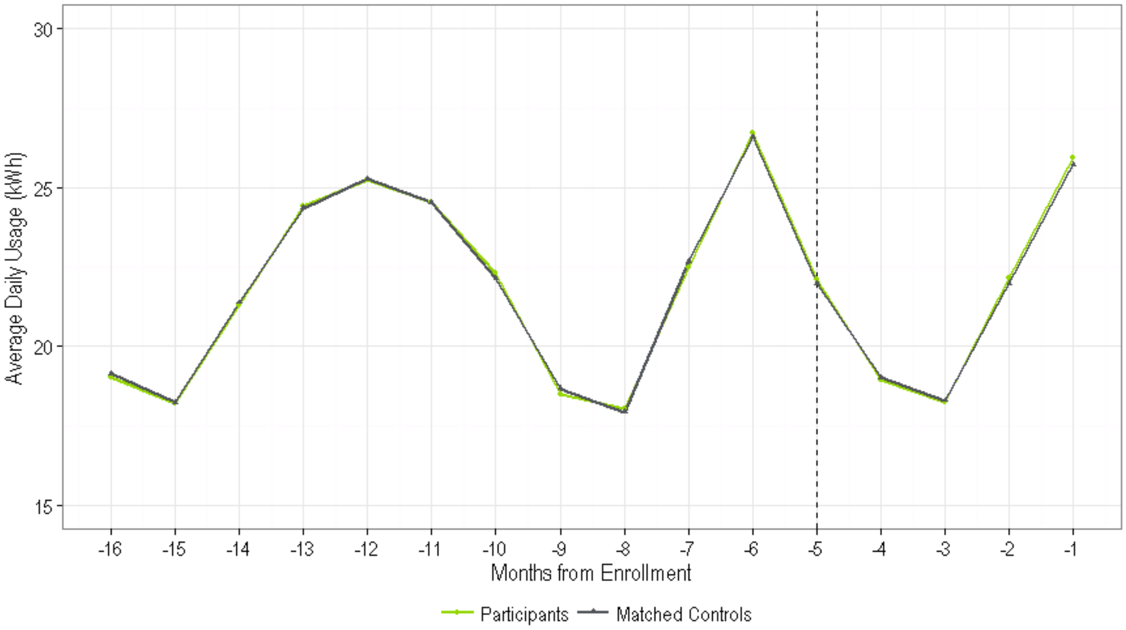
[104] Navigant used households in the following ZIP codes in the pool of non-participants from which to draw matched controls: 01601, 01602, 01603, 01604, 01605, 01606, 01607, 01608, 01609, 01610, 01611, 01501, 01527, 01545, 01505, 01583, 01520, 01612, 01524, 01542, 01537, 01540, 01590, 01519, 01560, 01588, 01534, 01568, 01532, 01581, 01522, 01507, and 01562.

and reduce potential model specification bias by assuring that the distribution of X is the same for treatment and control observations.

In this evaluation, the outcome variable is daily post-program period energy use, and the available exogenous covariate with by far the greatest correlation with this outcome variable is average daily use in the same month of the pre-program period, $PrekWh_{k,t}$, where k indexes the customer and t indexes the month. After drawing matches, the evaluation team ran the regression analysis to further control for any remaining imbalance in the matching on this variable. If, for instance, after matching the participants use slightly more energy on average in the pre-program period than their matches—i.e., they are higher baseline energy users—then including $PrekWh_{k,t}$ as an explanatory variable in a regression model predicting daily energy use during the post-program period prevents this remaining slight difference in baseline energy use from being attributed to the program.

Matches were draw on a 12-month period from September 2012 to August 2013; this left a 4-month test period from September 2013 to December 2013 to see how the matches performed outside of the matching period but before the program started. The expectation is that the participants and their matched controls should have similar usage both during the matching period and during the test period. To ensure that the quality of the matches selected using this method was high, Navigant examined the average usage of the participants and their selected matches in both the matching and test periods as shown in Figure A-2.

Figure A-2. Usage by Participants and Matching Controls in the Matching and Test Periods



Source: Navigant analysis

The development of a matched comparison group is viewed as a useful pre-processing step in a regression analysis to assure that the distributions of the covariates (i.e., the explanatory variables on which the output variable depends) for the treatment group are the same as those for the comparison group that provides the baseline measure of the output variable. This minimizes the possibility of model specification bias.

After matches were drawn, energy impacts were estimated for each year and technology/price group using regression analysis of monthly billing data as shown in Equation A-2. For 2014, energy impacts were estimated for the full year. For 2015 and 2016, savings were estimated separately in each month by interacting the participant variable in Equation A-2 with the monthly dummies.

Equation A-2. Post-Program Regression Model to Estimate Energy Savings

$$y_{k,t} = \beta_1 Participant_k + \sum_i \beta_{2i} Month_{i,t} + \sum_i \beta_{3i} Month_{i,t} \cdot PrekWh_{k,t} + \beta_4 cdd_{k,t} + \beta_5 hdd_{k,t} + \varepsilon_{k,t}$$

Where:
$y_{k,t}$ = The average daily consumption of kWh by household *k* in bill period *t*.
$Participant_k$ = A dummy variable equal to one if household *k* is a participant in the Pilot, and zero otherwise.
$Month_{i,t}$ = A dummy variable equal to one when *i* equals *t*, and zero otherwise. In other words this is a monthly fixed effect.
$PrekWh_{k,t}$ = Household *k*'s average daily consumption of kWh in the same calendar month of the pre-program year (2013) as the calendar month of month *t*.
$cdd_{k,t}$ = The cooling degree days in bill period t for household *k* – base is 65°F.
$hdd_{k,t}$ = The heating degree days in bill period t for household *k* – base is 65°F.

In each regression, the coefficient β_1 is the estimate of the reduction in average daily kWh consumption by program participants.

A.4 Bill Savings

CPP Customers

To estimate the monthly bill impacts of the Pilot for CPP customers, Navigant calculated the bill amount using actual usage under the Smart Rewards TOU pricing rates and the counter-factual bill amount using counter-factual usage in the absence of the program under the Basic Rate. Counter-factual usage was estimated using the energy savings estimated in Equation A-2. In cases where the energy savings were not statistically significant at the 90% level, Navigant still used the point estimate of savings to estimate counter-factual usage. In an unbiased regression, the point estimate of savings is a more accurate estimate of savings than zero, even when the point estimate is not statistically significant. Bill savings were calculated by technology level and were split out by income level.[105]

National Grid gave Navigant the actual bill amount paid by each participant in the Pilot; the TOU rates are shown in Table A-1. To estimate the counter-factual bill amount, the evaluation team calculated counter-factual usage in the absence of the program and multiplied it by the Basic Rate shown in Table A-2 to get commodity cost. Navigant then applied the non-commodity charges which were the same for the TOU rate and the Basic Rate. Once the evaluation team knew the bill amount under the program and in the absence of the program, subtraction gave the bill savings. These steps are laid out in Equation A-3.

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[105] Low-income customers are given a 25% discount on their entire bill, including both the commodity and non-commodity charges.

Equation A-3. Bill Savings Calculation for CPP Customers

$$Pilot\_Cost = actual\_usage * basic\_rate$$

$$Counter\_Cost = basic\_rate * (actual\_usage * (1 - energy\_savings)) + non\_commodity\_charges$$

$$bill\_savings = Pilot\_Cost - Counter\_Cost$$

Table A-1. Smart Energy Solutions Pricing Rates

Effective for Usage During the Month of:	Residential (R-1, R-2)			
	Rate (cents / kWh)			
	Smart Rewards Pricing			Conservation Day Rebate
	Peak Period	Off-Peak Period	Peak Event Period	
December, 2016	9.369	7.742	45.853	(45.853)
November, 2016	9.369	7.742	45.853	(45.853)
October, 2016	7.744	6.421	37.416	(37.416)
September, 2016	7.702	6.379	37.374	(37.374)
August, 2016	7.702	6.379	37.374	(37.374)
July, 2016	7.702	6.379	37.374	(37.374)
June, 2016	7.702	6.379	37.374	(37.374)
May, 2016	7.702	6.379	37.374	(37.374)
April, 2016	12.463	10.226	62.636	(62.636)
March, 2016	12.463	10.226	62.636	(62.636)
February, 2016	12.463	10.226	62.636	(62.636)
January, 2016	12.463	10.226	62.636	(62.636)
December, 2015	12.463	10.226	62.636	(62.636)
November, 2015	12.463	10.226	62.636	(62.636)
October, 2015	8.859	7.313	43.544	(43.544)
September, 2015	8.859	7.313	43.544	(43.544)
August, 2015	8.859	7.313	43.544	(43.544)
July, 2015	8.859	7.313	43.544	(43.544)
June, 2015	8.859	7.313	43.544	(43.544)
May, 2015	8.859	7.313	43.544	(43.544)
April, 2015	15.537	12.675	79.730	(79.730)
March, 2015	15.537	12.675	79.730	(79.730)
February, 2015	15.537	12.675	79.730	(79.730)
January, 2015	15.537	12.675	79.730	(79.730)

Source: National Grid

Table A-2. Basic Rate

Fixed Price Options	
Effective During the Period of:	Rate (cents / kWh)
11/1/16 – 12/31/16	9.787
10/1/16-10/31/16	8.084
5/1/16 – 9/30/16	8.042
11/1/15 – 4/30/16	13.038
5/1/15 – 10/31/15	9.257
11/1/14 – 4/30/15	16.273

Source: National Grid

PTR Customers

For PTR customers, the bill savings were due to the rebates paid by National Grid during Peak Events since these customers were not on the TOU rate. This report shows the rebate paid out by the Company for usage reduction during Peak Events. National Grid calculated reduced usage as the difference between metered usage during the Peak Event and “normal” usage, defined as average usage during the ten prior non-holiday, non-Conservation Day weekdays after accounting for a day-of adjustment to capture weather differences, time of event, pre-cooling, etc. The reduction was multiplied by the per-kWh cost of the rebate (see Table A-1) to determine the total rebate due to the customer.[106]

A.5 Load Shifting

In addition to capturing demand savings during a Peak Event, Equation A-1 was also set up to capture snapback after an event, peak savings during times outside of a Peak Event, and evidence of load shifting to weekends.

The coefficient on $qh_{i,t} \cdot s_{s,r,t}$ which is the quarter-hour (or hour in 2016) dummy interacted with the snapback dummy captures whether participants increased usage after the Peak Event relative to what they would have used in the absence of the event. Such snapback would reduce the total demand reduction attributable to the Pilot. A positive coefficient indicates that snapback occurred.

The coefficient on $peakhour\_evtyr_t$ captures the demand reduction during peak hours (8 a.m. to 8 p.m.) in the event year (2015 or 2016) that are not also during Peak Events. A negative coefficient indicates a reduction in usage due to the program. This captures whether the Pilot reduced peak usage when a Peak Event was not called.

The coefficient on $weekend\_evtyr_{d,t}$ captures the change in usage on weekends in the event year (2015 or 2016). This indicates whether participants shifted usage from weekdays which have TOU pricing to weekends which have a flat rate. A positive coefficient indicates that load shifting to the weekend occurred.

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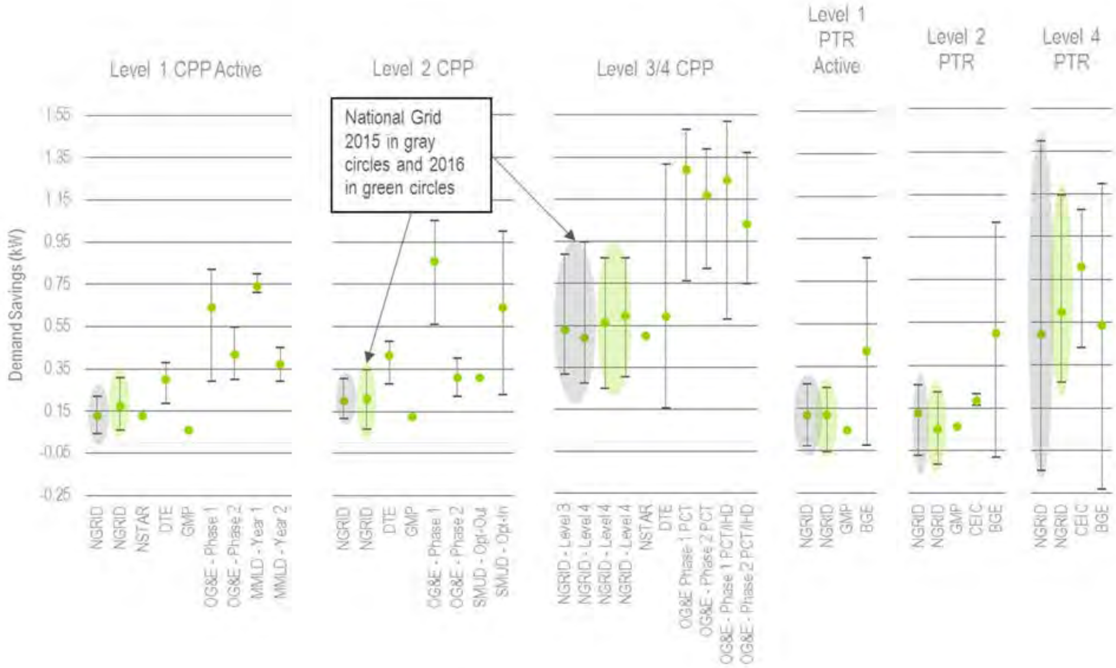
[106] Details can be found in: D.P.U. No. 1237, Tariff for Basic Service, September 3, 2014.

APPENDIX B. ADDITIONAL IMPACT ASSESSMENT RESULTS

B.1 Peak Event and Load Shifting Impacts

Figure B-1 shows comparisons of the Pilot to other utility programs for the absolute impacts during Peak Event hours. The Pilot had slightly lower absolute impacts than the comparison programs for most of the technology/price groups. Combined with the percentage comparisons, this suggests that National Grid has slightly lower baseline usage than most of the comparison utilities. Lower baseline usage among National Grid customers could cause National Grid's total savings to be slightly lower than those for comparable programs even though the percentage savings were the same.

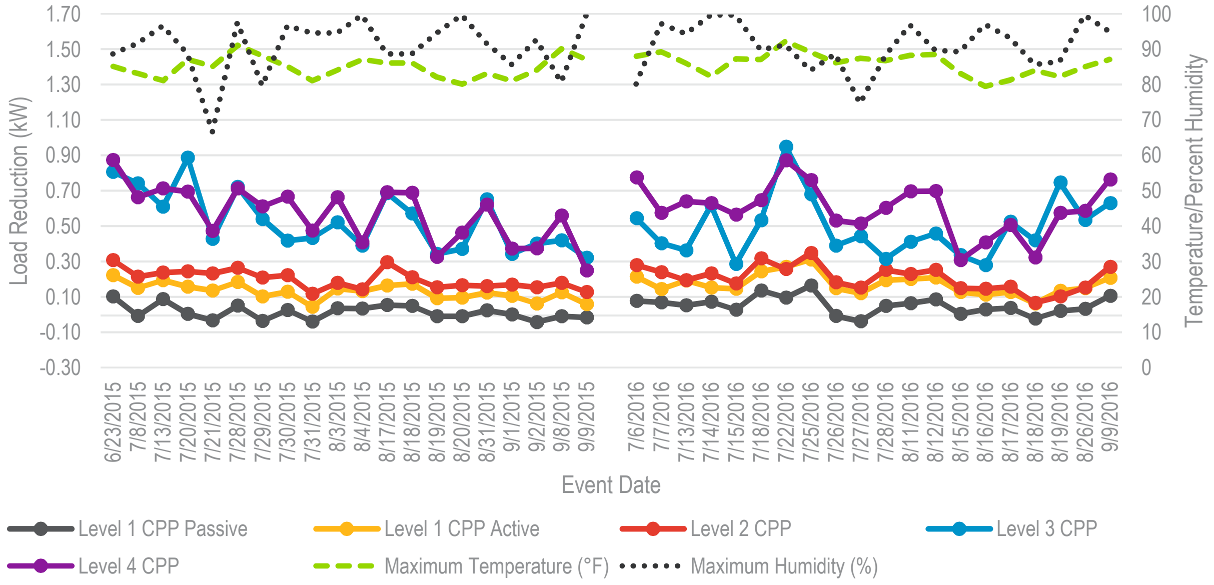
Figure B-1. Peak Event Impacts Absolute Comparison to Other Utilities



Source: Navigant analysis and the Smart Grid Investment Grant program

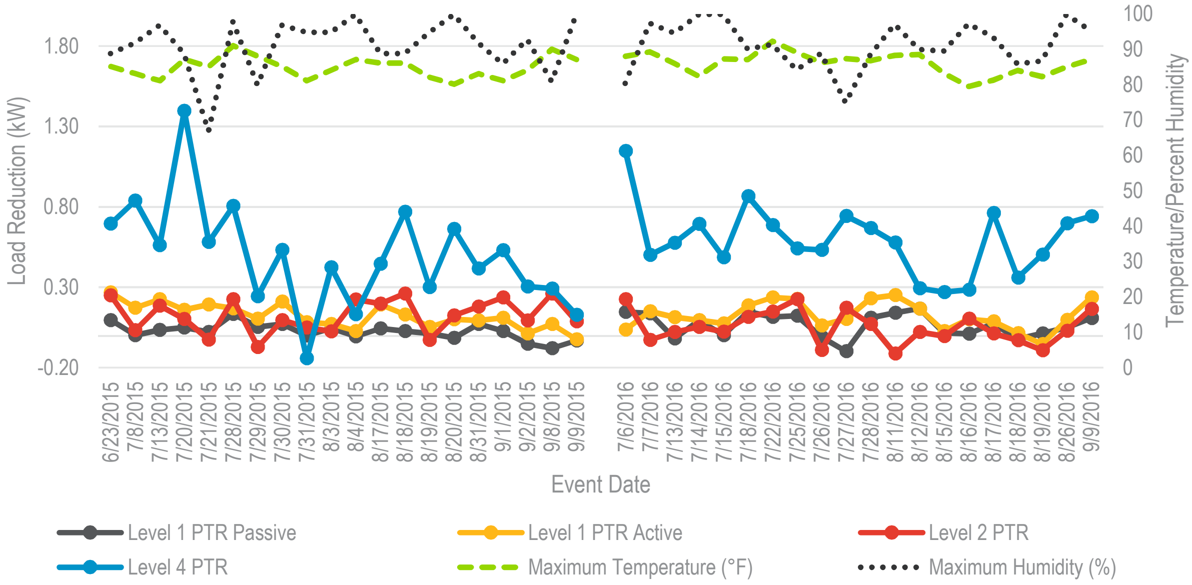
Figure B-2 shows the average absolute impact for each event for the five CPP customer groups, and Figure B-3 shows the average absolute impact for each event for the four PTR groups. The absolute savings followed the same patterns as the percentage savings, with steady impacts for Levels 1 and 2 in both years and decreasing impacts throughout the summer for Levels 3 and 4 in 2015 and steady impacts in 2016. Absolute impacts for passive customers in Level 1 increased from 2015 to 2016.

Figure B-2. Absolute Savings for CPP Customers



Source: Navigant analysis

Figure B-3. Absolute Savings for PTR Customers



Source: Navigant analysis
Note: Level 3 PTR is left out as this group only had one customer in 2015 and two in 2016.

Absolute and percentage impacts by technology/price group for each Peak Event in the two summers of the Pilot are shown in Table B-1 through Table B-4. Positive values indicate savings, or a decrease in electricity usage, and negative values indicate dissavings, or an increase in electricity usage.

Table B-1. Percentage Demand Impact for each Peak Event by Technology/Price Group (2015)

Event Date	Level 1 CPP Passive		Level 1 CPP Active		Level 1 PTR Passive		Level 1 PTR Active		Level 2 CPP		Level 2 PTR	Level 3 CPP		Level 4 CPP		Level 4 PTR	
June 23rd	9%	*	21%	*	9%	*	23%	*	27%	*	20%	50%	*	48%	*	31%	*
July 8th	-1%		15%	*	0%		15%		21%	*	3%	49%	*	38%	*	40%	*
July 13th	8%	*	19%	*	3%		20%	*	23%	*	16%	40%	*	40%	*	29%	*
July 20th	0%		13%	*	4%		11%		20%	*	8%	45%	*	34%	*	49%	*
July 21st	-3%	*	12%	*	2%		16%	*	21%	*	-2%	26%	*	26%	*	27%	*
July 28th	4%	*	16%	*	12%	*	14%		22%	*	16%	35%	*	35%	*	33%	*
July 29th	-3%	*	9%	*	5%		9%		18%	*	-6%	29%	*	28%	*	10%	
July 30th	2%	*	12%	*	6%		16%	*	19%	*	8%	26%	*	34%	*	26%	*
July 31st	-4%	*	5%		0%		8%		12%	*	5%	32%	*	29%	*	-9%	
August 3rd	3%	*	14%	*	4%		6%		16%	*	2%	33%	*	33%	*	21%	
August 4th	3%	*	13%	*	-1%		3%		14%	*	18%	28%		25%	*	8%	
August 17th	4%	*	14%	*	4%		14%	*	23%	*	15%	33%	*	31%	*	20%	
August 18th	4%	*	14%	*	2%		10%		16%	*	17%	29%	*	30%	*	30%	*
August 19th	-1%		8%	*	1%		4%		13%	*	-2%	20%		17%	*	14%	
August 20th	-1%		9%	*	-2%		8%		15%	*	10%	23%		27%	*	32%	*
August 31st	2%	*	11%	*	6%		7%		14%	*	14%	37%	*	31%	*	22%	
September 1st	0%		11%	*	3%		11%		17%	*	17%	25%		23%	*	28%	*
September 2nd	-4%	*	6%	*	-5%		1%		14%	*	7%	25%	*	20%	*	14%	
September 8th	-1%		10%	*	-7%		5%		15%	*	17%	21%	*	25%	*	13%	
September 9th	-1%		5%	*	-3%		-2%		10%	*	6%	16%		12%	*	6%	
Average	**1%**		**12%**	*	**2%**		**10%**		**17%**	*	**9%**	**31%**	*	**29%**	*	**22%**	

Source: Navigant analysis

Note: An asterisk (*) indicates that the majority of the event hours were statistically significant at the 90% confidence level for the indicated group.

Table B-2. Percentage Demand Impact for each Peak Event by Technology/Price Group (2016)

Event Date	Level 1 CPP Passive		Level 1 CPP Active		Level 1 PTR Passive		Level 1 PTR Active		Level 2 CPP		Level 2 PTR	Level 3 CPP		Level 4 CPP		Level 4 PTR	
July 6th	6%	*	17%	*	11%	*	3%		23%	*	15%	25%	*	33%	*	46%	*
July 7th	6%	*	14%	*	12%	*	13%		23%	*	-2%	26%	*	34%	*	28%	*
July 13th	5%	*	18%	*	-2%		10%		19%	*	2%	21%	*	34%	*	29%	*
July 14th	7%	*	15%	*	8%	*	8%		21%	*	4%	40%	*	37%	*	38%	*
July 15th	2%	*	13%	*	0%		6%		16%	*	2%	15%		28%	*	23%	
July 18th	10%	*	20%	*	11%	*	14%	*	25%	*	8%	26%	*	30%	*	38%	*
July 22nd	7%	*	20%	*	8%	*	16%	*	20%	*	10%	39%	*	34%	*	26%	*
July 25th	11%	*	23%	*	8%	*	15%	*	26%	*	14%	29%	*	31%	*	21%	*
July 26th	-1%		13%	*	-1%		5%		16%	*	-6%	20%	*	25%	*	24%	*
July 27th	-3%	*	10%	*	-8%	*	8%		13%	*	12%	22%	*	24%	*	32%	*
July 28th	4%	*	16%	*	8%	*	17%	*	21%	*	5%	15%		27%	*	29%	*
August 11th	5%	*	15%	*	10%	*	17%	*	18%	*	-7%	17%	*	28%	*	22%	*
August 12th	6%	*	16%	*	11%	*	11%	*	19%	*	1%	20%	*	29%	*	12%	
August 15th	0%		12%	*	1%		2%		13%	*	0%	19%	*	16%	*	14%	
August 16th	3%	*	12%	*	1%		10%		15%	*	9%	20%		27%	*	18%	
August 17th	3%	*	13%	*	7%		8%		16%	*	1%	35%	*	31%	*	44%	*
August 18th	-2%	*	6%	*	-2%		1%		7%	*	-2%	26%	*	18%	*	19%	
August 19th	2%	*	13%	*	1%		-5%		10%	*	-7%	43%	*	31%	*	25%	*
August 26th	3%	*	14%	*	4%		8%		14%	*	2%	29%	*	29%	*	33%	*
September 9th	9%	*	18%	*	9%	*	19%	*	23%	*	11%	32%	*	36%	*	34%	*
Average	**4%**	*	**15%**	*	**5%**		**9%**		**18%**	*	**3%**	**26%**	*	**29%**	*	**28%**	*

Source: Navigant analysis

Note: An asterisk (*) indicates that the majority of the event hours were statistically significant at the 90% confidence level for the indicated group.

Table B-3. Absolute Demand Impact (kW) for each Peak Event by Technology/Price Group (2015)

Event Date	Level 1 CPP Passive		Level 1 CPP Active		Level 1 PTR Passive		Level 1 PTR Active		Level 2 CPP		Level 2 PTR	Level 3 CPP		Level 4 CPP		Level 4 PTR	
June 23rd	0.101	*	0.222	*	0.267	*	0.095	*	0.307	*	0.250	0.806	*	0.872	*	0.695	*
July 8th	-0.009		0.150	*	0.173		0.002		0.213	*	0.032	0.740	*	0.662	*	0.838	*
July 13th	0.086	*	0.193	*	0.226		0.034	*	0.236	*	0.185	0.609	*	0.712	*	0.561	*
July 20th	0.003		0.157	*	0.159		0.049		0.244	*	0.102	0.886	*	0.694	*	1.396	*
July 21st	-0.034	*	0.135	*	0.193		0.021	*	0.232	*	-0.026	0.426	*	0.472	*	0.581	*
July 28th	0.050	*	0.184	*	0.168	*	0.133		0.264	*	0.225	0.720	*	0.712	*	0.805	*
July 29th	-0.037	*	0.102	*	0.104		0.052		0.208	*	-0.071	0.539	*	0.611	*	0.243	
July 30th	0.025	*	0.129	*	0.210		0.072	*	0.222	*	0.095	0.417	*	0.665	*	0.532	*
July 31st	-0.040	*	0.043		0.083		-0.001		0.117	*	0.050	0.432	*	0.474	*	-0.142	
August 3rd	0.035	*	0.147	*	0.072		0.044		0.178	*	0.026	0.520	*	0.662	*	0.423	
August 4th	0.034	*	0.131	*	0.028		-0.006		0.141	*	0.224	0.388		0.407	*	0.131	
August 17th	0.054	*	0.164	*	0.193		0.043	*	0.295	*	0.198	0.686	*	0.691	*	0.445	
August 18th	0.049	*	0.173	*	0.130		0.028		0.210	*	0.261	0.571	*	0.687	*	0.769	*
August 19th	-0.010		0.091	*	0.052		0.012		0.153	*	-0.028	0.341		0.325	*	0.300	
August 20th	-0.011		0.095	*	0.101		-0.015		0.165	*	0.124	0.370		0.462	*	0.662	*
August 31st	0.023	*	0.124	*	0.093		0.071		0.160	*	0.180	0.650	*	0.621	*	0.416	
September 1st	0.000		0.105	*	0.109		0.027		0.169	*	0.237	0.341		0.372	*	0.530	*
September 2nd	-0.043	*	0.061	*	0.012		-0.051		0.153	*	0.093	0.400	*	0.373	*	0.304	
September 8th	-0.011		0.125	*	0.072		-0.079		0.178	*	0.261	0.419	*	0.559	*	0.292	
September 9th	-0.017		0.058	*	-0.025		-0.031		0.126	*	0.087	0.320		0.249	*	0.129	
Average	**0.012**		**0.129**	*	**0.121**		**0.025**		**0.199**	*	**0.125**	**0.529**	*	**0.564**	*	**0.496**	

Source: Navigant analysis

Note: An asterisk (*) indicates that the majority of the event hours were statistically significant at the 90% confidence level for the indicated group.

Table B-4. Absolute Demand Impact (kW) for each Peak Event by Technology/Price Group (2016)

Event Date	Level 1 CPP Passive		Level 1 CPP Active		Level 1 PTR Passive		Level 1 PTR Active		Level 2 CPP		Level 2 PTR	Level 3 CPP		Level 4 CPP		Level 4 PTR	
July 6th	0.076	*	0.213	*	0.146	*	0.036		0.278	*	0.226	0.544	*	0.773	*	1.146	*
July 7th	0.069	*	0.144	*	0.137	*	0.151		0.239	*	-0.028	0.402	*	0.574	*	0.500	*
July 13th	0.052	*	0.191	*	-0.018		0.114		0.194	*	0.022	0.362	*	0.639	*	0.576	*
July 14th	0.071	*	0.151	*	0.093	*	0.095		0.231	*	0.053	0.617	*	0.628	*	0.694	*
July 15th	0.026	*	0.145	*	0.001		0.075		0.175	*	0.024	0.285		0.564	*	0.486	
July 18th	0.135	*	0.244	*	0.149	*	0.186	*	0.317	*	0.116	0.531	*	0.646	*	0.865	*
July 22nd	0.095	*	0.269	*	0.116	*	0.236	*	0.257	*	0.149	0.947	*	0.871	*	0.686	*
July 25th	0.163	*	0.310	*	0.123	*	0.227	*	0.347	*	0.225	0.679	*	0.758	*	0.541	*
July 26th	-0.008		0.148	*	-0.009		0.062		0.182	*	-0.090	0.388	*	0.530	*	0.532	*
July 27th	-0.039	*	0.120	*	-0.098	*	0.103		0.152	*	0.172	0.442	*	0.513	*	0.742	*
July 28th	0.049	*	0.193	*	0.109	*	0.230	*	0.252	*	0.072	0.313		0.602	*	0.667	*
August 11th	0.064	*	0.200	*	0.141	*	0.251	*	0.228	*	-0.113	0.410	*	0.696	*	0.577	*
August 12th	0.085	*	0.208	*	0.167	*	0.167	*	0.252	*	0.022	0.457	*	0.697	*	0.293	
August 15th	0.003		0.126	*	0.017		0.027		0.148	*	-0.004	0.335	*	0.307	*	0.269	
August 16th	0.029	*	0.112	*	0.010		0.101		0.145	*	0.105	0.278		0.406	*	0.284	
August 17th	0.036	*	0.127	*	0.074	*	0.088		0.157	*	0.012	0.524	*	0.505	*	0.761	*
August 18th	-0.024	*	0.061	*	-0.022		0.014		0.065	*	-0.030	0.419	*	0.322	*	0.360	
August 19th	0.02	*	0.134	*	0.013		-0.054		0.102	*	-0.092	0.745	*	0.574	*	0.502	*
August 26th	0.032	*	0.148	*	0.050	*	0.097		0.152	*	0.029	0.534	*	0.586	*	0.696	*
September 9th	0.105	*	0.206	*	0.107	*	0.236	*	0.269	*	0.164	0.629	*	0.762	*	0.740	*
Average	**0.052**	*	**0.173**	*	**0.065**		**0.122**		**0.207**	*	**0.052**	**0.492**	*	**0.598**	*	**0.596**	*

Source: Navigant analysis
Note: An asterisk (*) indicates that the majority of the event hours were statistically significant at the 90% confidence level for the indicated group.

Absolute snapback impacts by technology/price group for each Peak Event in each summer of the Pilot are shown in Table B-5 and Table B-6. As noted in Section 3.4.1 no snapback was found for Level 2 customers on either rate, thus these groups are left out of the table. Negative values indicate snapback, or an increase in electricity usage subsequent to a Peak Event, and positive values indicate continued lower usage subsequent to a Peak Event.

Table B-5. Absolute Snapback (kW) for each Peak Event by Technology/Price Group (2015)

Event Date	Level 1 CPP Passive		Level 1 CPP Active		Level 1 PTR Passive		Level 1 PTR Active		Level 3 CPP		Level 4 CPP		Level 4 PTR	
June 23rd	-0.02	*	0.05	*	0.04		0.00		-0.23	*	-0.14	*	0.17	
July 8th	-0.06	*	-0.04	*	0.00		-0.01		-0.42	*	-0.22	*	-0.43	*
July 13th	0.07	*	0.09	*	0.00		0.03		-0.18		0.03		0.03	
July 20th	-0.14	*	0.00		-0.17	*	0.00		-0.42	*	-0.45	*	0.35	
July 21st	-0.09	*	-0.01		0.02		-0.36	*	-0.53	*	-0.36	*	-0.15	
July 28th	0.08	*	0.07	*	0.00		0.00		-0.01		-0.22	*	-0.27	
July 29th	0.00		0.03	*	0.09	*	0.00		-0.55	*	-0.14		-0.12	
July 30th	0.02	*	0.00		0.00		0.00		-0.61	*	-0.18	*	-0.14	
July 31st	-0.04	*	-0.01		-0.08	*	0.00		-0.17		-0.23	*	-0.91	*
August 3rd	0.00		0.07	*	0.00		0.00		-0.43	*	-0.15	*	-0.29	*
August 4th	0.07	*	0.10	*	-0.03	*	0.00		-0.36	*	-0.11	*	-0.16	
August 17th	0.14	*	0.09	*	0.03	*	0.00		0.20		-0.10	*	-0.05	
August 18th	0.05	*	0.04	*	0.05	*	0.00		-0.13		-0.18	*	-0.13	
August 19th	0.00		0.00		0.00		0.00		-0.47	*	-0.30	*	-0.38	*
August 20th	0.01		0.00		0.00		0.00		-0.55	*	-0.22	*	-0.31	
August 31st	0.00		0.00		0.00		0.00		-0.37	*	-0.49	*	-0.50	*
September 1st	-0.02	*	0.00		0.00		0.00		-0.31	*	-0.26	*	0.00	
September 2nd	-0.01		0.00		0.00		0.00		-0.43	*	-0.40	*	-0.61	*
September 8th	0.00		0.02	*	0.00		0.02		-0.15		-0.16	*	-0.69	*
September 9th	0.00		-0.09	*	0.00		0.00		-0.13		-0.34	*	-0.71	*
Average	**0.00**		**0.02**		**0.00**		**-0.02**		**-0.31**	*	**-0.23**	*	**-0.27**	

Source: Navigant analysis

Note: An asterisk (*) indicates that the majority of the event hours were statistically significant at the 90% confidence level for the indicated group.

Table B-6. Absolute Snapback (kW) for each Peak Event by Technology/Price Group (2016)

Event Date	Level 1 CPP Passive		Level 1 CPP Active		Level 1 PTR Passive		Level 1 PTR Active		Level 3 CPP		Level 4 CPP		Level 4 PTR	
July 6th	0.096	*	0.07	*	0.177	*	0		-0.123		-0.149	*	0.175	
July 7th	0.076	*	0.04	*	0.108	*	0		-0.299	*	-0.14	*	-0.122	
July 13th	0.032	*	0.04	*	0		0		-0.352	*	-0.205	*	-0.251	
July 14th	0.037	*	0.03	*	0		0		0.147		-0.104	*	-0.078	
July 15th	0.083	*	0.11	*	0.135	*	0		-0.071		0.012		0.053	
July 18th	0.108	*	0.07	*	0.152	*	0		0.135		-0.096	*	-0.058	
July 22nd	0.221	*	0.22	*	0.093	*	0		0.289		0.255	*	0.114	
July 25th	0.144	*	0.13	*	0.201	*	0		-0.119		-0.063		-0.301	
July 26th	0.006	*	0.02	*	0		-0.227	*	-0.263	*	-0.35	*	-0.537	*
July 27th	-0.034	*	-0.06	*	0		0		-0.481	*	-0.616	*	-0.703	*
July 28th	0.067	*	0.10	*	0		0		0.021		-0.146	*	-0.619	*
August 11th	0.101	*	0.08	*	0.123	*	0		-0.358	*	-0.019		-0.65	*
August 12th	0.043	*	0.00		0.127	*	0		-0.319	*	-0.136	*	-0.196	
August 15th	0.007	*	-0.03		0		-0.308	*	-0.14		-0.39	*	-0.639	*
August 16th	0.033	*	0.02	*	0		0		-0.249	*	-0.192	*	-0.097	
August 17th	0.094	*	0.10	*	0.127	*	0		-0.061		-0.096	*	-0.28	
August 18th	-0.034	*	0.00		0		0		-0.247	*	-0.373	*	-0.416	*
August 19th	0		0.04	*	0		-0.045	*	0.364	*	-0.132	*	-0.034	
August 26th	0		0.02	*	0		-0.285	*	-0.183		-0.242	*	0.22	
September 9th	0.099	*	0.10	*	0.028	*	0		-0.002		-0.084	*	-0.124	
Average	**0.06**		**0.06**		**0.06**		**-0.04**		**-0.12**	*	**-0.16**		**-0.23**	*

Source: Navigant analysis

Note: An asterisk (*) indicates that the majority of the event hours were statistically significant at the 90% confidence level for the indicated group.

B.2 Arrearages Analysis Tables

Table B-7 through Table B-10 show the results of Navigant's review of credit and collections for Pilot participants versus other Worcester customers. This analysis included review of:

- End of Pilot arrears balances and customer counts for 30/60/90+ day periods;

- End of Pilot arrears balances and customer counts for accounts flagged as medical or life support, and therefore not subject to disconnections;
- Disconnection service history before and during the Pilot; and,
- Uncollectible account history before and during the Pilot.

Overall compared to Worcester customers not in the Pilot, a smaller portion of the Pilot participants had disconnections or uncollectible balances. However, this was true in 2014, before the Pilot began, as well as during the Pilot in 2015 and 2016. A similar percentage of customers within and outside of the Pilot had arrears balances. The average dollar amounts per customer with arrears, disconnects, or uncollectible balances were also similar for Pilot and non-Pilot customers. Therefore, the Pilot did not appear to have a large impact on any of these metrics.

Table B-7. Arrears Balances for 30/60/90+ Days

	30 Day Arrears	60 Day Arrears	90 and Plus Day Arrears	Total Arrears
Worcester Non-Pilot Customers	$3,595,793	$1,911,086	$11,390,436	$16,897,315
Pilot Participants	$504,055	$272,787	$1,900,085	$2,676,928
	30 Day Arrears - Customer Counts	**60 Day Arrears - Customer Count**	**90 and Plus Day Arrears - Customer Count**	**Total Arrears - Customer Counts**
Worcester Non-Pilot Customers	19,899	12,846	10,412	20,451
Pilot Participants	3,289	1,913	1,507	3,363
	30 Day Arrears -Average Per Customer	**60 Day Arrears - Average Per Customer**	**90 and Plus Day Arrears - Average Per Customer**	**Total Arrears - Average Per Customer**
Worcester Non-Pilot Customers	$181	$149	$1,094	$826
Pilot Participants	$153	$143	$1,261	$796
	30 Day Arrears - Customer Counts as % of Customer Base	**60 Day Arrears - Customer Counts as % of Customer Base**	**90 and Plus Day Arrears - Customer Counts as % of Customer Base**	**Total Arrears - Customer Counts as % of Customer Base**
Worcester Non-Pilot Customers	28%	18%	15%	29%
Pilot Participants	32%	18%	15%	32%

Source: Navigant analysis

Table B-8. Arrears Balances for Medical and Life Support Accounts

	Total Medical & Life Support Accounts	Accounts with Arrears Balance	Share of Medical & Life Support Accounts with Arrears Balances	Average Arrears Per Account
Worcester Non-Pilot Customers	1,245	885	71%	$4,129
Pilot Participants	155	121	78%	$5,031

Source: Navigant analysis

Table B-9. Disconnection Service History

Year	Worcester Non-Pilot Customers			Pilot Participants		
	Total Number of Customers			Total Number of Customers		
2014	69,029			11,184		
2015	70,090			10,555		
2016	69,915			10,361		
	Number of Disconnected Customers	Total $ Amount in Arrears	Average $ Amount Per Disconnected Customer	Number of Disconnected Customers	Total $ Amount in Arrears	Average $ Amount Per Disconnected Customer
2014	2,536	$3,305,180	$1,303	282	$332,185	$1,178
2015	4,140	$5,327,681	$1,287	314	$372,751	$1,187
2016	4,348	$4,881,481	$1,123	598	$777,486	$1,300
	Percentage of Total Customers Disconnected			Percentage of Total Customers Disconnected		
2014	3.7%			2.5%		
2015	5.9%			3.0%		
2016	6.2%			5.8%		

Source: Navigant analysis

Table B-10. Uncollectible Account History

Year	Worcester Non-Pilot Customers			Pilot Participants		
	Total Number of Customers			Total Number of Customers		
2014	69,029			11,184		
2015	70,090			10,555		
2016	69,915			10,361		
	Number of Uncollectible Customers	Total $ Amount in Arrears	Average $ Amount Per Uncollectible Customer	Number of Uncollectible Customers	Total $ Amount in Arrears	Average $ Amount Per Uncollectible Customer
2014	4,044	$4,636,522	$1,147	272	$349,719	$1,286
2015	4,411	$5,666,770	$1,285	434	$556,184	$1,282
2016	4,998	$5,810,217	$1,163	617	$788,534	$1,278
	Percentage of Total Customers with Uncollectibles			Percentage of Total Customers with Uncollectibles		
2014	5.9%			2.4%		
2015	6.3%			4.1%		
2016	7.1%			6.0%		

Source: Navigant analysis

APPENDIX C. DETAILED SURVEY, INTERVIEW, AND FOCUS GROUP RESULTS

Throughout every stage of the Pilot, National Grid sought customer feedback in order to understand customer awareness and experiences with the rates, technologies, and operation of Peak Events. Navigant completed several surveys, interviews, and focus groups, which are summarized in the body of this report. This appendix details customer responses to the following data collection activities:

1. Meter Decline Survey, November 2013
2. Pre-Pilot Survey, February 2014
3. Pre-Pilot Commercial Interviews, April-May 2014
4. Post Installation Survey, April 2014-March 2015
5. Post Event Surveys, June-July 2015 & July-August 2016; End of Summer Survey, September 2015; and End of Pilot Survey, October 2016
6. End of Summer Low-Income Focus Groups, September 2015 & September 2016
7. End of Summer Commercial Interviews, October 2015
8. Opt Out & Drop Out Survey, November 2015 & October 2016

C.1 Meter Decline Survey, November 2013

The rate at which National Grid customers declined to have a smart meter installed (4%) was within the range of full-scale deployments by other utilities, some of which did not initially offer the option to opt out of meter installation (Table C-1). Seventy customers who had actively declined a meter were interviewed by phone in order to understand why they opted out of the meter installation. Customers who did not have an installation completed due to technical problems were not addressed in this survey.

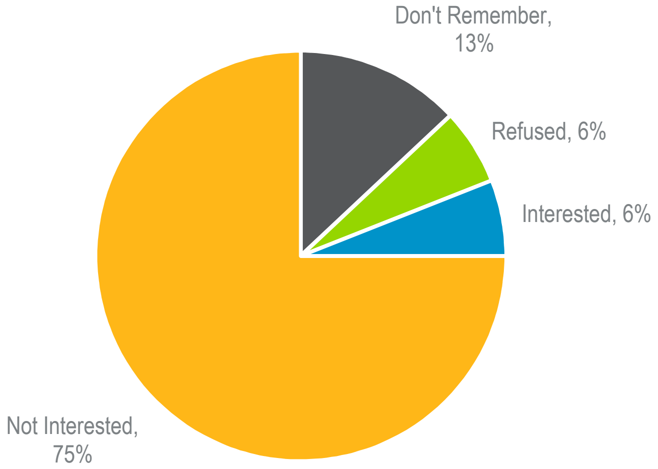
Table C-1. Comparison of Meter Decline Rate to Other Meter Installations

Utility	Total Residential Customers (#)	Opt Out (#)	Percentage Opt Out	Notes on Opt Out
BC Hydro	2,000,000	60,000	3%	Full system deployment
SCE	4,283,836	23,100	1%	Full system deployment
PG&E	5,500,000	42,905	1%	Full system deployment
Central Maine Power	620,000	8,000	1%	Full system deployment
SDG&E	1,249,104	2,227	<1%	Full system deployment

Source: Navigant analysis of the meter decline survey and other utility meter deployments

Customers who declined a meter tended to not have knowledge about the Pilot; as shown in Figure C-1, 75% were not interested in participating in the Pilot at all.

Figure C-1. Desire of Customers who Declined Meter to Participate in Pilot



Source: Navigant analysis of the meter decline survey (N=70)

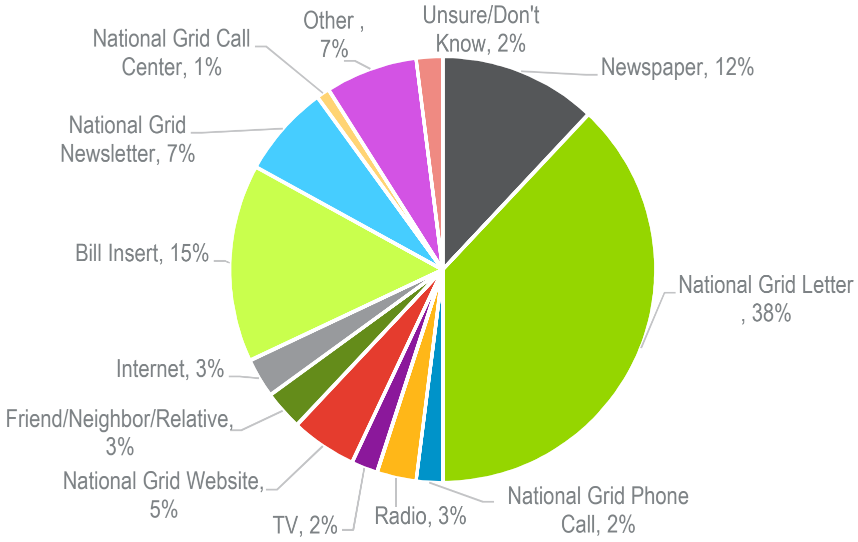
When asked why they declined to have a meter installed, 61% of customers cited only one reason for declining, 31% cited two reasons, and 7% cited three reasons. The single most often cited reason was “I won’t benefit from this,” followed by health and safety concerns.

C.2 Pre-Pilot Survey, February 2014

The Smart Energy Solutions pre-pilot survey was fielded to potential Pilot participants from January 9, 2014 to February 12, 2014. The survey was available to a total population of 12,823 residential customers through an online survey and in-bound and out-bound phone calls. A total of 1,470 residential customers completed the survey, or approximately 11.5% of the eligible population. The survey contained questions about a wide range of topics including demographic information, Pilot awareness and attitude, end-use appliance information, and energy usage habits. The survey was built upon the pre-pilot survey developed as part of the *Common Evaluation Framework* produced by the Massachusetts Smart Grid Collaborative Technical Subcommittee. With National Grid and DPU approval, some modifications were made to the survey to accommodate the Smart Energy Solutions Pilot.

At the time of the survey, almost 50% of customers surveyed had read, seen, or heard information about Smart Energy Solutions within the previous three months. The most common way that customers had heard about the Pilot was from a National Grid communication (letter or bill insert) (see Figure C-2).

Figure C-2. How Customers Heard of the Pilot

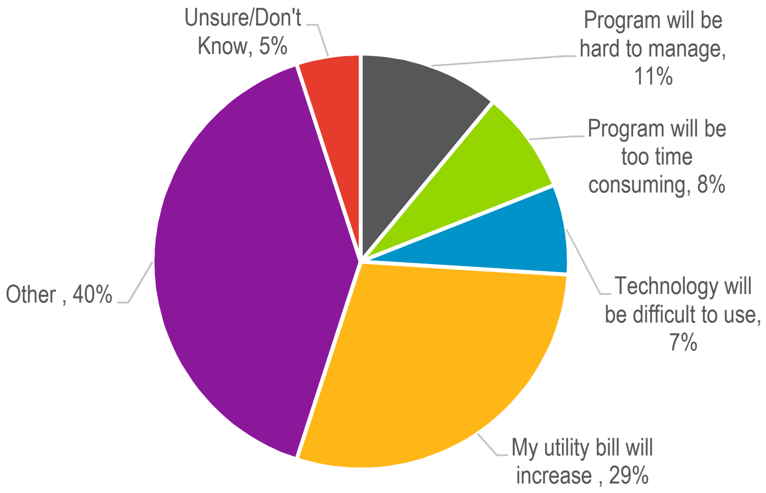


Source: Navigant analysis of pre-pilot survey (N=706)

Within the respondents’ verbatim responses, many requested more information about the Pilot. Many respondents across all demographic segments also expressed interest in participating in the Pilot if it could provide them a better way to manage their energy usage and decrease their monthly energy bill.

The majority (53%) of customers did not have any concerns about participating in the Pilot. Of those that did have concerns, the most common was with their bill increasing, as shown in Figure C-3. Verbatim responses showed a similar pattern and are represented in the “Other” category.

Figure C-3. Reasons for Concern with Pilot Participation



Source: Navigant analysis of pre-pilot survey (N=323)

C.3 Pre-Pilot Commercial Interviews, April-May 2014

Navigant contacted 99 commercial customers in the Pilot area to establish a focus group to discuss their understanding of the Pilot before it began. After five attempts and having only recruited four customers, Navigant decided to interview the customers individually rather than convene a focus group. The interviews provided insight into how much each customer knew about Smart Energy Solutions, how they believed it would affect them, and how much they knew about the Sustainability Hub. The customers represented a variety of services: commercial landlord, construction and real estate development, automotive services, and operations for the City of Worcester. There were no retail sales businesses among the sample.

The evaluation team found that customers appeared to be unaware of the products and services available to them, including technology packages and the Sustainability Hub. Overall, the customers' feedback emphasized their communication desires, including the following:

- **Desire for personal National Grid contact.** Customers said that they would appreciate more personal interactions with National Grid in order to learn about the program. They wanted to receive emails about the program directly from a contact at National Grid and know that they could easily call or email a National Grid employee with questions.
- **Preference for web-based information presentment.** Besides emails, these customers would like to access information about the Pilot online rather than via a smartphone app or IHD.

Although National Grid had not released any information about the program rate before the interviews took place, customers understood the program rates when the evaluation team explained them. Two of the interviewees raised concerns that they could not shift their electricity usage because their business model depends on their using energy-intensive heavy equipment during weekday business hours. The participants' responses suggested that it would be important for National Grid to emphasize how the rate plans may affect commercial as well as residential customers during the Pilot.

C.4 Post Installation Survey, April 2014-March 2015

Navigant completed 241 surveys out of a population of 743 National Grid residential customers who had technologies installed between April 2014 and February 2015. Customers reported strong satisfaction with installation:

- 98% of participants reported that installers appeared at the scheduled day and time
- 90% of participants received the equipment they expected
- 99% of participants received training
- 91% of participants received hands-on demonstrations
- 67% of participants found explanations of how equipment worked "very clear" and 27% found explanations "somewhat clear"
- Verbatim responses indicated some participants were not able to access expected usage/cost data or thought it insufficient for their needs

C.5 Post Event Survey, June-July 2015 & July-August 2016; End of Summer Survey, September 2015; and End of Pilot Survey, October 2016

Navigant achieved 2,974 completes across four post event surveys and two end of season surveys (Table C-2). The majority of respondents were Level 1 customers, which was not surprising considering most participants have Level 1 technology.

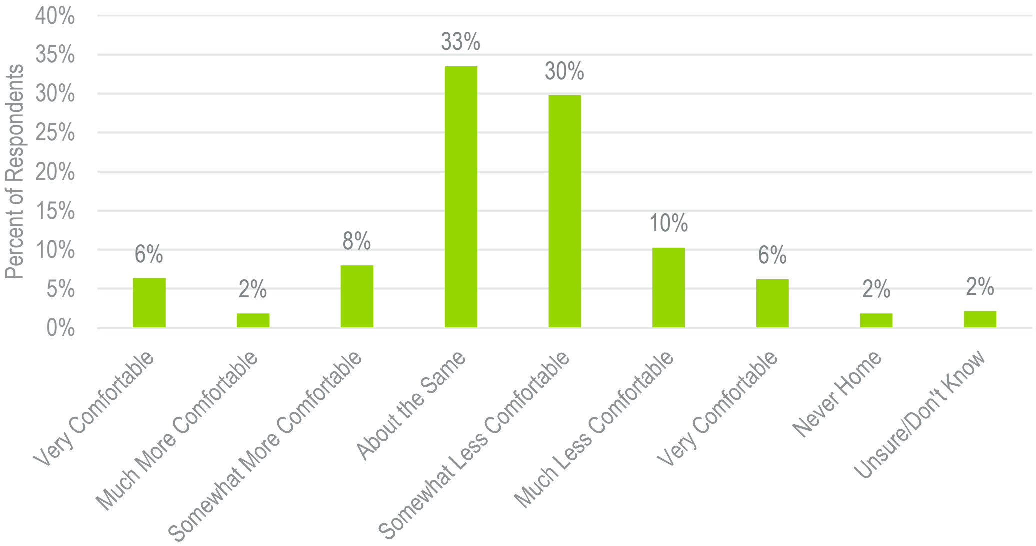
Table C-2. Number of Respondents per Post Event, 2015 End of Summer, and 2016 End of Pilot Survey by Technology Package

Survey	Level 1	Level 2	Level 3	Level 4	Totals
Post Event #1 - June 2015	307	154	10	54	**525**
Post Event #2 - July 2015	167	68	5	30	**270**
End of Summer - September 2015	315	118	7	66	**506**
Post Event #3 - July 2016	377	130	6	50	**563**
Post Event #4 - July 2016	325	112	4	54	**495**
End of Pilot - October 2016	381	144	11	79	**615**

Source: Navigant analysis of post event, 2015 end of summer, and 2016 end of pilot surveys

In comparison to a typical afternoon, participants in the Pilot reported that they were generally equally or less comfortable in their home during the Peak Events, as shown in Figure C-4.

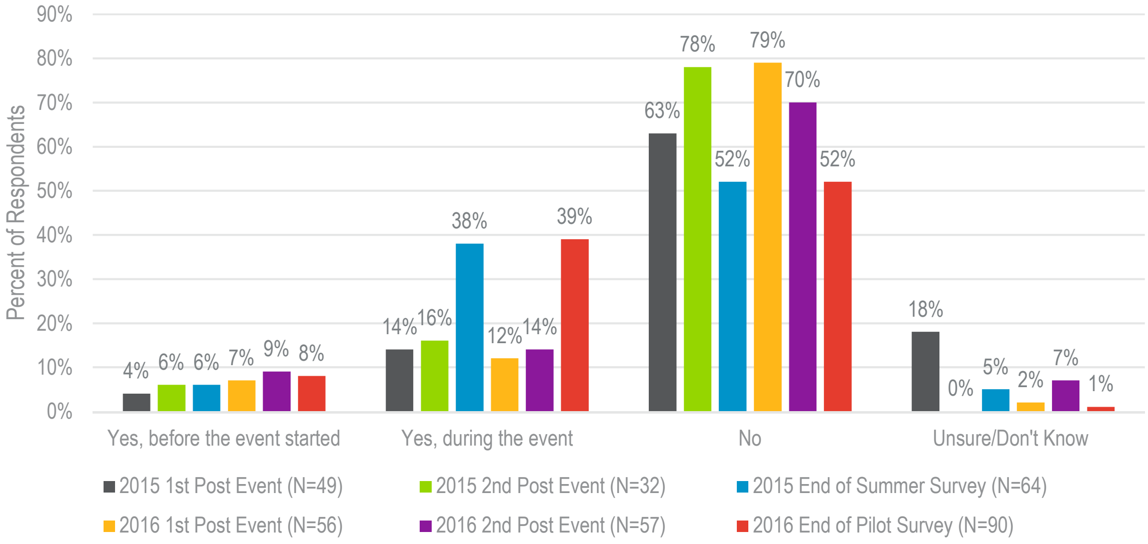
Figure C-4. Comfort during Peak Events Compared to a Typical Afternoon with Similar Temperatures



Source: Navigant analysis of 2016 end of pilot survey (N=615)

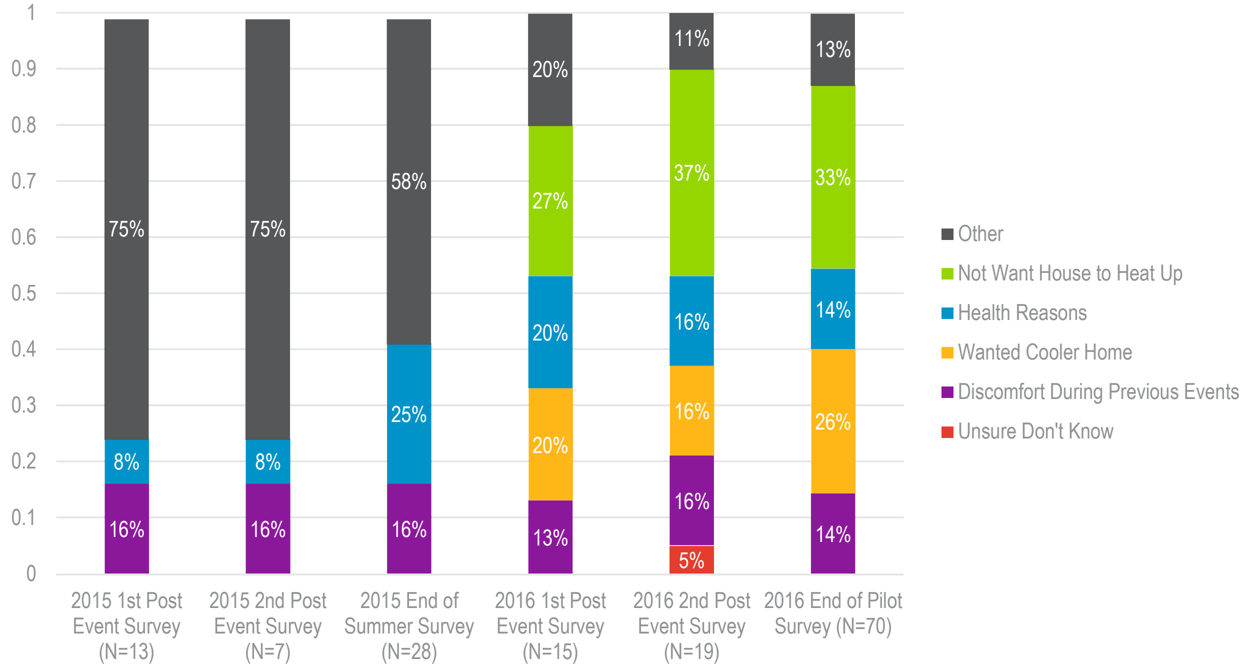
The end of pilot survey asked respondents with a thermostat a series of questions about how they used their thermostat during Peak Events throughout the two summers. In each year as the summer progressed, respondents reported using the override button on their thermostat more frequently (see Figure C-5). In each summer, a little under 40% of customers indicated overriding their thermostat at least once during a Peak Event. As shown in Figure C-6, when asked in the post event and end of season surveys, customers cited comfort and health as reasons for overriding the thermostat adjustment ("Other" responses were primarily about comfort or confirming that there were no other reasons for the override). Nearly two-thirds of thermostat respondents were satisfied with their smart thermostat; few participants (7%) were dissatisfied with the smart thermostat.

Figure C-5. Occurrence of Smart Thermostat Overrides



Source: Navigant analysis of post event (N=49, N=32, N=56, N=57), 2015 end of summer (N=64), and 2016 end of pilot (N=90) surveys

Figure C-6. Reasons for Smart Thermostat Overrides



Source: Navigant analysis of post event (N=13, N=7, N=15, N=19), 2015 end of summer (N=28), and 2016 end of pilot surveys (N=70)

Half of respondents that had a smart plug reported using it during Peak Events in 2015 and 30% reported doing so in 2016. In 2015, those who used their smart plug plugged it into small appliances and electronics (26%), lamps or other light fixtures (8%), refrigerator or freezer (4%)—although National Grid told customers not to use the smart plug for these appliances—room air conditioner or dehumidifier (4%), or other uses (8%). In 2016, those who did not use their smart plug reported that they had forgotten about the Smart Plug (20%), did not understand its purpose (16%), or did not know how to use it (9%). Most customers were satisfied or very satisfied with the smart plug.

C.6 Low-Income Focus Groups

Purpose and Recruitment

To gain a nuanced understanding of how low-income participants perceived and adjusted to the Pilot, Navigant hosted three low-income focus groups: two in 2015 and one in 2016. Using a script developed by Navigant and approved by National Grid and low-income stakeholders, recruiters offered a $150 incentive for participation in a 90-minute discussion with a Navigant moderator. Almost all of the participants in the three groups had technology Level 1, and all but two participants were on the CPP program rate.

In 2015, 22 Pilot participants whose self-reported income was less than or equal to 60% of Massachusetts median income, accounting for household size, took part in the two focus groups.

In 2016, to reach customers at even lower income levels, Navigant recruited participants whose self-declared income was at or below 200% of federal poverty levels. Although 13 customers agreed to participate, only 6 appeared for the group.[107]

Participants varied in their household composition, including single parents (male and female), single elders, elders with grandchildren, families with one or more people with health problems such as asthma, families with seriously ill members, and one college student.

Focus Group Discussion Topics and Responses

Focus group topics included:

- Energy affordability and options and practices for reducing electricity use;
- Presence of very young, elderly, ill, and disabled household members, or pets during Peak Events;
- Participant awareness of events and responses to them;
- Awareness of program technology and reasons for not signing up;
- Internet access, familiarity, and usage; and,
- Awareness of program rates, bill protection, and ability to initially choose and later switch rates.

Through these three focus groups, low-income customers reported several concerns about participating in the Pilot including:

- Keeping the home cool for homebound parents, members in poor health, babies, and/or pets;
- Electricity expenses and affordability;
- Options for reducing their electricity usage; and
- Desire for more information and transparency about their particular electric usage and bill savings opportunities.

Unsurprisingly, participants expressed considerable concern about electricity cost and affordability. They were positive about the Pilot, engaged, and felt they were able to manage their electricity use; however, in more detailed discussion some said they had few options for making real reductions. They were highly aware of events and most preferred text and email event notifications. However, some expressed the opinion that if they missed a notification or a family member kept the air conditioning running they were being penalized for not cutting back during the event. The two participants on the PTR rate were aware of rebates for conserving electricity but did not understand how the rebates were calculated, even when an explanation was provided.

Participants were not aware of a number of factors that might affect their participation in the Pilot, including rate choices, technology options, and bill protection. All of the groups strongly expressed a

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[107] This occurred despite reminder phone calls made the day before the focus group to those who had agreed to participate.

desire for more information and more explanation, such as what sort of rate would provide the lowest cost given their particular circumstances. Despite this, focus group participants were positive about the Pilot overall and showed a willingness to learn and to do as much as they could to take actions that would lower their electric bills.

In all three groups, participants reported taking the maximum measures they could think of to reduce electricity usage during events, even if those actions affected their comfort or feeling of wellbeing. These actions included conversations with family members to impress the importance of taking actions such as playing video games on battery operated handheld devices rather than online or on the television with a video game console. Participants reduced or completely turned off all lighting, clothes and dishwashers, and air conditioning during events, including households who had elderly or sick members. One person reported closing every circuit breaker in the house except for the 20-year-old refrigerator. Many recipients left the home, going to libraries, museums, stores, or any publicly open place that had air conditioning, but for the longer Peak Events that strategy was not always practical, especially around mealtimes. In 2016, which had several back-to-back events, participants expressed weariness by the second or third day and some said they gave up trying at some point. From these actions participants felt they used considerably less electricity but they did not see bill reductions in line with their actions. There was no awareness of bill protection or the net effect of truing up bills on an annual basis. This lack of bill protection awareness was not limited to low-income participants, as demonstrated in surveys.

Participants were very aware of the rewards platform and were positive about it. However, they had little or no awareness of National Grid's energy efficiency programs or programs offered through community groups like Worcester Community Action, although one person was having an old refrigerator replaced, apparently through the Low-Income Retrofit initiative.

Participants had little or no awareness of rate choices at the outset of the Pilot or their ability to switch to the PTR rate. One participant with a chronically ill household member found out about the PTR pricing plan through a call to National Grid customer service and found that the switch made a substantial difference in their bill because they could not do without air conditioning.

Most Level 2 focus group participants were positive in their views about the IHD's, however the great majority of focus group participants were unaware of the technology choices. When participants had an opportunity to see the IHDs in person during the focus groups they were very positive about the technology offerings as tools in managing electricity usage.

C.7 End of Summer Commercial Interviews, October 2015

As there were too few commercial customers in the Pilot area to survey, Navigant interviewed four commercial participants in order to obtain qualitative input about their 2015 summer season experience. National Grid and Navigant identified approximately 275 commercial participants on general service (G1) rates, but the majority were property owner accounts and almost all were on the Critical Peak Pricing (CPP) rate with Level 1 technology. Navigant sought a variety of participants, aiming to talk to customers with Level 2 or higher technology as well as a PTR customer, focusing on retail and office customers. Customers received a $200 honorarium or charity donation for a 30-minute interview. The four interviewed customers were all on the CPP rate with Level 1 technology.

The evaluation team found that the commercial customers interviewed were continuing business as usual and with one exception were not aware of their rate choice within the Pilot. The participants knew about the CPP pricing plan but not the PTR pricing plan and knew about the events but were unable to adjust their usage during them.

Given the very low response rates and the amount of effort exerted to recruit just five customers for interviews in 2015, as well as the small number of commercial participants in the Pilot, Navigant did not conduct commercial interviews in 2016.

C.8 Opt Out & Drop Out Surveys, November 2015 & October 2016

Customers could change rates or leave the Pilot at any time. Navigant surveyed these customers on a rolling basis to understand their reasons for “opting out” (*i.e.*, switching from CPP to PTR) or dropping out of the program, based on whether enough customers had dropped out or opted out to have a statistically significant customer pool to survey. Enough customers had dropped out of the program, or switched to the PTR rate by November 2015 to field a survey. Due to the very low rate of opting out and dropping out, a second survey was not fielded until the end of the Pilot in October 2016.

Across both surveys Navigant completed surveys with 42 customers (Table C-3). Six of the PTR respondents dropped out before the Pilot rates-go-live date of January 1, 2015, and the rest dropped out during the Pilot.

Table C-3. Opt Out & Drop Out Customers Surveyed by Technology Package

Technology Package	2015		2016	
	Opt Out	Drop Out	Opt Out	Drop Out
Level 1	5	14	2	6
Level 2	1	6	0	3
Level 3	1	1	0	0
Level 4	1	0	0	2
Total	**8**	**21**	**2**	**11**

Source: Navigant analysis of the opt out and drop out surveys

Survey responses indicated that customers that dropped out of the program felt:

- More information was needed on the Pilot;
- Peak Event hours were inconvenient;
- The Pilot intruded on privacy and personal decision-making;
- The Pilot increased their bills;
- Savings didn’t justify the effort; and,
- They could not change electric usage due to equipment they needed to use.

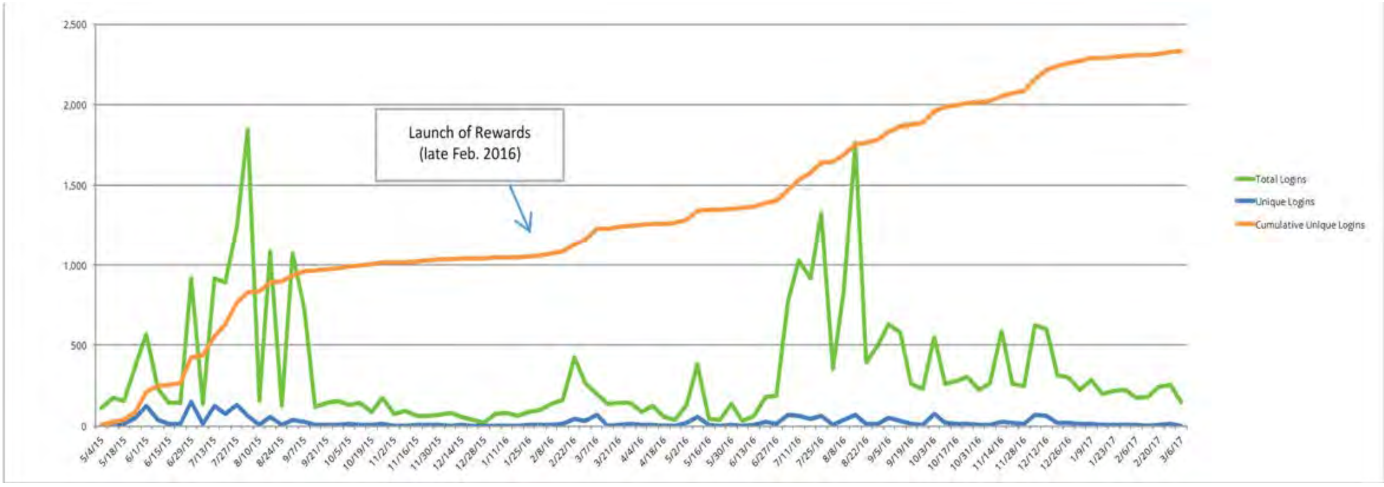
APPENDIX D. REWARDS PLATFORM EFFECTIVENESS

The rewards platform on the WorcesterSmart web portal was launched in February 2016. As of March 2017, over 2,200 rewards had been redeemed by Pilot participants. The following results came from National Grid's internal assessment of the platform's effectiveness.

Web Portal Logins

Since launching the rewards platform, there has been a considerable increase in the total logins to the web portal (Figure D-1). After the launch of the rewards platform, the average weekly login count jumped from 323 (from 5/4/15 to 2/21/16) to 360 (from 2/22/16 to 3/6/17) – an 11.5% increase. While logins spiked after the initial program launch in 2014 and again during the first Peak Event season in 2015, they plateaued following the Pilot's first Peak Event season – until the February 2016 addition of rewards reinvigorated customer interest.

Figure D-1. Weekly Web Portal Logins, May 2015 – March 2017



Source: National Grid

*The "cumulative logins" are cumulative as of this chart's start date (i.e. they exclude unique logins prior to 5/04/2015).

Communication Click-to-Open Rates

Table D-1 details the click-to-open rates (the key measurement for conversion) for Peak Event-related communications in 2015 and 2016. These rates generally improved from 2015 to 2016. For emails sent to customers the day before Peak Events click-to-open rates increased by 18.4%, and for emails sent the day of Peak Events click-to-open rates increased by 9.2%.

Table D-1. Click-to-Open Rates for Peak Event Emails in 2015 and 2016

	Click-to-Open Rates	
Peak Event Emails Sent	**2015**	**2016**
Day Before	5.91%	7.0%
Day Of	8.7%	9.5%
Day After	31.0%	22.6%

Source: National Grid

Program Satisfaction

National Grid also found that the rewards platform positively impacted customer satisfaction. In a survey conducted by National Grid in January and February 2017, 83% of customers rated the value of the rewards feature as a 4 or 5 on a 5-point scale. Ranked among other web portal site and program features (such as Peak Event content, energy-saving tips, and energy insights), the rewards feature received the highest customer satisfaction score. Furthermore, 68% of customers reported that email content relating to rewards and contests helped them to save energy and money in their homes. These survey results suggest that rewards are a significant motivator and driver of site traffic, engagement, and energy savings.

APPENDIX E. MEDIA COVERAGE OF SMART ENERGY SOLUTIONS

Various media sources have covered Smart Energy Solutions from different points of view. National Grid's "listen, test, learn" approach lends itself to reviewing criticism and praise, and adjusting the Pilot or providing additional information to customers.

The following summarizes a selection of these stories:

Title: A Controversy Erupts in Worcester: All Eyes on Smart Grid Plan

Date: January 30, 2014

Link: http://worcestermag.com/2014/01/30/controversy-erupts-worcester-eyes-smart-grid-plan/20499

Summary: This article, written early in the Pilot—after meter installation was completed and just as technologies and rates were offered, provides coverage of National Grid's cooperation with neighbors to build a communications tower. It details concerns that some customers have about smart meter radio frequency, as well as information National Grid provided about smart meter radio frequency strength in order to educate people about the low health risk posed by smart meters.

Title: National Grid Smart Grid Program Launches Technology Phase

Date: April 1, 2014

Link: http://www.golocalworcester.com/news/national-grid-smart-grid-program-launches-technology-phase

Summary: Released during National Grid's customer technology launch, this article discusses the customer-facing and grid-facing investments covered in the Pilot. It provides detail on the distribution and communication infrastructure investment.

Title: National Grid's Sustainability Hub Gathers Customers and Community

Date: December 16, 2014

Link: http://www.intelligentutility.com/article/14/12/national-grid-s-sustainability-hub-gathers-customers-and-community

Summary: This op-ed by National Grid's VP of Customer Strategy and Engagement, Ed White, summarizes the Sustainability Hub's first year as an educational tool and community space. It highlights events held at the Sustainability Hub, individuals and groups who visit the Hub to learn about the Pilot and sustainability, as well as community groups that use the Hub as a meeting space.

Title: Worcester Smart Grid Up and Running as National Grid Launches Pilot Program

Date: January 15, 2015

Link: http://www.masslive.com/news/worcester/index.ssf/2015/01/worcester_smart_grid_up_and_r.html

Summary: Written shortly after the Pilot rates went live, this article summarizes rate offerings and describes meters, anticipated customer savings, as well as National Grid's smart grid distribution system investments. It also cites Worcester's diversity as the driver to have the Pilot in Worcester.

Title: National Grid's Smart Energy Solutions Program Adds Interactive Energy Savings Features

Date: April 30, 2015

Link: http://3blmedia.com/News/National-Grids-Smart-Energy-Solutions-Program-Adds-Interactive-Energy-Savings-Features

Summary: Written in the first quarter that Pilot rates went live, this article summarizes the customer portal, IHD, and app, as well as how the Pilot's smart grid investments have reduced outage restoration times.

Title: A year in, Smart Energy program bright idea for most

Date: September 12, 2015

Link: http://www.telegram.com/article/20150912/NEWS/150919656/101448

Summary: This front-page article in the Sunday Worcester Telegram & Gazette documents the positive program experience of multiple customers, as well as presenting results from the first summer of Conservation Days. The article also introduces the natural link between Smart Energy Solutions and National Grid's Grid Modernization Plan that was filed with the DPU in 2015.

Title: CEIVA Energy Technology Powers 20% Additional Savings for National Grid's Smart Energy Solutions Customers

Date: October 12, 2015

Link: http://www.businesswire.com/news/home/20151012005202/en/CEIVA-Energy-Technology-Powers-20-Additional-Savings

Summary: This article, published after customers' first summer on the Pilot rates, summarizes the technologies offered. It highlights customer bill savings and other technologies offered to customers.

Title: Carlos Nouel and Nick Corsetti on Jordan Levy Show

Date: July 15th, 2015

Summary: Carlos Nouel and Nick Corsetti on Jordan Levy radio show to discuss Smart Energy Solutions.

Title: Marcy Reed on Jordan Levy Show

Date: October 15th, 2015

Summary: Marcy Reed on Jordan Levy radio show, mentions Smart Energy Solutions.

Title: Worcester Habitat for Humanity chapter to dedicate first Veterans Build home today

Date: February 12, 2016

Link: http://www.telegram.com/article/20160212/NEWS/160219927

Summary: This article discusses National Grid's partnership with Habitat for Humanity to provide an energy efficient home to a veteran and his family. As part of Smart Energy Solutions, this home features in-home technology tools and energy efficient washer, dryer, and heating systems.

Title: Worcester smart grid pilot reports $1.25M savings

Date: February 25, 2016

Link: http://www.telegram.com/article/20160225/NEWS/160229460

Summary: This article, written after the first year of the pilot, describes the details of National Grid releasing the results of the first year of the program. The results revealed customers participating in the Pilot saved $1.25 million on their electricity bills, which is equivalent to powering a local library for almost a year. The first year results also highlighted the program's retention customer satisfaction rates. This report tremendously helped National Grid to make improvements for the second year, such as better communication with customers before and during Conservation Days and providing more information on saving energy through the online portal.

Title: National Grid touts success in first-year of Worcester Smart Grid program

Date: March 1st, 2016

Link: http://www.masslive.com/news/worcester/index.ssf/2016/03/national_grid_touts_success_of.html

Summary: This article gives a short explanation of what Smart Energy Solutions is and summarizes the successes of the first year of the program. The successes mentioned include $1.25 million in customer savings, 2,300 Megawatt-hours saved, a 98 percent retention rate, and a 72 percent customer satisfaction rate.

Title: Ed White on Jordan Levy Show

Date: March 14th, 2016

Summary: Ed White on Jordan Levy radio show mentions Smart Energy Solutions.

Title: Smart Grid pilot at $55M and counting

Date: May 23rd, 2016

Link: http://www.wbjournal.com/article/20160523/PRINTEDITION/305209985/smart-grid-pilot-at-55m-and-counting

Summary: This article explains some of the challenges regarding National Grid's budget for the Smart Grid pilot. Planned financial contributions and unexpected cost overruns have resulted in National Grid exceeding the program's initial budget ($45.5M). Consequently, the Massachusetts Attorney General's Office has flagged the pilot with concerns of excess spending and called for an investigation at the end of the pilot. The overrun includes $20 million for investments in distribution systems and $35 million for all program costs, technologies, outreach, and solutions. Costs were unexpectedly high because the original budget assumed community donations that it didn't receive. However, the benefits of the Sustainability Hub and Smart Energy Solutions program have exceeded initial expectations.

Title: Chronicle/Problem Solvers: A House Full of Energy Saving Tips-National Grid's Sustainability Hub in Worcester

Date: June 10th, 2016

Link: http://www.wcvb.com/article/chronicleproblem-solvers-a-house-full-of-energy-saving-tips/8103467

Summary: The local news show "The Chronicle" visited the Sustainability Hub in the summer of 2016 to show how the Sustainability Hub is a resource for energy efficiency and "smart" appliance information. Interviews with staff and interns give tips on how to be more energy efficient, what energy efficient products and appliances are available, and other energy saving ideas and information available at the Hub.

Title: Connected controversies: The NTP cell phone study and wireless electric meters

Date: June 23rd, 2016

Link: https://worcestermag.com/2016/06/23/connected-controversies-ntp-cell-phone-study-wireless-electric-meters/43751

Summary: This article describes the preliminary results of U.S. Department of Health and Human Services' National Toxicology Program's study testing links between cancer and chronic exposure to radiation emitted from wireless devices, including National Grid's smart meters. The results revealed strong evidence that such exposure is associated with certain cancer formation (testing on rodents). Major controversy surrounds the assumption that weak exposures (sub-thermal) are assumed to be safe. Some Worcester residents are in opposition to National Grid's wireless meter pilot because of health risks, privacy, and circulation of the community's energy dollars. The article also highlights how other countries have taken precautions surrounding low intensity, high-frequency electromagnetic fields.

Title: National Grid taps Itron for Massachusetts smart metering plan in grid modernization effort

Date: July 27th, 2016

Link: http://www.utilitydive.com/news/national-grid-taps-itron-for-massachusetts-smart-metering-plan-in-grid-mode/423337/

Summary: This article, appearing in July 2016, discusses National Grid's (NG) decision to use the tech and services company Itron to supply the platform for the Advanced Metering Functionality for its grid modernization plan. It highlights National Grid's four proposals, of varying scale, to the Department of Public Utilities (DPU) to meet grid modernization requirements set by state regulators. The decision to use Itron for this next phase of modernization is dependent on DPU approval, and the two companies agreeing to a contract.

Title: National Grid Pursues Smart Energy Solutions Extension

Date: September 1st, 2016

Link:http://www.electricenergyonline.com/detail_news.php?ID=594760&titre=National+Grid+Pursues+Smart+Energy+Solutions+Extension

Summary: This article, written in September 2016, discusses National Grid's plans to extend the Smart Energy Solutions pilot program in Worcester for an additional two years. National Grid recently filed a request to the Department of Public Utilities (DPU) to expand on infrastructure investments, customer engagement and improvements to electric services. The program has also helped inform National Grid's grid modernization in Massachusetts, later filed to the DPU.

Title: Monfredo: How Safe are the Electromagnetic Fields Emitted by Wireless Technology?

Date: September 3rd, 2016

Link: http://www.golocalworcester.com/news/monfredo-how-safe-is-the-electromagnetic-fields-emitted-by-wireless-technol

Summary: This article, posted on the Go Local Worcester website, presents information, research, and opinions that are concerned about the use of technology, specifically Wi-Fi-enabled technology, and its health effects on students and children who are consistently exposed to it. The National Grid pilot program smart meters are briefly mentioned as one of the expanded uses of such technology. The author, who expresses concern about the possible health-risk associated with these technologies, presents scientists, organizations, and countries who have either expressed concern, or taken action, on limiting exposure to Wi-Fi technology and lists suggestions for possible equipment that limits exposure. In the end, the author advocates its readers to do more research on the subject to become better informed.

Cases 17-E-0238 and 17-G-0239

Exhibit__(SAMIP-2)
1 of 1

IS Projects Allocated to AMI

Project	Title	Type of Cost	AMI Allocation
4704A	CSS customer Enhancements	Capital & Expense	100
4704L	Information Management & Advanced Analytics	Capital & Expense	17.28
4704M	Cloud Computing & Data Lake	Capital & Expense	17.28
4704J	ESB and API Integration	Capital & Expense	30.57
NA	Energy Monitoring Portal	Expense	100
NA	Customer Load Management	Expense	100
4704N	Cyber	Capital & Expense	31.22
4704I	Telecoms	Capital & Expense	26.45

Distribution Automation

RESULTS FROM THE SMART GRID INVESTMENT GRANT PROGRAM

September 2016

SMARTGRID.GOV
RECOVERY ACT SMART GRID PROGRAMS

U.S. DEPARTMENT OF
ENERGY
Office of Electricity Delivery
and Energy Reliability

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Executive Summary

Across the United States, more than 6 million miles of distribution lines and more than 200,000 distribution circuits provide the critical link between the bulk power grid and 160 million electricity customers.[1] Distribution automation (DA) uses digital sensors and switches with advanced control and communication technologies to automate feeder switching; voltage and equipment health monitoring; and outage, voltage, and reactive power management. Automation can improve the speed, cost, and accuracy of these key distribution functions to deliver reliability improvements and cost savings to customers.

Prior to ARRA, the widespread adoption of DA technology was hampered by a lack of data on performance, cost, and benefits in real-world applications. This report shares key results from the 62 SGIG projects implementing DA technologies and also documents lessons learned on technology installation and implementation strategies. With this report, the U.S. Department of Energy (DOE) aims to further accelerate grid modernization by helping decision makers better assess the benefits and costs of DA investments and learn from leading-edge utilities.

The Smart Grid Investment Grant (SGIG) Program

The American Recovery and Reinvestment Act (ARRA) of 2009 provided DOE with $3.4 billion to invest in 99 SGIG projects to modernize the electric grid, strengthen cybersecurity, improve interoperability, and collect smart grid impact data. Electricity industry recipients matched or exceeded this investment dollar-for-dollar.

Deployment of DA accounted for more than a quarter of the $7.9 billion total SGIG investment. SGIG utilities installed nearly 82,000 smart digital devices to upgrade 6,500 U.S. distribution circuits, including:

DA Asset	Total Installed
Remote Fault Indicators	13,423
Smart Relays	11,033
Automated Feeder Switches	9,107
Automated Capacitors	13,037
Automated Voltage Regulators	10,665
Transformer Monitors	20,263
Automated Feeder Monitors	4,447

Utilities also invested in the high-bandwidth, low-latency communications systems and information management and control systems that form the backbone of DA operations.

Major Findings

SGIG projects demonstrated that DA technologies and systems can achieve substantial grid impacts and benefits that met and often exceeded pre-project expectations, including:

- → **Improved fault location, isolation, and service restoration capabilities** that result in fewer and shorter outages, lower outage costs, reduced equipment failure, and fewer inconveniences for consumers.
- → **Improved distribution system resilience to extreme weather** events by automatically limiting the extent of major outages and improving operator ability to diagnose and repair damaged equipment.

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[1] U.S. Energy Information Administration, "Electric power sales, revenue, and energy efficiency: Form EIA-861 detailed data files," Final 2014 data, October 21, 2015.

→ **More effective equipment monitoring and preventative maintenance** that reduces operating costs, enables more efficient use of capital assets, reduces the likelihood of equipment failures, and leads to fewer outages.

→ **More efficient use of repair crews and truck rolls** that reduces operating costs, enables faster service restoration, and lowers environmental emissions.

→ **Improved grid integration of selected distributed energy resources (DER)** such as thermal storage for commercial and municipal buildings.

Each SGIG DA utility installed a distinct set of DA assets, tested different capabilities, and deployed assets at a different scale—enabling each utility to test technology integration and explore costs and performance based on their individual objectives, systems, and experience levels. As a result, utility costs and performance were not directly comparable across all projects. Nonetheless, the SGIG projects produced important findings on DA technology performance and benefits in four key areas: reliability and outage management; voltage and reactive power management; equipment health monitoring, and integration of DER. This report also highlights select projects that exemplify the wide range of DA results and lessons learned.

Reliability and Outage Management

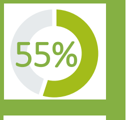
DA reduced the frequency, impact, duration, and cost of major storms and outage events, which significantly improved reliability indices for several utilities.

DA technologies provided advanced capabilities for operators to detect, locate, and diagnose faults. In particular, fault location, isolation, and service restoration (FLISR) technologies can automate power restoration in seconds by automatically isolating faults and switching some customers to adjacent feeders. FLISR can reduce the number of affected customers and customer minutes of interruption *by half* during a feeder outage for certain feeders. Fully automated switching and validation typically resulted in greater reliability improvements than operator-initiated remote switching with manual validation.

Precise fault location enabled operators to dispatch repair crews accurately and notify customers of outage status, which reduced outage length and repair costs, reduced the burden on customers to report outages, and increased customer satisfaction.

Per outage event, FLISR operations:[2]

Reduced number of customers interrupted by



Reduced customer minutes of interruption by

In 2013, 3 utilities reported System Average Interruption Frequency Index **(SAIFI) improvements of 17%-58%** from pre-deployment baselines

DA operations **avoided >197,000 truck rolls**[3] and **3.4 million vehicle miles traveled** from 2011 to 2015[4]

Savings reduced an estimated **2,350 metric tons of CO_2 equivalent—**the same amount produced to power 214 homes for a year[5]

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[2] Average per event for FLISR operations reported by five utilities over one year.

[3] Data from 16 reporting SGIG DA utilities from April 2011 to March 2015.

[4] Data from 18 reporting DA utilities from April 2011 to March 2015.

[5] Based on analysis of truck roll data from 18 SGIG DA utilities between April 2011 and March 2015, using U.S. Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator," last updated April 2014.

DA helped customers avoid outage costs and created operations and maintenance (O&M) efficiencies that led to savings for utilities.

For customers, DA operations during major storms saved one utility's customers on a 14-feeder segment $1.2 million in one year. For utilities, automating functions that previously required field crews to conduct on-site monitoring, maintenance, and repair reduced labor costs, truck rolls, vehicle-miles traveled, and replacement part costs.

FLISR and smart meters at the Electric Power Board of Chattanooga, TN helped operators **restore system-wide power about 17 hours earlier than without DA** after a July 2012 derecho. After another storm in February 2014, EPB was able to **restore power 36 hours faster and reduce affected customers from 70,000 down to 33,000**.

SGIG utilities in total **avoided $6.2 million in distribution operations costs** in about 1 year[6] and **avoided $1.46 million in switching costs** over 3 years[7]

Voltage and Reactive Power Management

Automated voltage regulation and power factor correction enabled utilities to reduce peak demands, more efficiently utilize existing assets, defer capital investments, and improve power quality for the growing digital economy.

Utilities used CVR to reduce feeder voltage levels, improve the efficiency of distribution systems, and reduce energy consumption, especially during peak demand periods.

Automated power factor correction provides grid operators with new capabilities for managing reactive power flows and boosting power quality. Several utilities improved power factors to near unity through integrated volt/volt-ampere reactive controls (IVVC), and one utility reduced reactive power requirements by about 10%-13% over one year.

Several utilities found that **CVR can result in energy savings of 2-4 percent on affected feeders**—a change that when applied system-wide could save hundreds of thousands of dollars in yearly energy costs and reduced environmental emissions

ConEdison **increased its 4kV substation capacity by 2.8 percent** under peak conditions using CVR, resulting in a net **savings of $15.7 million**.

O&M savings from CVR formed the largest portion by far of Duke Energy's 20-year smart grid business case, with a **net-present value of more than $155 million**

Southern Company realized about **$3.4 million in net present-value from deferred distribution capacity investments** by using automated capacitor banks to reduce reactive power loss.

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[6] Data from Nine SGIG DA utilities that reported savings from April 2013 to September 2014.

[7] Data from eight SGIG DA utilities that reported savings from April 2011 to March 2014.

Equipment Health Monitoring

Installing sensors on key components (e.g., power lines and transformer banks) to measure equipment health parameters can provide real-time alerts for abnormal equipment conditions as well as analytics that help utility engineers plan preventative equipment maintenance, repair, and replacement.

These technologies and systems also equip grid operators with new capabilities to better dispatch repair crews based on diagnostics data.

Florida Power and Light prevented an outage for 15,000 customers and avoided $1 million in restoration costs by identifying and repairing a transformer before it failed

Several utilities automated monitoring to reduce physical inspections, enable proactive maintenance, and better diagnose equipment failures

Integration of Distributed Energy Resources (DER)

Grid integration of DERs requires advanced tools to monitor and dispatch DERs, and to address new power flow and control issues, such as low-voltage ride through, harmonic injection, voltage fluctuations, and reactive power management. Some SGIG utilities evaluated distributed energy resource management systems (DERMS) and integrated automated dispatch systems (IADS) on small DER installments. A small number also tested thermal energy storage for commercial and government buildings.

Burbank Water and Power in California used DER management systems to control ice storage systems that made ice overnight to power daytime air conditioning loads, which reduced the buildings' cooling requirements by about 5%

Key Lessons and Conclusions

Many DA utilities faced a learning curve that required new business practices, custom solutions, and extensive training and testing. Tackling new technical challenges revealed valuable lessons learned that can help other electric utilities embarking on DA projects:

- **Return on Investment for a Specific Technology or Function is Utility-Specific:** Cost-effectiveness depends on a number of factors, including project scale, the functionality of individual devices, the utility's learning curve, and the need for wholly new software and systems or the ability to retrofit. Larger scale projects saw the most significant results and could better leverage foundational investments in communications infrastructure and information systems integration.
- **DA Applications Produce Large Volumes of New Data for Processing and Analysis**: Installing thousands of smart monitoring devices gave operators unprecedented levels of data to process, store, analyze, error-check, and turn into actionable information. Operators recommended establishing policies for data storage, retention, access, and security from the start.
- **Standard Protocols for Data Interfaces Were Limited**: Ensuring uniform data standards among a wide range of technologies and systems was a challenge. Many utilities used standard protocols to build data interfaces among software applications.

- **Extensive Equipment Testing and Customization May Be Required**: Automated devices typically need more frequent firmware and software upgrades than traditional utility equipment, requiring more frequent field tests and evaluations. Standard templates from vendors also typically require customization to meet each utility's unique distribution system configurations. Many found that lab conditions for testing field device communications did not always accurately represent field conditions.
- **DA Requires Increased Workforce Training and Expertise**: DA brings changes in grid operations that require increased training and expertise for field technicians, engineers, and grid operators, particularly in database management, data analytics, information systems, and cybersecurity.
- **Communications Systems Need Comprehensive Planning for Multiple Smart Grid Functions**: Many utilities attempted to realize synergies in their communications strategies by leveraging new systems for DA, AMI, and other smart grid applications. This requires comprehensive evaluation of communications requirements from the start of project planning.
- **Systems Integration is a Critical Element of DA Deployment**: Multiple information management and control systems all need access to new data streams to effectively accomplish DA functions. Systems integration proved to be one the most significant challenges during DA implementation under SGIG, particularly for those utilities deploying DA equipment for the first time. Integration often required developing customized software for data processing, error checking, and coding.
- **Cybersecurity and Interoperability Are Integral to Smart Grid**: Cybersecurity was a cornerstone of the SGIG program from its onset. Sound cybersecurity policies, plans, and practices were integrated throughout each project lifecycle, including design, procurement, installation, commissioning, and ongoing maintenance and support.

Future Directions and Next Steps

With the SGIG projects complete, the vast majority of SGIG DA utilities are expanding their smaller-scale DA deployments in a phased approach to upgrade more feeders and substations, focusing on poor performers or those that serve critical business needs for reliability. Several also plan to extract more value from existing deployments by upgrading communications capacity, activating unused DA functions embedded in existing devices and management systems, and installing new devices and systems on already automated feeders and substations.

DOE continues to support grid modernization through research, development, demonstration, analysis, and technology transfer activities. While the SGIG program is now complete, grid modernization remains an important national priority. DOE through the Grid Modernization Initiative (GMI) recently released a Grid Modernization Multi-Year Program Plan (MYPP) that describes the challenges and opportunities for achieving a modern, secure, sustainable, and reliable grid and how DOE will help achieve this through programs and activities. The Grid Modernization Lab Consortium, a multi-year collaboration among 14 DOE National Laboratories and regional networks, will enable DOE in developing and implementing the activities in the MYPP. [8]

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[8] DOE, Grid Modernization Initiative, *Grid Modernization Multi-Year Program Plan*, November 2015.

DA deployments highlighted several continuing challenges for grid modernization:

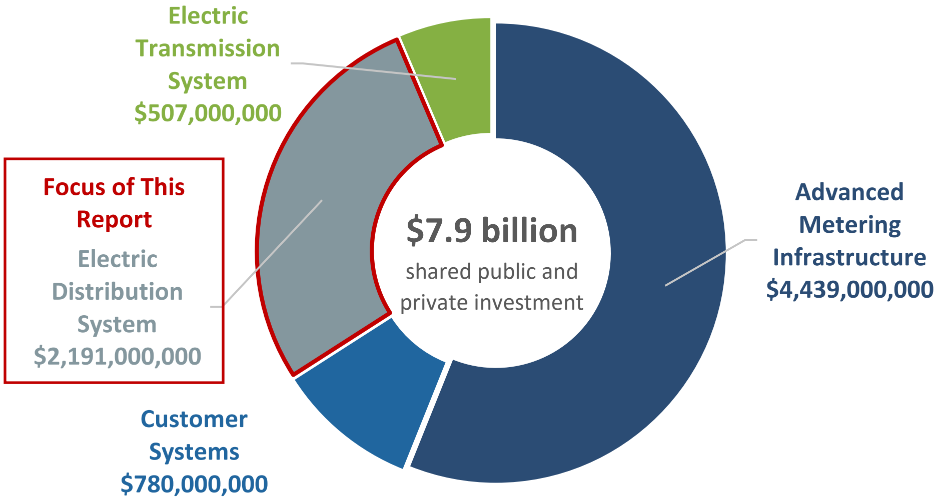
- Improved cybersecurity and interoperability standards, protocols, tools, and techniques for safe, rapid, and cost-effective DA implementation.
- Faster simulation methods and more robust control approaches to operate modern grid systems with large amounts of variable generation.
- High-resolution, low-cost sensors that report real-time conditions along feeders to enhance distribution system operator visibility beyond substation assets.
- Advanced DERMS for integrating distributed and demand-response resources in a coordinated and cost-effective way.
- Advanced grid devices and power electronics, such as solid-state distribution transformers, offer enhanced functionality and flexibility to increase total system efficiency and manage microgrids.
- Lower cost and safer energy storage systems for improved DER integration and distribution system management.

1 Distribution Automation Deployment in the Smart Grid Investment Grants

In 2009, the U.S. Department of Energy (DOE) launched the Smart Grid Investment Grant (SGIG) program—funded with $3.4 billion dollars from the American Recovery and Reinvestment Act (ARRA) of 2009—to jumpstart modernization of the nation's electricity system, strengthen cybersecurity, improve interoperability, and collect an unprecedented level of data on smart grid and customer operations. When matched with an additional $4.5 billion in industry investment, the 99 SGIG projects invested a total of $7.9 billion in new smart grid technology and equipment for transmission, distribution, metering, and customer systems (see Figure 1).

The large public and private investments made under ARRA have accelerated smart grid technology deployments, providing real-world data on technology costs and benefits along with valuable lessons learned and best practices. This report informs electric utilities, policymakers, and other key stakeholders of the qualitative and quantitative impacts, benefits, costs, and lessons learned from SGIG projects that implemented distribution automation (DA). Most SGIG projects began in 2009 and concluded in 2015, making this the final report on DA results from the SGIG program.

Figure 1. Breakdown of $7.9 Billion SGIG Investment



DA investments in the electric distribution system totaled about $2.19 billion—including Recovery Act funds from DOE and cost share from the utilities—accounting for 27 percent of the total SGIG investment. Of the 99 total SGIG recipients, 62 utilities installed and evaluated one or more DA technologies and systems, and reported key results to DOE. (Many of these 62 DA projects also installed new advanced metering infrastructure [AMI] or customer-based technologies and systems. Project results specific to those technologies are reported separately in *Advanced Metering Infrastructure and Customer Systems: Results from the SGIG Program*. Separate SGIG projects that tested transmission system technologies reported results in *Advancement of Synchrophasor Technology in Projects Funded by the American Recovery and Reinvestment Act of 2009*.)

SGIG project funds were used for several purposes: the purchase, testing, and installation of hardware and software; conducting training; implementing cybersecurity protections; systems integration activities; data collection and analysis; and other technical and administrative tasks needed for successful completion of project objectives.

Full descriptions and results of all projects can be found on SmartGrid.gov. This report highlights select projects that exemplify the wide range of results and lessons learned from the SGIG DA projects.

1.1 DA Technologies and Functions Deployed in SGIG

DA applies advanced control and communication technologies and integrates digital controls, switches, and sensors to improve or automate electricity delivery functions that were previously either not possible or were performed using electro-mechanical or manual processes. DA can improve the speed, cost, and accuracy of several key distribution system processes, including fault detection, feeder switching, and outage management; voltage monitoring and control; reactive power management; preventative equipment maintenance for critical substation and feeder line equipment; and grid integration of distributed energy resources (DER). Table 1 describes the four key DA applications and the specific smart grid functions that SGIG utilities tested during the projects.

Table 1. SGIG Smart Grid Applications and Functions under DA Projects

DA Application	Specific Smart Grid Functions
Reliability and Outage Management	• Remote fault location and diagnostics • Automated feeder switching • Outage status monitoring and notification • Optimized restoration dispatch
Voltage and Reactive Power Management	• Integrated voltage and volt–ampere reactive (VAR) controls (IVVC) • Automated voltage regulation • Conservation voltage reduction (CVR) • Real-time load balancing • Automated power factor corrections
Asset Health Management	• Real-time or near real-time equipment health monitoring
Distributed Energy Resources (DER) Integration	• Integrated and automated DER dispatching and management • Operation of customer-sited thermal energy storage systems

Achieving these functions required the deployment of advanced field devices, including remote fault indicators, smart relays, automated feeder switches, feeder and transformer monitors, automated capacitors, and automated voltage regulators. These devices can work autonomously or be monitored and controlled via communications networks linked to back-office information management and control systems (Figure 2[9]). Optimizing the control and performance of DA operations relies heavily on robust communication systems to transmit large volumes of data, and effective systems integration to analyze data and provide actionable information for grid operators.

Figure 2. Illustration of a Distribution Automation System

To implement DA, advanced field devices are typically equipped with radio, wireless, or cellular communication to transmit data to collection points and ultimately back to utility control centers using backhaul communications networks. At the control center, the data is typically integrated into the supervisory control and data acquisition (SCADA) system, distribution management system (DMS), and outage management system (OMS) for processing, analysis, and action, either automatically or by operators. Table 2 outlines the nearly 82,000 DA field devices installed under SGIG.

Table 2. DA Asset Deployments under SGIG Projects

DA Asset	Total # Devices Installed	# of SGIG Utilities Deploying	Range of Installments by SGIG Utilities (Least to Most)
Remote Fault Indicators	13,423	17	3 – 4,755
Smart Relays	11,033	27	4 – 4,755
Automated Feeder Switches	9,107	39	2 – 2,193
Automated Capacitors	13,037	30	2 – 2,098
Automated Voltage Regulators	10,665	21	2 – 3,339
Transformer Monitors	20,263	8	2 – 17,401
Automated Feeder Monitors	4,447	19	2 – 1,583

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[9] Robert Uluski, "Developing a Business Case for Distribution Automation," *Electric Light & Power*, June 10, 2013.

Investor-owned utilities, municipal and public power utilities, and electric cooperatives all conducted and reported on SGIG DA projects. Most of the projects focused on testing only select applications, and thus each project installed a different combination of assets and conducted systems integration in different ways. Table 3 shows which devices and systems support each DA applications.

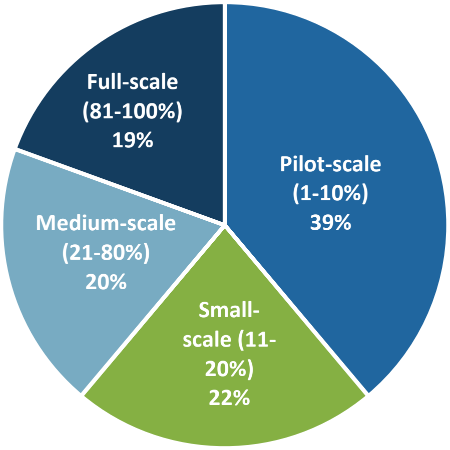
Table 3. Devices and Systems that Support DA Applications

DA Technologies and Systems		**DA Applications**			
		Reliability and Outage Management	Voltage and Reactive Power Management	Equipment Health Condition Monitoring	DER Integration
Devices	Remote Fault Indicators	●	●		
	Smart Relays	●			
	Automated Feeder Switches (or Reclosers)	●	●		
	Automated Capacitors		●		●
	Automated Voltage Regulators		●		●
	Automated Feeder Monitors	●	●	●	●
	Transformer Monitors			●	
Systems Integration	Communications and Backhaul Systems	●	●	●	●
	SCADA Systems	●	●		
	DMS	●	●	●	●
	Integration with AMI/Smart Meters	●	●	●	●
	OMS, GIS, CIS, Workforce Management Integration	●			

The majority of SGIG DA utilities were primarily interested in integration tests, technology performance evaluation, and cost-benefit analysis before committing to expanded DA deployments. Each utility deployed DA assets at a different scale to achieve distinct evaluation objectives. For example, one project deployed just 2 transformer monitors, while another deployed more than 17,000 (or about 86 percent of total installed by all SGIG projects). About 61 percent of the reporting utilities implemented DA at either a small scale (covering less than 20 percent of feeders) or pilot scale (covering less than 10 percent of feeders).

Just under 20 percent of reporting utilities implemented system-wide deployment of DA assets (covering more than 80 percent of feeders). For the most part, these utilities had previous experience with DA technologies and systems. Figure 3 shows the percentage of SGIG DA utilities that deployed DA assets at each scale.

Figure 3. Extent of SGIG DA Asset Deployments by Percent of Utility System (36 Projects Reporting)



Distribution Automation Field Devices[10]

Remote Fault Indicators

Remote fault indicators are sensors that detect when voltage and current levels on feeders are outside normal operating boundaries. Operators can use this information to rapidly determine the location of a fault (such as an equipment failure or tree contacting a power line), or distinguish between a fault and temporary high loads, such as high motor starting current. Fault indicators can be equipped with visual displays to assist field crews, and connected to communications networks that are integrated with SCADA, OMS or DMS to provide greater accuracy in locating and identifying faults.

Smart Relays

Smart relays apply sophisticated software to accurately detect, isolate, and diagnose the cause of faults. They may be installed in utility substations for feeder protection or on devices in automated switching schemes. Device controls are activated according to equipment settings and algorithms. The relays also store and process data to send back to grid operators and back office systems for further analysis. Recent advances in sensor and relay technologies have improved the detection of high-impedance faults—difficult to detect with conventional relays—that occur when energized power lines contact a foreign object, but such contact only produces a low-fault current.

Automated Feeder Switches and Reclosers

Automated feeder switches open and close to isolate faults and reconfigure faulted segments of the distribution feeder to restore power to customers on line segments without a fault. They are typically configured to work with smart relays to operate in response to control commands from autonomous control packages, distribution management systems, or signals from grid operators.

Switches can also be configured to open and close at predetermined sequences and intervals when fault currents are detected. This action, known as reclosing, is used to interrupt power flow to a feeder that has been impacted by an obstruction and reenergize after the obstruction has cleared itself from the line. Reclosing reduces the likelihood of sustained outages when trees and other objects temporarily contact power lines during storms and high winds.

[10] For additional descriptions of devices, communications networks, and information management systems, see DOE, *Reliability Improvements from the Application of Distribution Automation Technologies – Initial Results*, November 2012.

Automated Capacitors

Utilities use capacitors to compensate for reactive power requirements caused by inductive loads from customer equipment, transformers, or overhead lines. Compensating for reactive power reduces the total amount of power that need to be provided by power plants, resulting in a flatter voltage profile along the feeder, and less energy wasted from electrical losses in the feeder. A distribution capacitor bank consists of a group of capacitors connected together. The capacity of the banks installed on distribution feeders depends on the number of capacitors, and typically ranges from 300 to 1,800 kilovolt-ampere reactive (kVAR). Capacitor banks are mounted on substation structures, distribution poles, or “pad-mounted” in enclosures.

Automated Voltage Regulators and Load Tap Changers

Voltage regulators are types of transformers that make small adjustments to voltage levels in response to changes in load. They are installed in substations (where they are called load tap changers) and along distribution feeders to regulate downstream voltage. Voltage regulators have multiple “raise” and “lower” positions and can automatically adjust according to feeder configurations, loads, and device settings. For example, as load on distribution feeders increases, the amount of voltage drop along those feeders also increases. A voltage regulator on the feeder detects when voltages are above or below target levels and then automatically adjust voltages to stay within the desired range.

Automated Feeder Monitors

Feeder monitors measure load on distribution lines and equipment and can trigger alarms when equipment or line loadings reach potentially damaging levels. Monitors deliver data in near-real time to back office systems and analysis tools so that grid operators can effectively assess loading trends and take corrective switching actions, such as taking equipment offline, transferring load, or repairing equipment when necessary. These field devices are used in coordination with information and control systems to prevent outages from occurring due to equipment failure or overload conditions.

Transformer Monitors

Transformer monitors are equipment health sensors for measuring parameters, such as power transformer insulation oil temperatures, that can reveal possibilities for abnormal operating conditions and premature failures. These devices can be configured to measure different parameters on many types of devices. Typically, these devices are applied on substation transformers and other equipment whose failure would result in significant reliability and cost impacts for utilities and customers.

Communications Networks

Many SGIG utilities expanded the communications networks for distribution systems to acquire large volumes of new data from sensors, process the data, and send control signals with low-latency to operate equipment. Communications networks allow utilities to connect devices to each other and to SCADA, DMS, and other information and control systems, which greatly expands the capabilities of grid operators to manage power flows and address reliability issues.

SGIG utilities leveraged a variety of wired and wireless communications technologies to support their smart grid application. Choosing the most suitable communication technologies and configurations required utilities to examine multiple requirements, considering all current and future smart technologies that may use the networks:

- Bandwidth
- Latency
- Cost
- Reliability and coverage
- Spectrum availability[11]
- Backup power needs
- Cybersecurity considerations

Most utilities use at least two-layer communication systems to communicate between field devices and information and control systems. Typically, the first layer of the network connects substations and distribution management systems at headquarter locations. Some utilities use existing SCADA communications systems for this layer. Many SGIG utilities chose high-speed, fiber optic or microwave communications systems, while some chose to contract third-party telecommunication vendors for their high speed cellular network.

The second layer of the network typically connects substations with field devices, where most SGIG utilities did not have a legacy system to leverage. Many SGIG utilities chose some form of wireless network for this layer, including radio frequency mesh or Wi-Fi.

Information Management and Control Systems

DMS, OMS, SCADA, and AMI can all play critical roles in automating distribution system functions. Their effective integration is often key to successful DA efforts. For example, OMS and DMS are typically used to integrate various sources of fault information—from line sensors, reclosers, AMI, and customer calls—and display this data on geographic information system (GIS) and SCADA screens for both control room operators and field crews. With low-latency communications networks, this information can be updated in near real time.

DA projects ideally include field device integration with the DMS, which is typically used to monitor the system for feeder and equipment conditions that may contribute to faults and outages, identify faults, and determine optimal switching schemes to restore power to the greatest amount of load or number of customers. DMS deployments can involve varying degrees of sophistication, from data collection and monitoring to highly complex, automated systems capable of independently managing the operation of the distribution system. Greater levels of sophistication and centralized controls are typically associated with producing greater levels of smart grid capabilities.

DMS integrate data from sensors, monitors, and other field devices to assess conditions and control the grid. They act as visualization and decision support systems to assist grid operators with monitoring and controlling distribution systems, components, and power flows. DMS can be used to automate or support voltage and volt-ampere reactive (VAR) controls, as well as other activities that increase the

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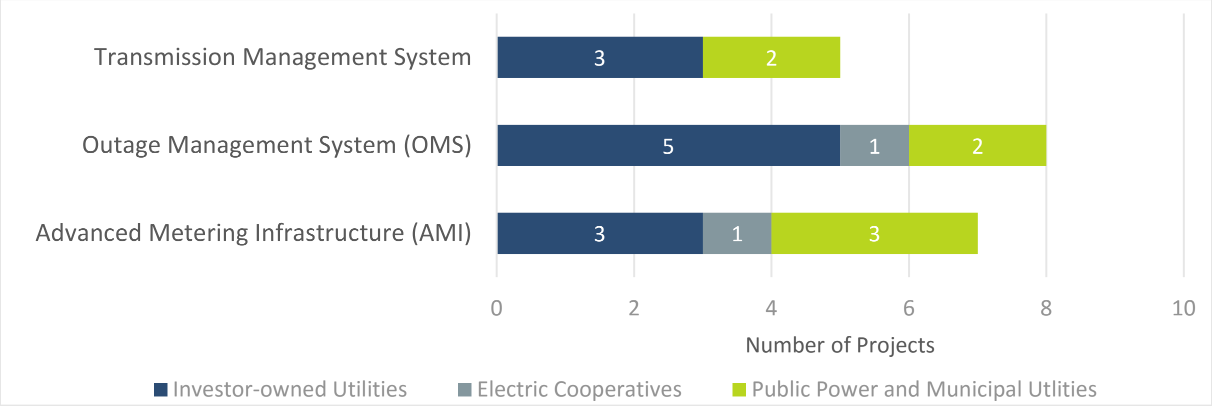
[11] The Federal Communications Commission (FCC) manages and licenses the electromagnetic spectrum for the communications of commercial users and state, county, and local governments, including commercial and non-commercial fixed and mobile wireless services, broadcast television and radio, satellite, and other services. Frequency bands are reserved for different uses. There is a finite amount of spectrum and a growing demand for it. See FCC, "About the Spectrum Dashboard."

efficiency of distribution operations and maintenance. A DMS continuously updates models of the distribution system in near real time so grid operators can better understand distribution system conditions at all times. Changes in system loads, outages, and maintenance issues are typically presented to operators through dashboards and visualization tools.

Fifteen of the SGIG DA utilities reported that they integrated their DMS with one or more additional information management or control systems (see Figure 4).

Figure 4. Number of SGIG DA Utilities that Integrated DMS with Other Types of Information Management and Control Systems (15 utilities reporting)



OMS are information management and visualization tools that analyze outage data and status of protective devices to determine the scope of outages and the likely location of problems. An OMS compiles information on the times and locations of customer calls, smart meter outage notifications, and fault data from monitoring and protective devices in substations and on feeder lines. Advanced OMS integrates smart meter data from AMI networks to improve detection of outage location and number of customer impacted. Currently, most OMS incorporate GIS to help repair crews get to outage locations more quickly, often with a better idea of the problem.[12] By filtering and analyzing outage information from multiple sources, modern OMS can provide grid operators and repair crews with more specific and actionable information to manage outages and restorations more precisely and cost-effectively.

Figure 5. A Visual Display from an Outage Management System

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[12] Typically, distribution system operators use information provided by the OMS to direct field crews to outage locations. Crews do not typically do this on their own unless they have mobile devices with links to the OMS. Several of the SGIG DA utilities found advantages from equipping field crews in this way and decentralizing aspects of service restoration activities.

1.2 Project Build and Impact Metrics

Each SGIG project collected and reported two types of metrics: 1) **build metrics**, including the number of installed devices, device functions, and their costs; and 2) **impact metrics** (e.g., fewer outages, reliability index improvements, reduced line losses, reduced electric demand) that assessed the effects of the new technologies and systems on grid operations and business practices. Appendix B includes a detailed review of the data collection and analysis process.

At the outset of the SGIG program, DOE collaborated with each of the project teams to develop a Metrics and Benefits Reporting Plan (MBRP) outlining how the utility would collect and report metrics over the course of the project. DOE analysis[13] of the DA projects involved the assessment of four key components (see Figure 6), along with lessons learned.

Figure 6. SGIG Analysis Process

- ***Assets*** (e.g., automated feeder switches)
- ***Functions*** (e.g., switches automatically open/close to reconfigure power flows)
- ***Impacts*** (e.g., fewer and shorter power outages)
- ***Benefits*** (e.g., lower economic losses from outages)

Because DA involves not only new technologies but also new business practices and procedures, DOE analysis also included assessment of lessons learned and best practices from the SGIG projects.

1.3 Key Data Limitations and Considerations

This report is designed to present a comprehensive review of DA technology impacts and benefits reported under the SGIG program. **Results on DA technology cost, performance, and savings were not directly comparable across *all* 62 DA projects for a number of reasons, including utility size and project scale, differences in the specific devices and functions deployed, pre-project technology maturity, and baseline data availability.** Several factors are important to consider when evaluating project data and results in this report:

- **SGIG DA utilities did not deploy every technology or function**, and therefore did not all report results for every data point. As a result, select charts and graphs are marked with notations such as “36 projects reported this data point.” In some cases, the most significant benefits represent experiences from a small number of projects. While several DA utilities deployed more than one DA asset or tested more than one application, almost all of the DA assets were deployed by 30 or fewer utilities. Similarly, a large percentage of certain DA devices were deployed by only a

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[13] The DOE analysis approach is further outlined in: Electric Power Research Institute (EPRI), *Guidebook for Cost/Benefit Analysis of Smart Grid Demonstration Projects*, Revision 1, December 2012.

handful of SGIG utilities**.** For exampl**e,** 78 percent of SGIG remote fault indicators were deployed by just 3 utilities.

- **As expected, large-scale technology deployments produced the most significant and meaningful impacts and benefits. The DA projects had a wide range of scale,** and directly comparing technology results across all projects at different scales was not meaningful; instead, the report includes aggregated results where possible and individual project results as examples. Some results were reported by only a small subset of utilities.
- **The SGIG DA utilities had differing levels of experience and expertise with DA** technologies and systems. Utilities that had steeper learning curves yielded limited impact data during time periods when they were first installing and operating the new technologies.
- **Individual project case studies are highlighted in this report, including certain project costs and benefits, to present a range of examples on the DA technology cost-benefit ratio**. Though all projects reported DA implementation costs, [14] costs varied greatly among projects and average DA implementation costs were not reliable metrics for several reasons:
  - Utilities did not uniformly measure and report total equipment costs. In reporting the total cost per device, many utilities included several different non-hardware costs—including software and licensing fees, hardware installation labor, IT testing and requirements gathering, project management, software integration, and staff training. These costs can vary greatly based on the utility's prior DA experience and existing technology platforms.
  - Small-scale deployments are not able to achieve the same economy of scale as large-scale deployments, given the fixed cost of new system implementation.
  - Costs may vary based on different capabilities or functionalities of individual devices.
  - Some utilities deployed wholly new equipment, whereas others may have been able to retrofit existing devices to operate in an automated fashion.
  - DA hardware and software was largely purchased by 2010, making it likely that cost data is not indicative of current or future equipment costs.
- **Some utilities had trouble establishing reliable historical baselines from which to measure improved performance.** Accurately measuring the impact of DA technologies required consistent measurement of historical performance—before the technologies were implemented. Several utilities underestimated the time, effort, and engineering expertise required to accurately measure smart grid impacts and historical baselines. Some utilities had difficulty measuring year-to-year performance changes attributable to SGIG deployments versus those resulting from routine feeder maintenance, storm damages, and changing customer demographics.

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[14] Information on how individual projects deployed funds and evaluated impacts can be found on the Project Information page at SmartGrid.gov.

2 Major Findings: Reliability and Outage Management

Improving grid reliability can reduce economic losses and customer inconveniences from sustained power interruptions, which are estimated to cost the economy almost $80 billion annually.[15] Table 4 summarizes select results from the 46 SGIG DA utilities that applied DA for reliability and outage management.

Table 4. Reliability and Outage Management Results from DA Investments

Primary Aim	• Fewer and shorter power disruptions for customers • Improved reliability performance, as measured by standard reliability indices (such as SAIFI and SAIDI)—which may be tied to utility performance standards			
Smart Grid Function	Remote fault location and diagnostics	Fault location, isolation, and service restoration (FLISR) and automated feeder switching	Outage status monitoring and customers notifications	Optimized restoration dispatch
Description	Without DA, utilities rely primarily on customer calls to identify outages. With DA, operators receive field telemetry from fault indicators, line monitors, and smart meters to rapidly pinpoint and diagnose issues.	FLISR operations quickly reconfigure the flow of electricity and can restore power to many customers who would otherwise have experienced sustained outages.	DA provides operators with comprehensive and real-time outage information, and alerts customers with more timely and accurate information about restoration.	By integrating distribution, outage management, and geographic information systems, utilities can precisely dispatch repair crews and accelerate restoration.
Key Impacts and Benefits	• Overall reduced customer minutes of interruption (CMI) • Shorter outage events with fewer affected customers • Lower or avoided restoration costs • Faster response, dispatch of repair crews, and prioritization of repairs	16 utilities reported reductions of about **146 million customer minutes of interruption** over three years For an outage event, FLISR operations showed: • Up to **45% reduction in number of customers interrupted** • Up to **51% reduction in customer minutes of interruption** About **270,000 fewer customers experienced sustained interruptions** (of >5 minutes) compared to estimated outcomes without FLISR One utility reported repair crews spent approximately 560 fewer hours annually assessing outages			

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[15] Lawrence Berkeley National Laboratory, Cost of Power Interruptions to Electricity Consumers in the United States, LBNL-58164, (LBNL, 2006).

2.1 Remote Fault Location, Isolation, and Service Restoration using Automated Feeder Switching

DA technologies provided advanced capabilities for operators to detect, locate, and diagnose faults. Remote fault indicators, relays, and reclosers provide access to real-time data on key feeders, which when delivered to a fully functional DMS, can help operators accurately determine causes and locations of faults and the extent of outages when they occur.

In addition, utilities with AMI can configure smart meters to generate "last gasp" signals when they lose power. Control room operators can also "ping" smart meters to confirm power outages or restoration status. Integrating AMI data with DMS, OMS, and GIS can thus help operators pinpoint and visualize outages, and deploy repair crews to precise fault locations. Several DA utilities also implemented AMI as part of their SGIG projects.[16]

Many SGIG utilities deployed DA technologies for more than simple fault indication. Fault location, isolation, and service restoration (FLISR) technologies and systems involve automated feeder switches and reclosers, line monitors, communication networks, DMS, OMS, SCADA systems, grid analytics, models, and data processing tools. These technologies work in tandem to automate power restoration by automatically isolating faults and restoring service to remaining customers by transferring them to adjacent feeders via tie lines. This can reduce the number of customers impacted by a fault and the length of an interruption.

FLISR systems can operate autonomously through a distributed or central control system (e.g., DMS), or can be set up to require manual validation by control room operators. Implementing autonomous, fully automated FLISR systems typically requires extensive validation and calibration processes to ensure effective and reliable operations. Automated FLISR actions typically take less than one minute, while manually validated FLISR actions can take five minutes or more.

Figure 7 presents simplified examples (A-D) to show how FLISR operations typically work. In Figure 7-A, the FLISR system locates the fault, typically using line sensors that monitor the flow of electricity and measures the magnitudes of fault currents, and communicates conditions to other devices and grid operators.

Once located, FLISR opens switches on both sides of the fault: one immediately upstream and closer to the source of power supply (Figure 7-B), and one downstream and further away (Figure 7-C). The fault is now successfully isolated from the rest of the feeder.

With the faulted portion of the feeder isolated, FLISR next closes the normally-open tie switches to neighboring feeder(s). This re-energizes portion(s) of the feeder without a fault and restores services to all customers served by these feeder sections from another substation/feeder (Figure 7-D). The fault isolation feature of the technology can help crews locate the trouble spots more quickly, resulting in shorter outage durations for the customers impacted by the faulted section.

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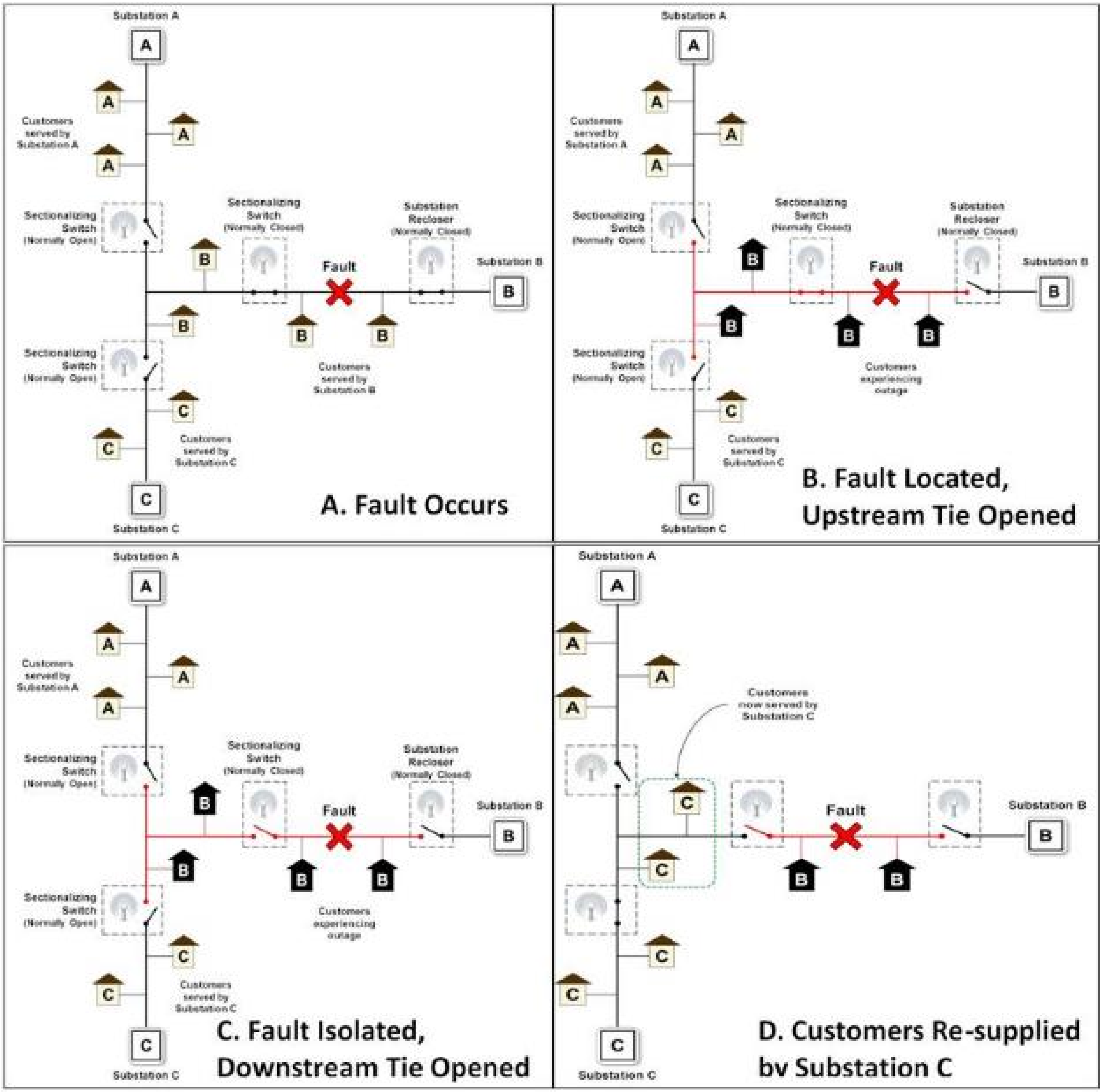
[16] SGIG results from AMI applications are presented separately in: DOE, *Advanced Metering Infrastructure and Customer Systems: Results from the Smart Grid Investment Grant Program*, 2016.

Figure 7. Illustration of FLISR Operations



Several SGIG utilities implemented FLISR in distinct ways. For example, Pepco's Automatic Sectionalizing & Restoration (ASR) schemes segment feeders into two, three, or four sections using closed remote-controlled switches or automatic circuit reclosers in the field. Duke Energy also installed "Self-Healing Teams" of field devices, which connect electronic reclosers and circuit breakers from two or three neighboring feeders and enable them to operate together in an integrated manner. See the case studies for detailed descriptions of how each utility designed and operated their FLISR functions.

→ See **Case Study:** Pepco (page 50)

→ See **Case Study:** Duke Energy (page 40)

Table 5 also summarizes some of the key FLISR activities within the SGIG program.[17]

Table 5. Overview of Five SGIG FLISR Utility Activities

	CenterPoint Energy	Duke Energy	Eversource	Pepco	Southern Company
Name of FLISR System	Self-Healing Grid	Self-Healing Teams	Auto Restoration Loops	Automatic Sectionalizing & Restoration	Self-Healing Networks
Field Devices Involved	Intelligent Grid Switching Devices act as switching devices and monitoring equipment	Electronic reclosers, circuit breakers, and line sensors	Telemetry communications, line sensors, and "smart" switches	Substation breakers, field switches, reclosers, and "smart" relays	Automated switches/ reclosers, and fault indicators
Mode of FLISR Operation	Manual validation required	Fully automated	Transitioned to full automation during the project	Fully automated	Fully automated
Location of FLISR Operations	Dedicated server; to be transitioned to DMS	Dedicated self-healing application	DMS	Dedicated server in the substation	Dedicated server or DMS

Key Result: Measurable Improvements in Reliability

DA implementation resulted in significant improvements in reliability indices for several SGIG utilities. Most utilities use reliability indices developed by the Institute of Electrical and Electronic Engineers (IEEE) to track performance and evaluate improvement needs. Table 6 provides a summary of the four primary reliability indices used by the electric power industry.

Table 6. IEEE Reliability Indices [18]

Reliability Index	Description	Equation
System Average Interruption Frequency Index (SAIFI)	The sum of the number of interrupted customers (N_i) for each power outage greater than five minutes during a given period, or **customers interrupted (CI)**, divided by the total number of customers served (N_T). This metric is expressed in the average number of outages per year. Major events are excluded.	$SAIFI = \frac{\sum N_i}{N_T} = \frac{CI}{N_T}$
System Average Interruption Duration Index (SAIDI)	The sum of the restoration time for each sustained interruption (r_i) multiplied by the number of customers interrupted (N_i), or **customer minutes interrupted (CMI)**, divided by the total number of customers served for the area (N_T). This metric is expressed in average minutes per year. Major events are excluded.	$SAIDI = \frac{\sum r_i N_i}{N_T} = \frac{CMI}{N_T}$

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[17] For more information, see: DOE, *Fault Location, Isolation, and Service Restoration Technologies Reduce Outage Impact and Duration*, (DOE, November 2014).

[18] IEEE, *Guide for Electric Power Distribution Reliability Indices*, IEEE Standard 1366-2012, (IEEE, 2012).

Reliability Index	Description	Equation
Customer Average Interruption Duration Index (CAIDI)	The sum of the restoration time for each sustained interruption (r_i) multiplied by the number of customers interrupted (N_i), or CMI, divided by the sum of the number of customers interrupted (N_i). This metric is commonly expressed in minutes per outage. Major events are excluded.	$CAIDI = \frac{\sum r_i N_i}{\sum N_i} = \frac{CMI}{\sum N_i}$
Momentary Average Interruption Frequency Index (MAIFI)	The sum of the number of momentary interruptions (IM_i) multiplied by the number of customers interrupted for each momentary interruption (N_{mi}) divided by the total number of customers served (N_T). This metric is expressed in momentary interruptions per year.	$MAIFI = \frac{\sum IM_i N_{mi}}{N_T}$

The best way to evaluate the impact of DA technologies on system reliability is to compare reliability indices before and after deployment using a well-established pre-deployment baseline. Unfortunately, many SGIG utilities had trouble establishing accurate, reliable pre-deployment baselines from which to measure performance improvements. It is recognized that the process of developing a baseline is complex and time consuming for utilities. Simply comparing reliability indices from year to year—rather than against a baseline—cannot effectively measure the full impact of DA investments.[19]

Utilities that **did** compare results against pre-deployment baselines reported significant reliability improvements with DA. In 2013 alone, three utilities reported SAIFI improvements of 17 percent to 58 percent compared to pre-deployment baselines (see Figure 8). [20] SAIFI is the primary metric used to track the frequency of outages.

The impact of DA on reliability depends on the system design and its potential for improvement. Utilities that applied DA technologies to the worst feeders first saw a larger relative impact than utilities who applied DA to feeders with less room for improvement.

PPL Electric Utilities Corporation estimated a 58 percent decrease in the average number of interruptions experienced by customers in 2013, and a 55 percent drop in the average number of customer minutes interrupted. Based on these results, PPL estimates a 25 percent improvement in reliability over the subsequent five years through the continued deployment of DA.

Duke Energy also reported experiencing a 17 percent improvement in SAIFI 2013 from DA operations in Ohio, while the Northern Virginia Electric Cooperative (NOVEC) compared 2011-2013 data from 41 feeders with pre-deployment five-year benchmarks and showed improvements across all major reliability indices.

→ See **Case Study:** PPL Electric Utilities Corporation (page 48)

→ See **Case Study:** Northern Virginia Electric Cooperative (page 34)

→ See **Case Study**: Duke Energy (page 40)

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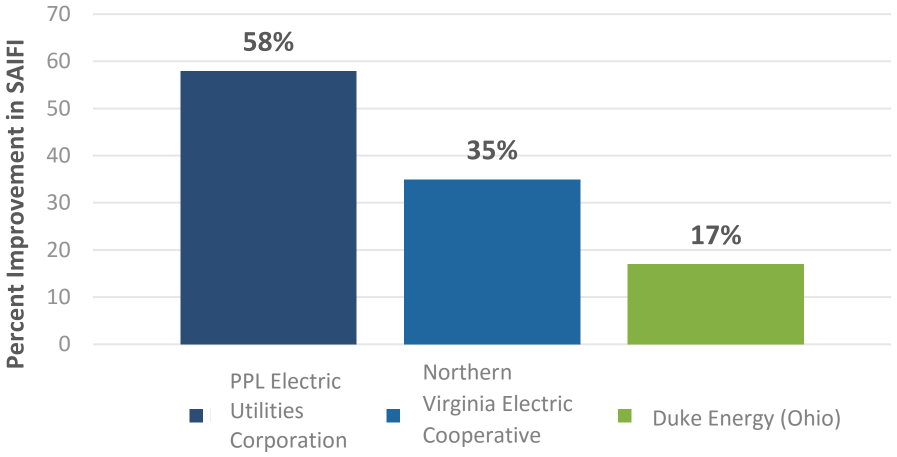
[19] For example, Appendix D shows SAIFI, SAIDI, CAIDI, and MAIFI comparisons from summer 2013 to summer 2014 for several utilities implementing DA. The data demonstrates that many utilities experienced reliability improvements year over year with DA, while others saw *decreased* reliability after DA deployments. Without well-documented pre-deployment baselines for comparison, changing weather from year to year (e.g., more/fewer storms) or changing system configurations can obscure the true reliability impact of DA technologies.

[20] Baselines are not always explicitly stated.

Figure 8. Percentage Improvements in SAIFI in 2013 Compared to Pre-Deployment Baselines



Several other utilities also reported improvements in their major reliability indices:

- The Electric Power Board (EPB) of Chattanooga, TN reported a 30 percent reduction in SAIFI and a 20 percent reduction in SAIDI from 2011 to 2014.
- Between April 2013 and September 2014, the Sacramento Municipal Utility District (SMUD) achieved reductions of 28 percent in SAIDI and 19 percent in SAIFI.

→ See **Case Study:** Electric Power Board (page 36)

→ See **Case Study:** Sacramento Municipal Utility District (page 67)

Key Result: Reduced Impact, Duration, and Cost of Major Storms and Outage Events

CMI is the restoration time for each sustained interruption multiplied by the number of customers interrupted during that outage, making it a valuable metric for assessing customer impacts from DA operations (see Table 6 in previous section for a detailed definition).

Over one year, FLISR operations during certain feeder outages *reduced by half* the number of affected customers and total customer minutes of interruption, according to data from five utilities. Five utilities (representing 10 operating companies) applied similar FLISR operations during 266 events between April 2013 and March 2014.[21] FLISR operations applied to either: (1) full-feeder outages where the fault is upstream of a sectionalizing switch (and thus interrupts service to all customers on a feeder), or (2) partial-feeder outages where the fault is downstream of a sectionalizing switch (and thus interrupts service to a portion of customers on a feeder). Figure 9 shows substantial reductions in the number of CI and CMI for both types of outages. Table 7 provides supporting data.

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[21] U.S. Department of Energy, *Fault Location, Isolation, and Service Restoration Technologies Reduce Outage Impact and Duration*, November 2014.

Figure 9. FLISR Effects on the Number of Customers Interrupted (CI) and Customer Minutes of Interruption (CMI) by Type of Outage

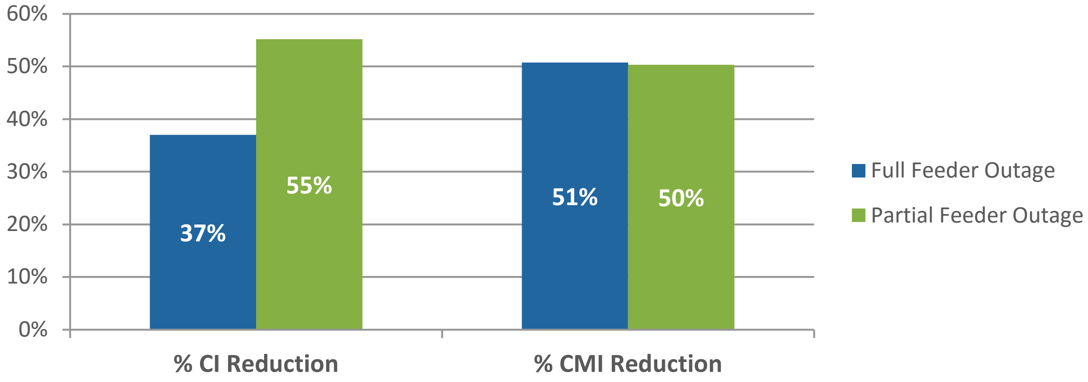

Table 7. Effects of FLISR Operations on CI and CMI by Type of Outage

Type of Outage	Total Estimated CI *without* SGIG technologies	Total Actual CI *with* SGIG technologies	**% Reduction of CI**	Total Estimated CMI ***without*** SGIG technologies	Total Actual CMI ***with*** SGIG technologies	**% Reduction of CMI**
Full Feeder Outage	255,424	160,972	**37%**	18,301,994	9,016,784	**51%**
Partial Feeder Outage	206,763	92,726	**55%**	17,470,615	8,676,751	**50%**

The same SGIG utilities found that fully automated switching and validation typically resulted in greater CI and CMI reductions than operator-initiated remote switching with manual validation. Figure 10 shows the percent reduction in CI and CMI by type of FLISR operating scheme for the same 266 FLISR events as above. Table 8 provides supporting data.

Figure 10. FLISR Effects on the Number of Customers Interrupted (CI) and Customer Minutes of Interruption (CMI) by Type of FLISR Operating Scheme

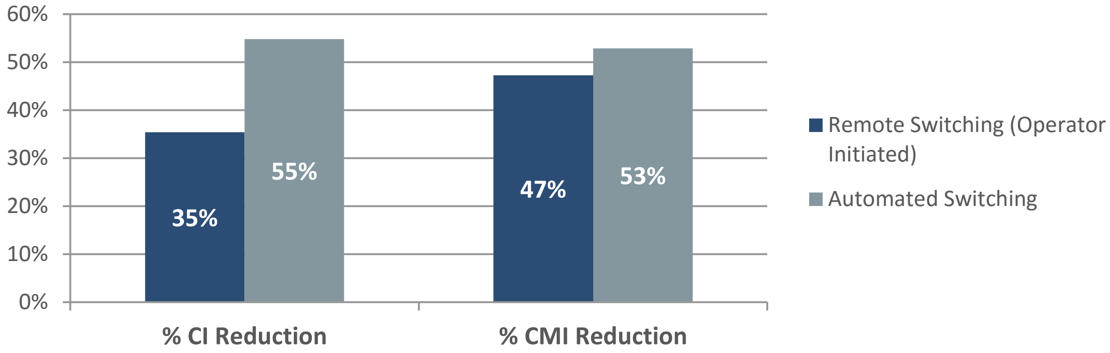

Table 8. Effects of FLISR Operations on CI and CMI by Type of FLISR Operating Scheme

Type of Switching	Total Estimated CI ***without*** SGIG technologies	Total Actual CI ***with*** SGIG technologies	**% Reduction of CI**	Total Estimated CMI ***without*** SGIG technologies	Total Actual CMI ***with*** SGIG technologies	**% Reduction of CMI**
Operator-Initiated	230,388	148,917	**35%**	15,037,440	7,926,425	**47%**
Fully Automated	231,799	104,781	**55%**	20,735,169	9,767,110	**53%**

Table 9 shows the potential magnitude of CMI impacts from DA operations over several months or years for 15 SGIG DA utilities. Due to data constraints, the period of data collection and reporting is not identical for all utilities; some reported data for only one month or one year, while others collected data for multiple years. The benefits of the technology likely continued well beyond these reporting periods.

Table 9. CMI Avoided by DA Operations

Seq. #	Utility	CMI Avoided	Period of Data Collection
1	Indianapolis Power & Light (IPL)	1,541,049	10/2013 – 09/2014
2	Eversource (formerly NSTAR)	18,831,841	10/2012 – 03/2015
3	Pepco—Washington, DC	1,813,656	04/2013 – 03/2015
4	Pepco—MD	4,914,654	04/2013 – 03/2015
5	Southern Company	17,194,770	04/2013 – 09/2014
6	Duke Energy Business Services	8,971,792	04/2013 – 03/2015
7	CenterPoint Energy	14,488,820	04/2013 – 09/2014
8	Electric Power Board (EPB)	42,848,905	10/2013 – 03/2014
9	Avista Utilities	35,609	08/2013
10	Atlantic City Electric	50,011	10/2013 – 03/2014
11	Duke Energy (formerly Progress Energy)	28,688,810	01/2012 – 08/2013
12	Sacramento Municipal Utility District (SMUD)	705,510	04/2013 – 09/2014
13	City of Leesburg	125,694	09/2014
14	PPL Electric Utilities Corporation	2,400,000	10/2012 – 09/2013
15	Burbank Water and Power (BWP)	4,411,791	07/2010 – 08/2014
	Total	**147,962,153**	

Several SGIG utilities experienced major storms or events during their project period and used DA technologies to significantly reduce restoration time and limit the number of customers affected. Fewer and shorter outages help customers avoid economic losses, inconveniences, and public health and safety risks. Individual case studies contain detailed descriptions of the following examples:

- FLISR and smart meters at EPB resulted in 36 million fewer CMI during a July 2012 derecho and helped operators restore system-wide power about 17 hours earlier than without DA. After another storm in February 2014, EPB was able to restore power 36 hours faster and reduce affected customers from 70,000 down to 33,000.
- When a garbage truck hit a power pole and caused almost 900 customers to lose power at Avista Utilities, FLISR restored more than 800 customers instantaneously, and the remainder within minutes.
- Florida Power and Light (FPL) saw about 9,000 fewer customer interruptions due to FLISR operations during Tropical Storm Isaac in 2012.

Many utilities use value-of-service studies, which involve statistical analyses of economic damages and willingness-to-pay by customers for more reliable electric service in order to estimate the monetary value of the benefits from reliability improvements. DOE developed the Interruption Cost Estimate (ICE) calculator, which is based on meta-analysis of utility value-of-service studies, as a tool for utilities to estimate economic benefits from investments in reliability improvements.[22] **At least three utilities were able to estimate their customers' savings as a result of DA operations during a major storm**:

→ See **Case Study:** Consolidated Edison (page 44)

→ See **Case Study:** Glendale Water and Power (page 81)

- Consolidated Edison used the ICE calculator to estimate more than $1.2 million in avoided interruption costs—largely benefitting industrial and commercial customers—for a 14-feeder system for a single year.
- Central Maine Power used the ICE calculator to estimate that SGIG DA investments in substation and line reclosers saved customers an average of $18,000 per outage involving line reclosers, and $29,000 per outage when the outage took out a substation. This utility estimated total customer savings of more than $935,000 in 2014, and expects avoided economic losses to total more than $20.7 million through 2020.[23]
- Glendale Water and Power (GWP) estimated the net present value of DA investments would increase by 42 percent if customer savings were included in the analysis.

A lack of standard metrics across utilities to measure storm response makes it difficult to compare benefits from investments in FLISR and automated feeder switching in a consistent manner across utilities. Outages occur in different seasons, at different times of day, or on different days of the week—all of which can affect how much an outage will cost utilities and customers, along with the estimated savings. Utilities that experience increased storm events in one year may realize greater overall benefits from DA technologies than other utilities that do not.

In addition, because weather events are random, predicting future storm impacts and benefits for inclusion in forward-looking business cases can be difficult. For example, the February 2014 snowstorm that affected the Electric Power Board (EPB) occurred on a weekend. Had the storm arrived on a weekday, there would have been lower overtime costs and the savings from fewer truck rolls would have been lower. Thus, the savings for improvements in outage management can be hard to estimate before the investments take place, as assumptions about weather events and other factors can turn out to be inaccurate. As a result, business cases need to contain contingencies that reflect uncertainties in the weather, timing, and other factors. To build a business case, it is important for utilities to collect data, no matter what metrics are used, to document impacts and benefits and provide information decision makers can use for business case analysis.

Key Result: Operations and Maintenance Efficiency and Savings

SGIG utilities reduced O&M costs by automating functions that previously required field crews to conduct on-site monitoring, maintenance, and repair functions. Reductions in labor costs, truck rolls, vehicle-miles traveled, and replacement parts can accrue to significant savings for operators. The SGIG DA utilities reported four major sources of labor cost savings in outage management:

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[22] Lawrence Berkeley National Laboratory, "Interruption Cost Estimate Calculator," 2015.

[23] Based on an estimate that the value of an average outage hour for an average customer (covering residential, commercial, and industrial customer classes) to be about $97 for 2014-2019.

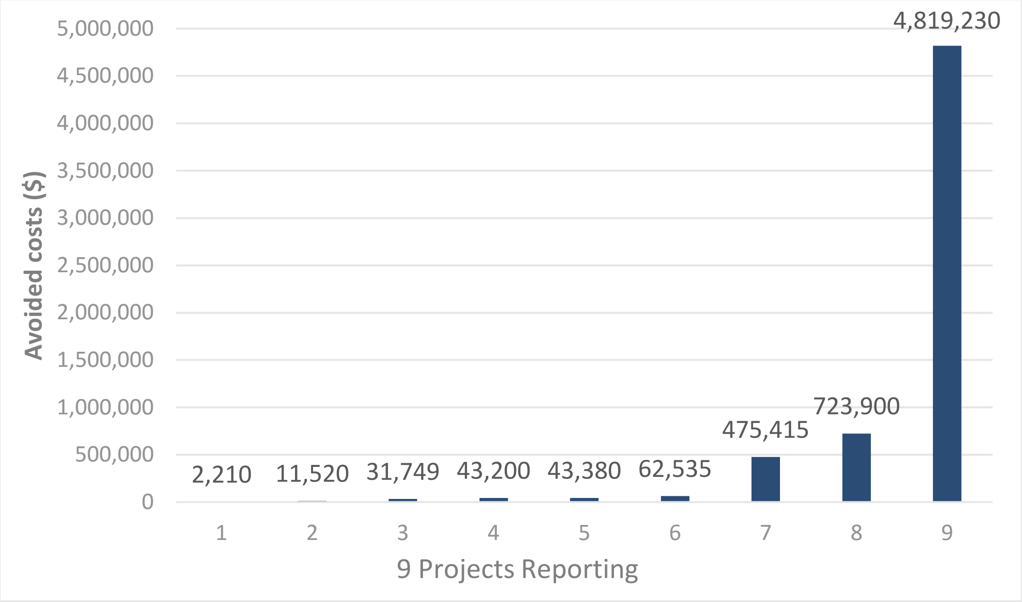
Exhibit__(SAMIP-3)

- Pre-empting and avoiding outages before they occur
- Proactively identifying outages during work hours, rather than waiting for customer calls (which typically come during nights and weekends)
- Optimizing truck rolls during an outage
- Correcting nested outages along with primary outages instead of coming back to them later

Utilities generally do not apply consistent metrics and tools to measure and compare the benefits from investments in reliability and outage management.

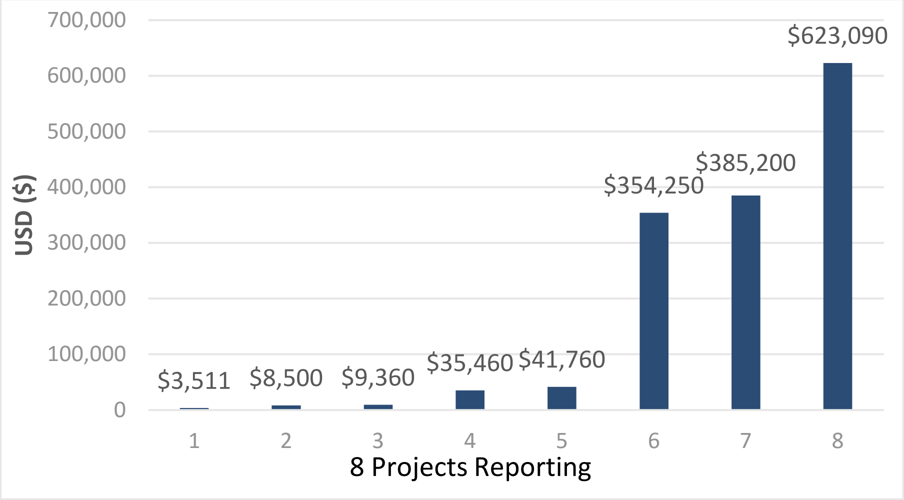
Nine SGIG DA utilities saved more than $6.2 million in total avoided distribution operations costs from April 2013 to September 2014 (see Figure 11). The utility that produced most of the benefits is one that implemented system-wide DA deployment.

Figure 11. Avoided Distribution Operations Costs for SGIG DA Utilities, April 2011 to September 2014 (9 Projects Reporting)



Savings from avoided switching costs totaled more than $1.46 million for eight SGIG DA utilities that reported savings from April 2011 to March 2014 (see Figure 12). Automated feeder switching reduces O&M costs by requiring fewer truck rolls and fewer instances where repairs crews are sent to accomplish feeder switching functions manually.

Figure 12. Avoided Switching Costs for SGIG DA Utilities, April 2011 – March 2014 (8 Projects Reporting)



There are several examples of SGIG DA utilities reducing labor resource requirements and service restoration costs, including the following:

- NOVEC's savings from DA operations were about $1,500 in avoided fuel and about $133,000 in labor savings from summer 2011-summer 2014.
- EPB reported saving about $1.4 million in avoided overtime costs following DA operations after a snowstorm in February 2014.
- Duke Energy (formerly Progress Energy) reduced its annual outage assessment activities by 20% (more than 500 hours).

Using an automated or remote-controlled approach to fault restoration and equipment health monitoring can resolve or prevent outages, ultimately reducing the labor hours of field crew and truck fleet vehicle miles. By identifying where on the grid a fault has occurred, DA also enables repair crews to be dispatched to precise locations for repair and restoration service activities. Reduced customer service labor hours also result from improvements in outage monitoring and notification. A more reliable estimated time of restoration (ETR) and more proactive customer outage notifications reduces call volume during outage events, thereby reducing labor hours for call center staff.[24]

In total, from April 2011 to March 2015, 16 reporting SGIG DA utilities avoided more than 197,000 truck rolls and 18 reporting DA utilities avoided more than 3.4 million vehicle-miles traveled as a result of various types of DA operations (see Figure 13 and Figure 14). The utilities in the two figures with the highest levels of O&M savings were the ones that pursued full-scale implementation of DA (i.e., #16 for truck rolls, and #17 and #18 for vehicle-miles traveled). The lowest savings per utility was 52 truck rolls and the highest per utility was 123,070. The lowest savings per utility was 86 avoided vehicle-miles and the highest was 1,705,601.

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[24] Because these types of savings cross-cut all four DA applications discussed in this report, it is not possible to attribute the savings to reliability and outage management alone. The SGIG utilities were not required to report O&M impacts specific to these categories, as doing so would have been cost prohibitive.

Figure 13. Total Avoided Truck Rolls by 16 SGIG DA Utilities, April 2011 – March 2015

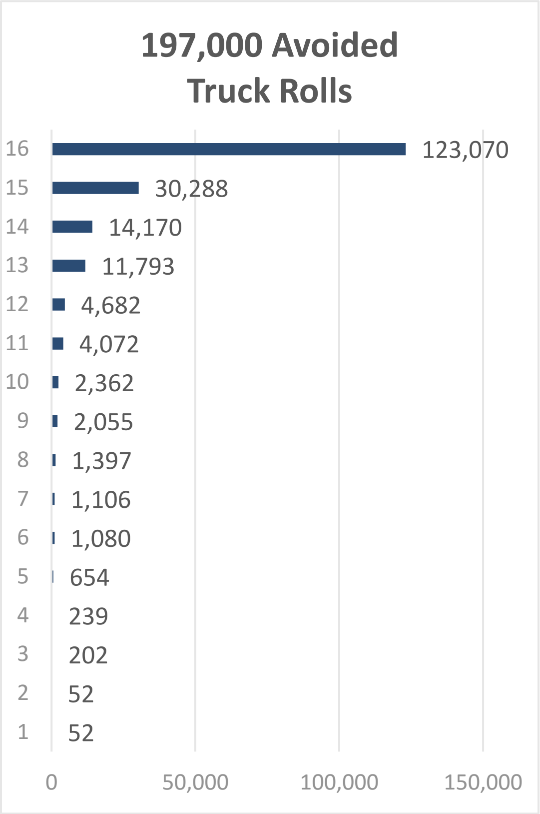
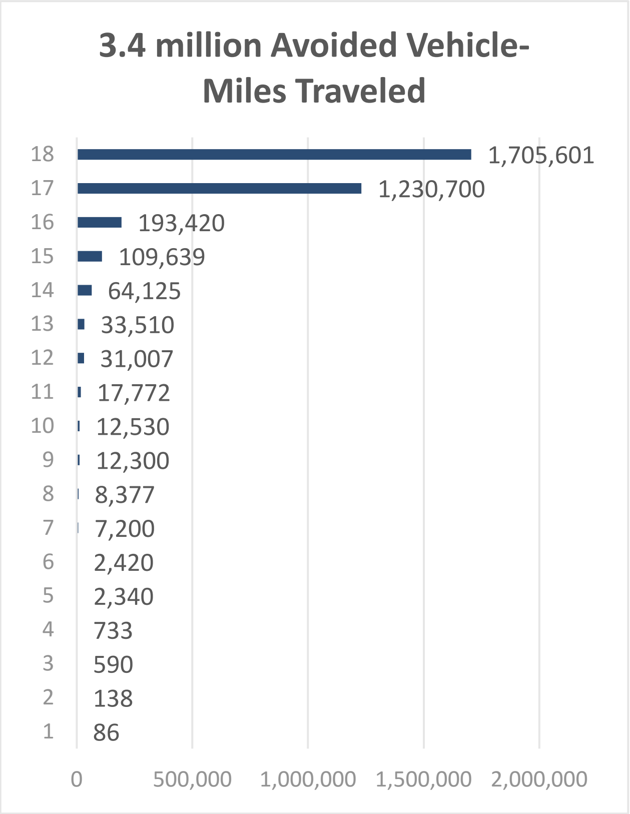


Figure 14. Total Avoided Vehicle-Miles Traveled by 18 SGIG DA Utilities, April 2011 – March 2015



Based on analysis of truck roll data from 18 SGIG DA utilities between April 2011 and March 2015, **it is estimated that DA operations resulted in reductions of about 2,350 metric tons of carbon dioxide-equivalent**, which equals the amount of carbon dioxide released from consuming about 264,000 gallons of gasoline.[25]

2.2 Outage Status Monitoring and Notification

Integrating information from monitoring devices and AMI with OMS and GIS enables utilities to provide customers with more accurate and timely information about the status of outages and restoration services. Automated features lower utility costs and customers benefit from better information about when services will be restored following outages.

Many utilities leverage smart meters and AMI to implement this functionality. Utilities set up automated processes for pinging meters over large areas when large outages are reported, and then target affected feeders and neighborhoods as service restoration activities progress. This saves valuable time in the minutes following an outage so operators do not have to undertake manual meter pings. Some utilities turn off the automated last gasp notifications in the initial phase of storm response, when emphasis is on restoring substations and transformers and a barrage of meter notifications can overwhelm OMS

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[25] U.S. Environmental Protection Agency, "Greenhouse Gas Equivalencies Calculator," last updated April 2014; Argonne National Laboratory (ANL), *GREET Model*, (ANL Systems Assessment Laboratory, 2015).

screens if the system is configured in that fashion. In these cases, meter notifications get turned back on once outages have been located and restoration activities are underway.

Utilities with other monitoring devices such as line monitors, fault indicators, and relays integrate information from these with smart meter data and OMS operations. The next task involves communicating with customers about the status of outage restoration activities. Notifications involve multiple channels including phone and text messages, email alerts, and website posts, sometimes including the estimated time to restoration of services. Glendale Water and Power's interactive voice response (IVR) software and Burbank Water and Power's OMS system that supports customer call-backs and notifications are two examples. Additional examples of customer notification are reported in *Advanced Metering Infrastructure and Customer Systems: Results from the SGIG Program*.

Key Result: Improved Customer Satisfaction and Public Awareness

Customer notifications and estimated restoration times help improve public awareness and planning, reduce the burden on customers to report outages, and increased customer satisfaction. CenterPoint Energy's Power Alert Service updated customers on restoration progress, and earned an 85 percent overall satisfaction rating.

When Hurricane Isaac hit Mississippi in 2012, Magnolia Electric Power Association (MEPA), a member of South Mississippi Electric Power Association (SMEPA), was required to give the Mississippi Emergency Management Agency updates three times a day on the status of outages and restoration efforts by county. With 5-second updates on SCADA data from system relays and monitors, and 15-second smart meter updates, MEPA was able to provide the requested outage reports relatively easily. Previously, during Hurricane Katrina in 2005, it took MEPA several hours to provide this information.

2.3 Optimized Restoration Dispatch

The availability of timely, accurate, and more comprehensive information about outages and the ability to process that data and deliver it to grid operators and repair crews accelerates restoration times and lowers costs, which benefits both utilities and customers. A key tool for supporting this smart grid-enabled function involves integration of OMS operations with workforce management systems (WMS). WMS is used to help field crews with software tools for automated scheduling, resource optimization, dynamic routing, and workflow management. WMS can set priorities for restoration tasks based on multiple criteria for level of importance and supports crew management, by tracking crew sizes, locations, and performance in restoring services.

Another way DA enables optimized crew dispatch is by enabling hot line tags to be placed remotely on distribution equipment. Hot line tags are placed on equipment during field activities to ensure worker safety. Traditionally, utilities typically sent repair crews to manually place physical tags on distribution equipment before crews could conduct operations and maintenance activities. These tags would carry warnings not to operate certain switches/relays because another team was at work elsewhere on the feeder. With smart systems in place, utilities can "tag" DA equipment remotely through SCADA, allowing restoration efforts to proceed faster and more safely.

Exhibit__(SAMIP-3)

Key Result: Faster, More Targeted, and Safer Restoration

The SGIG DA utilities implemented a variety of approaches to optimizing restoration dispatch activities. Individual case studies provide more detailed explanations of the following examples:

- Following a February 2014 storm, PECO was able to dispatch repair crews and restore services three days faster than they would have otherwise using AMI data (when smart meter roll out was 50 percent complete).
- The Sacramento Municipal Utility District (SMUD) used software for correlating, analyzing, and visualizing data from field devices, DMS, OMS, GIS, and weather forecasts. The new system quickly synthesizes numerous streams of disparate data and provides on-the-fly assessments of grid, asset health, weather, power supply, and electricity demand conditions.
- Consolidated Edison’s OMS has been merged with electric distribution and service mapping information, customer billing information, customer service call data, workforce and repair crew availability, and SCADA telemetry into one screen for control center operators.
- CenterPoint Energy’s OMS enables operators to visualize outages the moment they occur and often times, trucks are rolled before customer calls are received.

CASE STUDY: **NORTHERN VIRGINIA ELECTRIC COOPERATIVE (NOVEC)**

Electric Cooperative

Virginia

143,196 Customers

Distribution Circuits Impacted:	**105 (of 235)**	**Distribution Substations Impacted:**	**37 (of 53)**

DA Communication Network: IP-based communication links

Total Cost of DA Implementation under SGIG

$10,000,000

Distribution Automation Devices Deployed					
Automated Feeder Switches	✓	**14**	Remote Fault Indicators	✗	
Automated Capacitors	✓	**164**	Transformer Monitors	✓	**56**
Automated Regulators	✓	**340**	Smart Relays	✓	**25**
Feeder Monitors	✗		Fault Limiters	✗	
Automated Reclosers	✓	117	Smart Reclosers	✓	19
Substation Battery Bank Monitors	✓	33			

DA Improved Reliability from Five-Year Benchmarks: NOVEC reported reliability improvements on the 41 feeders installed with electronic vacuum reclosers and motor-operated air break switches. NOVEC analysis compared 2011-2013 data from 41 feeders for the major reliability indices with pre-deployment, five-year benchmarks and showed improvements across the board, as shown in Table 10.

Table 10. NOVEC Reliability Analysis, 2011-2013.

Analysis Period	SAIFI	SAIDI	CAIDI	MAIFI
Summer Benchmark	0.62	54.49	88.50	0.39
Summer 2011	0.66	38.32	57.93	0.21
Summer 2012	0.37	27.71	74.20	0.20
Summer 2013	0.40	22.53	70.63	0.15
Winter Benchmark	0.48	36.08	74.93	0.39
Winter 2011	0.27	21.63	68.55	0.40
Winter 2012	0.28	16.03	71.09	0.13

Improved Efficiencies Reduce Truck Rolls and Fleet Miles: NOVEC reduced truck rolls and fleet vehicle miles from improved efficiencies from a variety of automated field activities. Table 11 provides a summary of the savings.

Table 11. Summary of NOVEC Savings from DA Operations from 2011 to 2013.

Activity	Truck Rolls Avoided	Vehicle Miles Saved
Substation Inspection Reductions	150	1,200
Fault Response/Forensic Data Retrieval	300	18,000
Remote Hot Line Tagging	3600	57,600
Remote Equipment Setting Changes	300	2,400
Remote Inspection	100	6,000

Efficiencies Reduce Labor Costs and Produce Fuel Savings: NOVEC, which serves 155,000 customers, avoided 59 truck rolls and 831 vehicle-miles traveled covering the summer of 2011 through the summer of 2014. Assuming average costs per mile to fuel and maintain typical repair trucks (diesel-light truck Class 5) are about $1.88 per mile, and average labor costs per truck roll are about $160 (excluding overheads), then NOVEC's savings from these DA operations were about $1,500 in avoided fuel, and about $133,000 in labor savings.

Power Quality Monitors Reduce Voltage Variations: NOVEC used power quality monitors on meters and transformers to help reduce voltage variations such as sags and surges and power harmonics. NOVEC received daily reports from these monitors and was able to check the number of regulator operations per device, tap positions of regulators, and feeder voltage levels. Based on the operational information from the power quality monitors, NOVEC ensured service voltage levels to customers remained within the acceptable level (114 volts to 127 volts) by remotely controlling, or making timely repairs to, voltage regulators.

READ MORE ABOUT NOVEC'S PROJECT ON SMARTGRID.GOV:

Northern Virginia Electric Cooperative Project Page

Northern Virginia Electric Cooperative Project Description – *July 2014*

CASE STUDY: **ELECTRIC POWER BOARD OF CHATTANOOGA (EPB)**

Municipal/Public Utility

Tennessee, Georgia

172,079 Customers

Distribution Circuits Impacted: 232 (of 370)

Communication Network: Fiber optic network

Total Cost of DA Implementation under SGIG

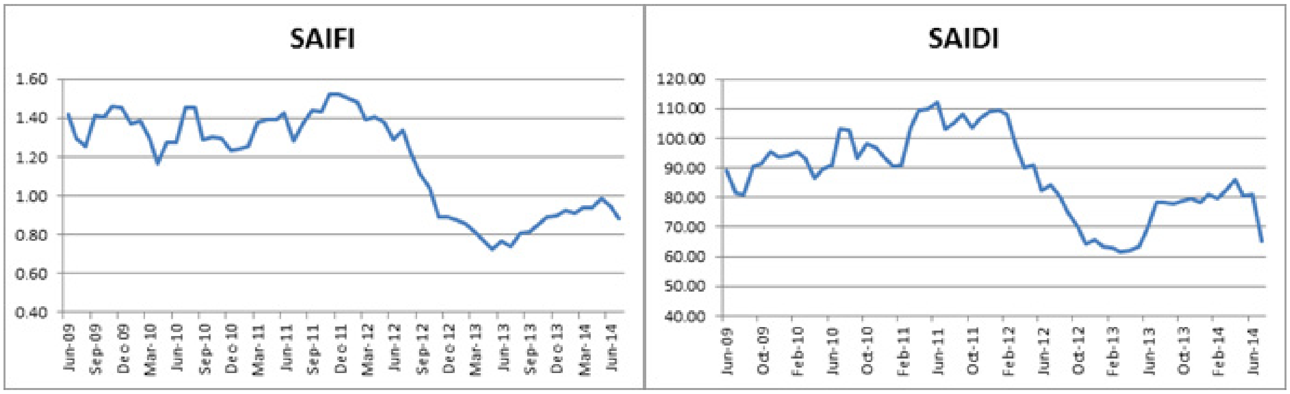
$49,878,568

Distribution Automation Devices Deployed				
Automated Feeder Switches	✓	1,294	Remote Fault Indicators	✗
Automated Capacitors	✗		Transformer Monitors	✗
Automated Regulators	✗		Smart Relays	✗
Feeder Monitors	✗			

Communication Upgrades Support Smart Grid and More: EPB installed an ultra-speed, high-bandwidth, fiber optic network that provides services beyond those for electric grid applications.

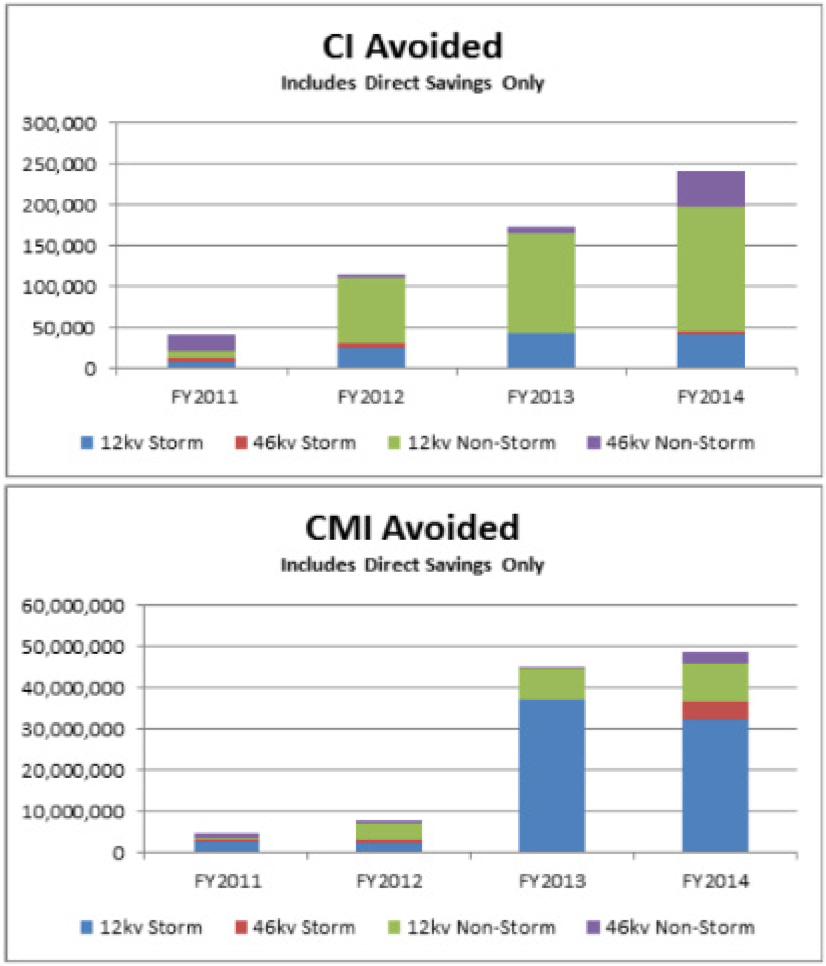
Sustained Outage Frequency Reductions Improve Reliability: EPB also reported a 30 percent reduction in SAIFI from 2011 to 2014. As shown in Figure 15, SAIDI also showed a 20 percent reduction over the same time period.

Figure 15. SAIFI and SAIDI Performance for EPB, 2009 – 2014



DA Operations Produce Customer Minutes of Interruption (CMI) Savings: Figure 16 shows improvement in CI avoided during the time period in which automated feeder switching (AFS), FLISR, and AMI technologies and systems were deployed and operated by EPB. The upper chart in the figure shows increases in avoided CI, and that in 2011-2013, the amount of avoided CI increased particularly for customers “upstream” of faults, an indicator that AFS and FLISR operations were effective. The lower chart in the figure shows improvements in the number of CMI experienced by customers.

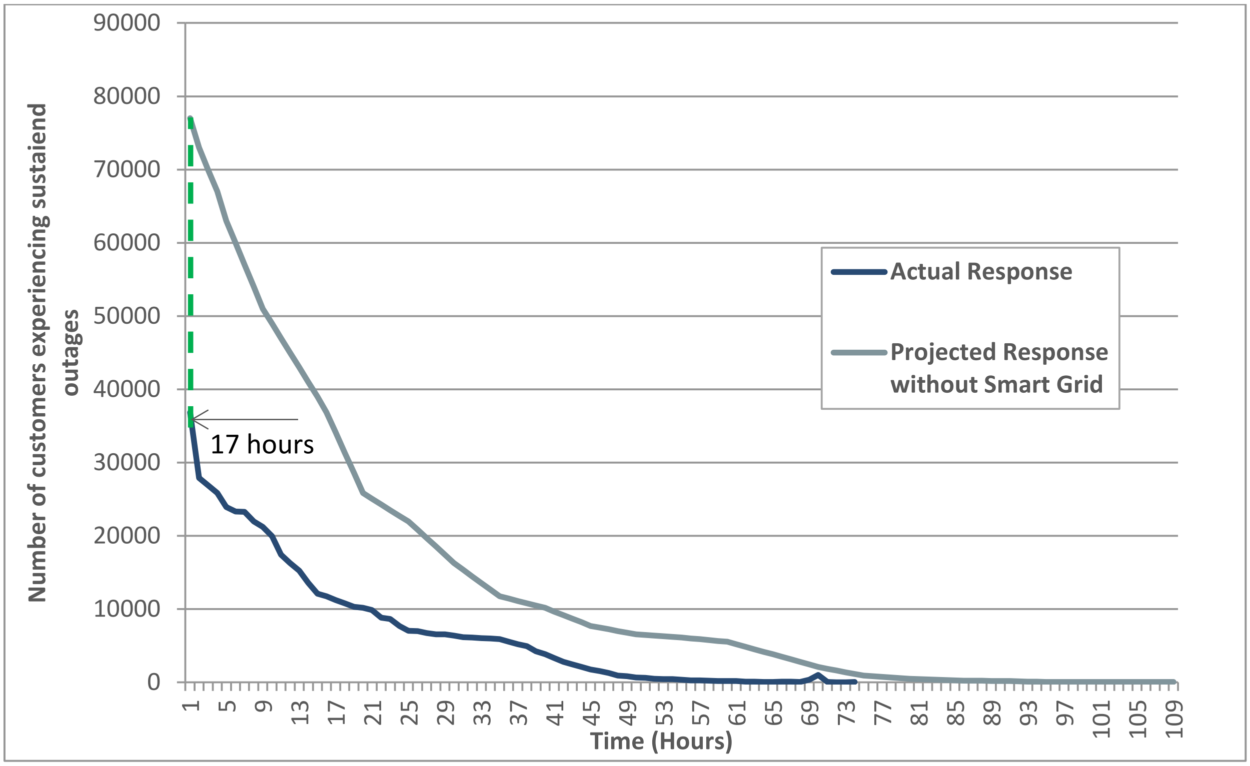
Figure 16. CI and CMI Improvements for EPB, 2010 – 2014



Instant Restoration Reduces the Extent of Major Outages: The July 2012 derecho that impacted much of the Midwest also struck Chattanooga, affecting about half of EPB’s customers. Because of EPB investments in smart switches and smart meters, the outage duration for all affected customers decreased by about half. This resulted in about 36 million fewer CMI than would have occurred without the new technologies.

AFS Enables System-Wide Restoration Days Faster Following Major Storms: Figure 17 shows the results of using smart switches and smart meters for storm restoration at EPB. The blue line shows the time it would have taken EPB to restore power to affected customers in this storm without application of AFS and AMI. The green line shows the improvement in restoration time due to these practices. Overall, EPB’s response was up to 17 hours faster due to the automated feeder switches, which restored power to 40,000 customers instantly and allowed crews to focus on a more limited number of issues. Smart meter data also helped operators verify outages, enabling EPB field crews to locate and fix downed lines faster and more efficiently.

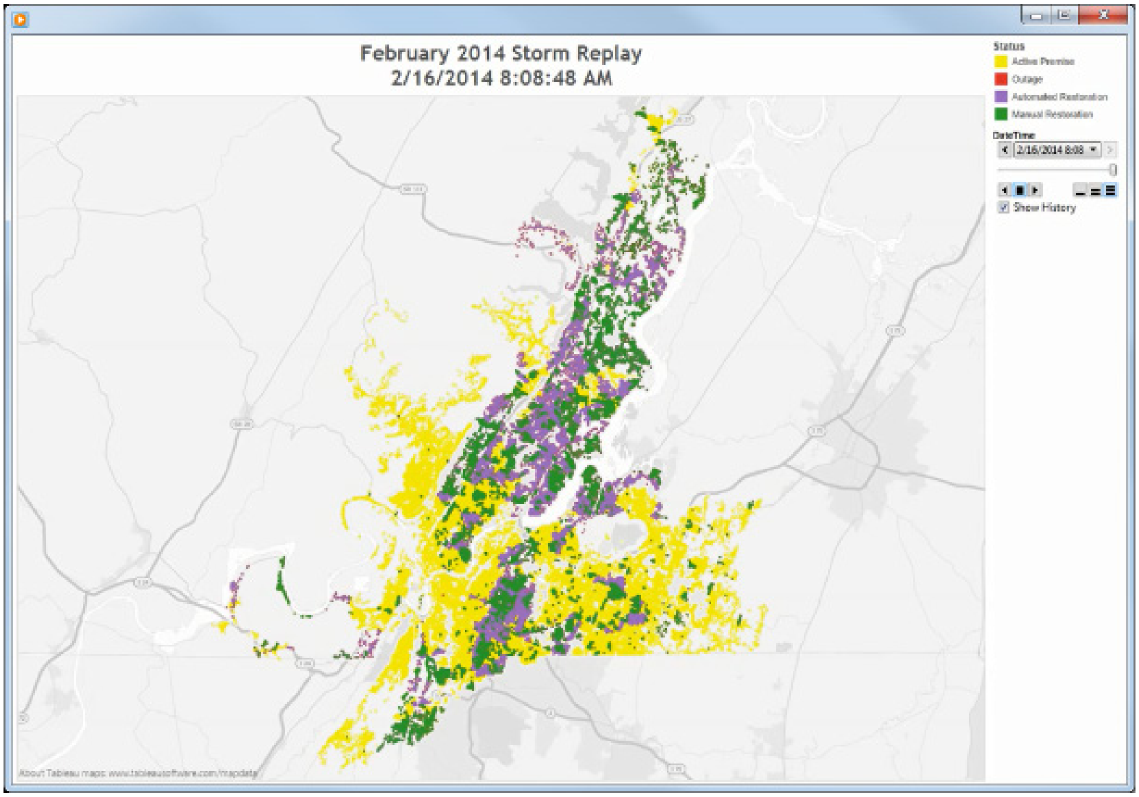
Figure 17. Improvement in Service Restoration by EPB Following a Storm in July 2012



EPB also experienced a snowstorm in February 2014 that affected more than 50 feeders and almost 33,000 customers. During the storm, EPB kept all of its smart switches active and did not deactivate FLISR capabilities. EPB reports that without the fault isolating capabilities of the smart switches, about 70,000 customers would have experienced sustained outages. EPB estimates that it was able to restore power about 36 hours earlier than would have been possible without smart grid deployments. Of those 36 hours avoided outage hours, EPB estimates about 16 were due to the self-healing actions of the smart switches, and about 20 were due to EPB's ability to "ping" smart meters, verify outage status, and redirect repair crews accordingly. EPB estimates it saved about $1.4 million in overtime costs for field crews during this storm.

Figure 18 shows a map of outage and restoration patterns from the snowstorm. The map shows the areas that were restored automatically (purple) and manually (green). Customers that were not interrupted are shown in yellow.

Figure 18: EPB Map of Outage and Restoration Patterns during a Snowstorm in February 2014



Business Case Analysis Considers Multiple Factors: The February 2014 snowstorm that affected the EPB occurred on a weekend. Had the storm arrived on a weekday, there would have been lower overtime costs and the savings from fewer truck rolls would have been lower. Thus, the savings for improvements in outage management can be hard to estimate before the investments take place, as assumptions about weather events and other factors can turn out to be inaccurate. As a result, business cases need to contain contingencies that reflect uncertainties in the weather, timing, and other factors. To build a business case, it is important for utilities to collect data, no matter what metrics are used, to document impacts and benefits and provide information decision makers can use for business case analysis.

Fiber Optic Network Extends Services: EPB installed an ultra-speed, high-bandwidth, fiber optic network which provides services beyond those for electric grid applications.

Future Deployment Will Provide Real-Time Information: EPB reports that the deployment of DA equipment is part of EPB's plan to more fully automate its distribution system. Moving forward, EPB expects data from the smart switches to provide information on real-time loadings on all of EPB's transformers so that demand can be better calculated and planned for, thus utilizing existing capital assets more effectively.

READ MORE ABOUT ELECTRIC POWER BOARD OF CHATTANOOGA'S PROJECT ON SMARTGRID.GOV:

Electric Power Board of Chattanooga Project Page

Electric Power Board of Chattanooga Project Description – *September 2014*

Electric Power Board of Chattanooga Case Study – *May 2011*

CASE STUDY: **DUKE ENERGY**

Investor-Owned Utility

Ohio, Indiana, Kentucky, North Carolina, South Carolina

4,514,000 Customers

Communication Network: Cellular DA and SCADA network

Total Cost of DA Implementation under SGIG

$189,471,768

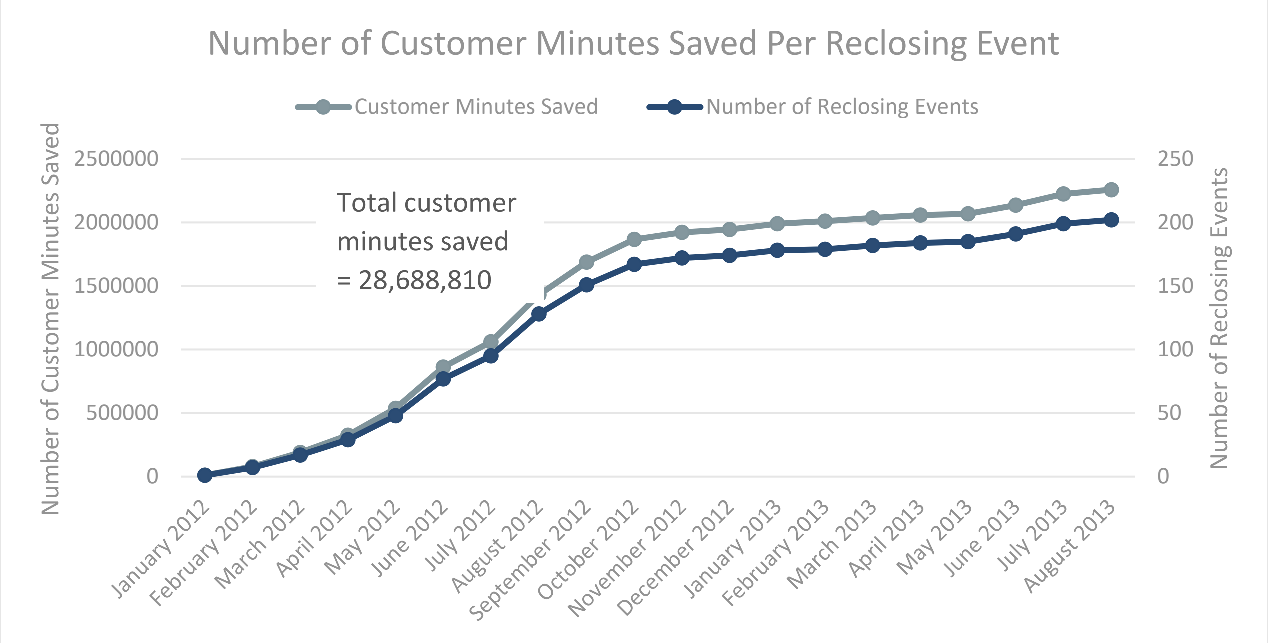
Distribution Automation Devices Deployed					
Automated Feeder Switches	✓	**914**	Remote Fault Indicators	✓	**4,755**
Automated Capacitors	✓	**2,098**	Transformer Monitors	✗	
Automated Regulators	✓	**914**	Smart Relays	✓	**4,755**
Feeder Monitors	✓	**83**			

DA Technologies Better Equip Field Crews: Duke Energy's approach emphasizes equipping field crews with key data and information tools. Instead of deploying field crews based on customer outage reports, line sensors and analysis software identify precise locations for repair, reducing costs and accelerating restoration of services.

Self-Healing Teams Enable Integrated FLISR Operations: Duke Energy installed "Self-Healing Teams" of field devices for FLISR operations. The teams of devices include centrally located control software and field installed electronic reclosers and switches that use digital-cell or radio communications. The device teams connect electronic reclosers and circuit breakers from two or three neighboring feeders and enable them to operate together in an integrated manner. These devices measure and digitally communicate information regarding distribution line loadings, voltage levels, and fault data to a central application that remotely locates and isolates faulted distribution line sections and automatically restores service to non-faulted line sections. Duke Energy used the following criteria to select the most advantageous feeders to implement Self- Healing Teams: feeder outage histories, availability of communications installations, and the number and type of customers on the feeder. Line sensors are placed at strategic locations along the feeder lines to help identify long-lasting faults and outages and to enhance the utility's response for accelerating restoration of services. Data from the line sensors are communicated to the utility's control room.

Re-Closure Activations Result in Avoided CMI: From January 2012 to August 2013, Duke Energy estimated avoiding about 28,688,810 CMI, due to re-closure activations, as shown in Figure 19. In 2014, after an additional 200 re-closers were installed, an estimated 111,200 additional CMI were avoided (75,400 CMI if major storms are excluded).

Figure 19. Number of Customer Minutes Saved Per Reclosing Event at Duke Energy



Smart Meter Data Improves Outage Diagnostics: As a part of its AMI system deployment, Duke Energy installed 966,000 smart meters with outage diagnostics features that allow the utility to "ping" meters and determine fault location. Its AMI system helped resolve 1,393 cases of single-call outages with remote diagnostics between 2010 and 2014.

Annual Outage Assessment Time Reduced: Duke Energy reports reductions in the amount of time spent annually assessing outages (including fault location) by more than 560 hours[26]. This impact results from applications of both fault location technologies and systems and AMI for pinging meters and confirming the status of power outages and restoration activities. Table 15 shows the results of Duke's estimates.

Table 12. Duke Energy Estimates of Reductions in Outage Assessment Activities

Duke Energy Estimates of Reductions in Outage Assessment Activities	
Outage Assessment Time Before SGIG (hours)	2,838
Outage Assessment Time After SGIG (hours)	2,270
Reduction in Outage Assessment Time (hours)	**568**
Percent Reduction in Outage Assessment Time (%)	**20%**

Service Voltage Level Reductions Lower Electricity Consumption: Management of peak demands through service voltage level reductions can reduce electricity consumption of end-use appliances and equipment and reduce customer bills. Reduction in electricity consumption is on the order of 1–3 percent. When implemented during peak hours, conservation voltage reductions (CVR) actions can supplement traditional demand-side management programs such as direct load controls, time-based rates, and incentive based programs. Duke Energy refers to its CVR actions as "Distribution System Demand Response" for this reason.

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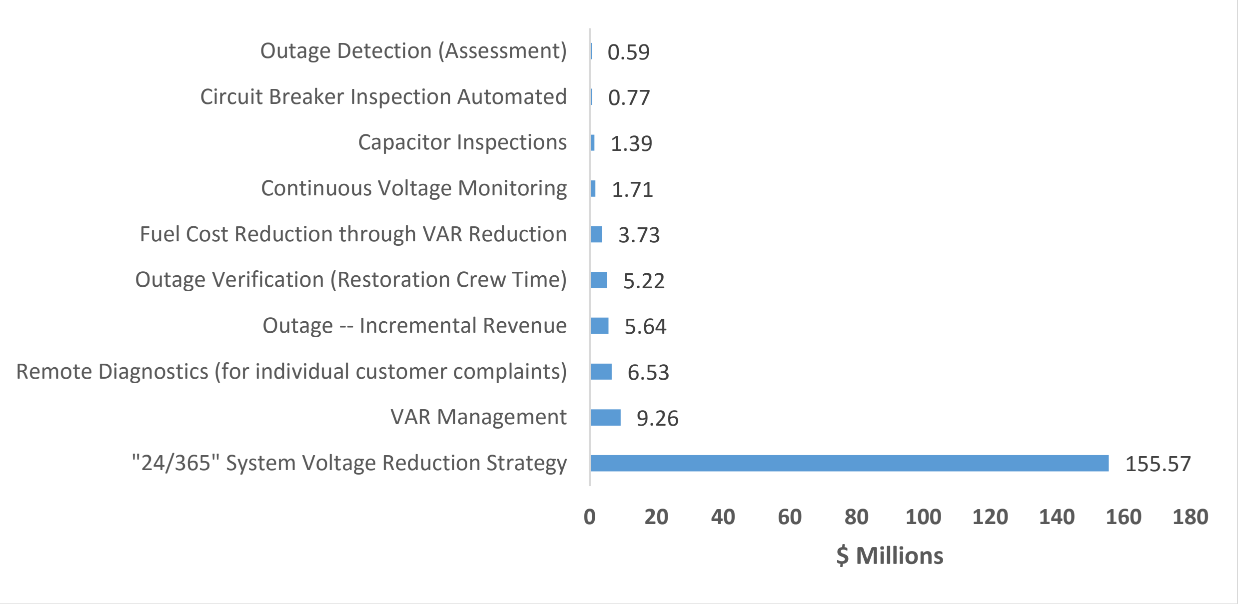
[26] Duke collected this data from work order management systems, service outage management systems, and labor timekeeping systems.

Continuous Voltage Optimization Vastly Improves Smart Grid Business Case: Duke Energy was among the first utilities to rigorously assess and establish the business case for its smart grid deployment. In 2011, Duke supported a third-party evaluation from the Public Utilities Commission of Ohio that validated 26 benefit areas.[27] Duke estimated the value of the revenue and benefit streams it can expect over 20 years, and discounted them to today's dollar to account for the changing value of money. Duke's deployment as of 2014 was tracking ahead of the 2011 estimated benefits in aggregate. Figure 20 shows that continuous voltage monitoring forms a large portion of the business case. Continuous voltage optimization can also reduce generation to avoid fuel costs and defer distribution capital investments. Other DA investments have smaller paybacks for Duke.

Figure 20. Estimated Net Present Value of Duke Energy's Smart Grid Program (2011 Dollars)



Integrated Volt/Volt-Ampere Reactive (VAR) Controls Achieve Voltage Reduction: Duke Energy used integrated volt/VAR controls to achieve consistent 2 percent voltage reduction on more than 200 circuits in Ohio. These reductions saved fuel and lowered customer bills, with no detrimental effects on service quality.

Remote Capabilities Reduce Physical Inspections: The remote capabilities of Duke Energy's new capacitor bank controllers reduced physical inspections by 1,085 units in 2013. Continuous monitoring instead of a once-a-year physical inspection reduces manual inspection costs and better optimizes voltage.

New DMS Integration Requires Change Management Practices: Under SGIG funding, Duke Energy installed a new DMS to enable new capabilities from device deployments, including FLISR, IVVC, and automated switching plans. The DMS now provides a data historian, Distribution Operations Training Simulator, and DMS/OMS interface capabilities across Duke's service territory. A key success for Duke Energy's smart grid project was the early implementation of business process management and change

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[27] MetaVu for the Staff of the Public Utilities Commission of Ohio, *Duke Energy Ohio Smart Grid Audit and Assessment*, (MetaVu, June 2011).

management best practices. Implementing a DMS and deploying distribution automation were large-scale efforts that required leadership and coordination across multiple business units. Duke Energy facilitated business process management and change management through its newly formed Grid Modernization Organization, which is responsible for industry trend identification, business case development, business and regulatory approval, and upon project approval, project management and business readiness activities.

Change management prepares people and processes for business changes, particularly those with project benefits that depend on employee adoption, usage, and commitment to project timelines. Effective organizational change was particularly critical for the implementation of a DMS and integration of distribution automation devices, which required staff, technology, and process integration across business units. For example, DMS changes the roles of the GIS and IT support from traditional back-office staff to operational partners within the business. Adequate communication was a must. DMS required equal IT and business support, so joint business and IT leadership was required for its success. For any large-scale smart grid effort, communications, business process management, and change management structures should be built into the project plan, and relevant business units should be engaged early and often.

Deployment Expansions Planned: Duke Energy plans to complete its 10-year plan for grid modernization and expand deployments of fault location, isolation, and system restoration technologies and systems ("Self-Healing Teams") to additional substations and feeders with focus on service territories in Indiana, Kentucky, Florida, and the Carolinas.

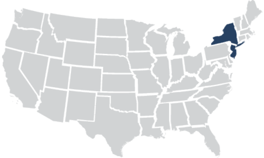
READ MORE ABOUT DUKE ENERGY'S PROJECT ON SMARTGRID.GOV:

Duke Energy Project Page

Duke Energy Project Description – *September 2015*

CASE STUDY: **CONSOLIDATED EDISON (CON EDISON)**

Investor-Owned Utility



New York, New Jersey

3,578,188 Customers

Distribution Circuits Impacted: 840 (of 2,297)

DA Communication Network: Master radio sites to upgrade SCADA and wireless

Total Cost of DA Implementation under SGIG

$272,341,798

Distribution Automation Devices Deployed

Automated Feeder Switches	✓	**797**	Remote Fault Indicators	✓	**1,851**
Automated Capacitors	✓	**449**	Transformer Monitors	✓	**17,401**
Automated Regulators	✓	**111**	Smart Relays	✓	**205**
Feeder Monitors	✓	**617**	Recloser Controls		307
Remote Battery Monitors	✓	**17**			

OMS, DMS, SCADA, and GIS Integration: Con Edison OMS has been merged with electric distribution and service mapping information, customer billing information, customer service call data, workforce and repair crew availability, and SCADA telemetry into one screen for control center operators. During outages, embedded models and analysis tools provides operators with predictions of field operations, actual data streams on grid conditions from SCADA, number of customers affected or restored, damage assessment information, and tracking of outage and restoration activities for managing and dispatching service and restoration crews and resources. This system also provides customer call center staff with maps of the grid showing the location of meters without power. This information is updated in near real time, is used to direct and manage field crews to restore power, and enables communications with customers on outage locations and estimated return to service times.

DA Greatly Reduces Customer Costs from Fewer and Shorter Outages: Con Edison used the ICE calculator to estimate the reduction in cost to customers for power interruptions occurring on its Orange & Rockland feeders. The calculator (which includes savings realized when adding distribution automation to circuits) estimates over $1.2 million reduction in interruption costs for the 14-feeder feeder system for a single year. These benefits were largely estimated to occur in the commercial and industrial customer classes, with the residential customers saving about $27,000. The impact of interruptions on industrial and commercial customers varies widely according to the type of business and the processes interrupted. The customer-average savings was about $650 per customer for larger customers and about $230 per customer for smaller customers.

Voltage Management Improves Substation Capacity under Peak Conditions: Through the use of overhead medium voltage distribution circuits and improved voltage management, Con Edison was able to improve voltage management capabilities; enhance power system measurement; reduce reactive power consumption; and improve asset utilization, capacity management, and energy efficiency. Deployments included installation of pole mounted distribution capacitors, load tap changer (LTC) controllers at 4 kilovolt (kV) unit substation transformers, power quality and battery monitoring systems, and development of 4kV grid models for enhanced load flow analysis. Table 21 summarizes the key results based on data through the end of 2013.

Table 13. Summary of Con Edison Voltage Control Results

Summary of Con Edison Voltage Control Results		
Asset Utilization and Capacity Management	i.	Increased 4kV unit substation capability by 31.1 megavolt-ampere (MVA) or 2.8% under peak conditions, resulting in a net savings of $15.7 million.
	ii.	Reduced 4kV system primary losses by 2.3% under peak conditions.
Voltage Controls for Reactive Power Management and Energy Efficiency	iii.	Reduced reactive power requirements at the aggregate level of 33 substations in Queens by about 12.3% and 9.9% over a one-year test period through the application of advanced LTC controls.
	iv.	Increased power factor at these same substations by about 2% and 1% over the same one-year test period.
	v.	Reduced annual system energy losses by 4,500 megawatt-hours (MWh), resulting in estimated annual energy savings of about $340,000.

DERMs Improves Control of Demand Resources: Con Edison's distributed energy resource management system (DERMS) was used to monitor and control a variety of supply and demand resources including distributed generation and storage, building management systems, and demand response customers.

Data Historian Improves Data Access and Management: Con Edison's data historian project implements a centralized data repository for all electric distribution SCADA data. The system is integrated with existing corporate data systems and provides a single point of access for all users of the company's electric distribution data. BWP's data historian is responsible for capturing and storing operational measurements for the electric distribution network and for providing analytical tools for assessing distribution performance.

READ MORE ABOUT CON EDISON'S PROJECT ON SMARTGRID.GOV:

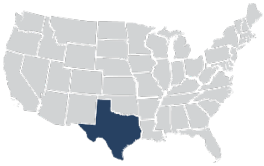
Consolidated Edison Company Project Page

Consolidated Edison Company Project Description – *August 2014*

Consolidated Edison Company Case Study – *May 2011*

CASE STUDY: **CENTERPOINT ENERGY**

Investor-Owned Utility



Houston, TX

2,320,156 Customers

Distribution Circuits Impacted:	**188 (of 1,516)**	**Distribution Substations Impacted:**	**31 (of 240)**

DA Communication Network: RF, WiMAX, and cellular technologies

Total Cost of DA Implementation under SGIG

$120,604,288

Distribution Automation Devices Deployed

Automated Feeder Switches	✓	**567**	Remote Fault Indicators	✗	
Automated Capacitors	✗		Transformer Monitors	✗	
Automated Regulators	✗		Smart Relays	✓	**171**
Feeder Monitors	✗				

DA Technology Package Enables FLISR Functions: CenterPoint Energy implemented its Intelligent Grid Switching Devices—a comprehensive package of DA technologies that perform a number of integrated grid functions. For example, Intelligent Grid Switching Devices use enclosures similar to line reclosers to provide reliable switching operations across thousands of operations without maintenance. Intelligent Grid Switching Devices also include monitoring equipment to measure load and voltage accurately and enable power quality analysis at the device. The system uses data storage and communications control packages that perform analytics and securely communicate rapidly with processors at both the substation and at the utility's central computing location.

OMS Integration Enables Outage Visualization and Efficient Dispatch of Repair Crews: CenterPoint Energy's OMS enables operators to visualize outages the moment they occur and trucks are often rolled before customer calls are received. In several cases, outages have been restored before customers were even aware that they had lost power. During large events, CenterPoint's OMS system can display results from thousands of last gasp smart meter signals, as well as data from SCADA and customer calls all on one screen, which enables operators to dispatch field crews more efficiently. Before this system was used, once a fault had been repaired, operators assumed all customers on the feeders had their power restored, which is not an accurate assumption during large scale outages. In some cases, customers involved in nested outages would still be without power and field crews would have to be dispatched a second time.

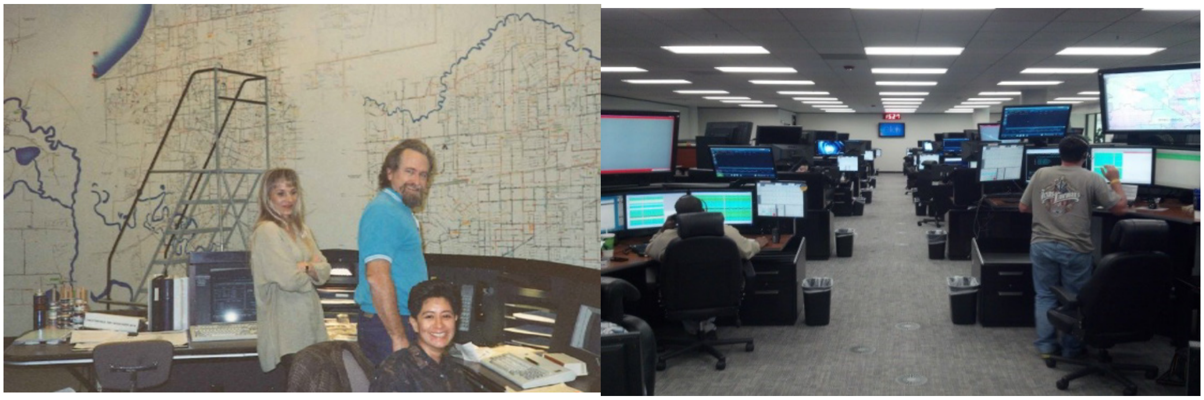
Improved Outage Alerts Increase Customer Satisfaction: CenterPoint Energy implemented a Power Alert Service (PAS) for customers using its OMS and AMI outage alerts to keep customers up-to-date with accurate information about the progress of restoration activities. Based on survey analysis, CenterPoint found customers highly satisfied with the service (see Figure 21).

Figure 21. Results of CenterPoint Energy Survey of Customer Satisfaction for Outage Information

Satisfaction Measures	
Overall Satisfaction with PAS: Combined responses for all delivery methods (email, text, and phone. 4 or 5 on a 5-point scale).	**85%**
Message Timeliness – "Power Out": Time to receive power out message met or exceeded expectations (4 or 5 on a 5-point scale).	**88%**
Message Timeliness – "Power On": Time to receive power on message met or exceeded expectations (4 or 5 on a 5-point scale).	**96%**
Usefulness of Information Provided: 4 or 5 on a 5-point scale.	**86%**
Estimated Restoration Time Accuracy: Power restored within +/- 30m of estimate.	**73%**

Advanced Distribution System Management Improves Planning: CenterPoint Energy's Advanced Distribution Management System (ADMS), which manages its FLISR operations, replaced the utility's legacy DMS, OMS, and distribution SCADA systems and allows the utility to use real-time smart meter and Intelligent Grid Switching Device data to better plan, engineer, and operate the grid. ADMS also integrates with the company's GIS, CIS, transmission management system, and many other back-office applications. ADMS capabilities include near-real time distribution load flow data capture and a platform for controlling FLISR operations. Figure 22 shows CenterPoint's distribution management system in 1993 and in 2014, illustrating how new technologies have made system operations increasingly digital.

Figure 22. CenterPoint Energy's DMS – 1993 and 2014



Post-SGIG DA Activities Planned: The utility plans to continue activities with its DMS vendor and user community to develop and deploy additional advanced capabilities and applications. CenterPoint plans to expand the capabilities of its Intelligent Grid Switching Devices from requiring manual validations to full automation, which will be tested on a limited number of substations and feeders before larger-scale deployments are implemented.

READ MORE ABOUT CENTERPOINT ENERGY'S PROJECT ON SMARTGRID.GOV:

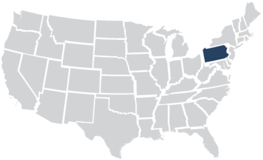
CenterPoint Energy Project Page

CenterPoint Energy Project Description – *September 2014*

CenterPoint Energy Case Study – *February 2012*

CASE STUDY: **PPL ELECTRIC UTILITIES CORPORATION**

Investor-Owned Utility



Pennsylvania

1,396,751
Customers

Distribution Circuits Impacted:	**50 (of 1153)**	**Distribution Substations Impacted:**	**10 (of 376)**

DA Communication Network: WiMAX, cellular, and fiber optic cable

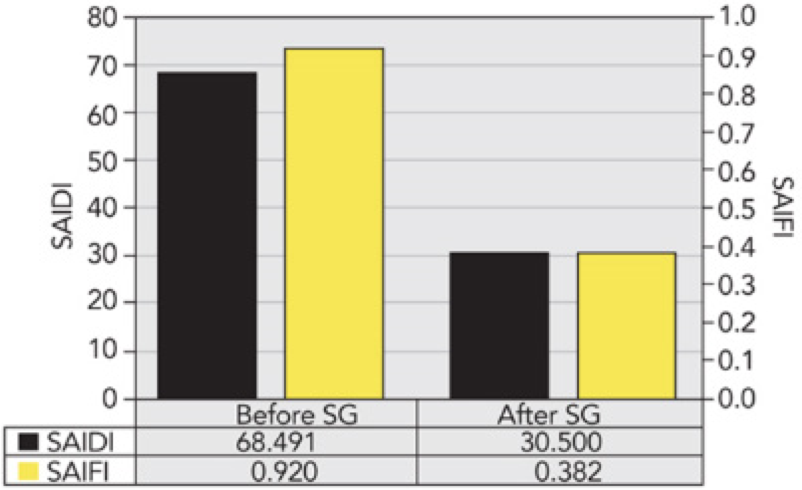
Total Cost of DA Implementation under SGIG

$38,108,290

Distribution Automation Devices Deployed					
Automated Feeder Switches	✓	**214**	Remote Fault Indicators	✗	
Automated Capacitors	✓	**195**	Transformer Monitors	✗	
Automated Regulators	✗		Smart Relays	✗	
Feeder Monitors	✗		Automated Reclosers	✓	77

DA Results in Sustained Reliability Improvements: PPL Electric Utilities Corporation estimated a 58 percent decrease in the average number of interruptions experienced by customers in 2013 (compared against a pre-deployment baseline), which also involved a 55 percent drop in the average number of customer minutes interrupted. PPL also estimated improvements in SAIDI over that same time period (see Figure 23).

Figure 23. SAIDI and SAIFI Improvements before and after Smart Grid (SG) Deployment, Estimated by PPL in 2013



Based on these results, PPL estimates a 25 percent improvement in reliability over the subsequent five years through the deployment of distribution automation. This estimate is based on analysis of PPL’s three-phase distribution circuits only, and excluded major events. Because 2013 was a good year weather-wise, PPL expects long-term effects to be somewhat lower than the effects shown in Figure 23.

Remote Switching Improves CMI: In January 2012, PPL accomplished remote switching and restored 300 customers approximately 30 minutes earlier than if done manually, resulting in a CMI improvement of 9,000. Following an overload condition on two main lines in March 2012, PPL rerouted power in five minutes to prevent a sustained outage of 2,600 customers. In September, 2012 interference by a squirrel caused circuit breaker damage which affected more than 3,000 customers. PPL estimates that about 330,000 CMI were saved using remote detection and restoration procedures.

Future DA Investments Plan to Upgrade All Feeders: PPL Electric Utilities Corporation plans to continue DA investments through 2018 until all feeders (about 1,140 total) are upgraded. This involves installation or replacement of approximately 3,400 devices in addition to the 1,500 devices installed as of 2014 that will receive new communications devices. Plans call for completing DA upgrades on remaining feeders within five years, and to install sensors on all three-phase capacitors within three years. Future DA investments are estimated to cost about $118 million. Future projects include about 3,000 automated feeder switches and 4,000 automated capacitor banks.[28]

READ MORE ABOUT PPL ELECTRIC UTILITIES CORPORATION'S PROJECT ON SMARTGRID.GOV:

PPL Electric Utilities Corporation Project Page

PPL Electric Utilities Corporation Project Description – *September 2014*

PPL Electric Utilities Corporation Case Study – *December 2011*

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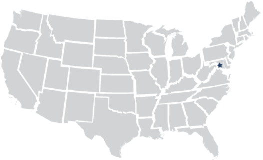
[28] DOE, *PPL Electric Utilities Corporation (PPL Smart Grid Project)*, 2014.

CASE STUDY: **PEPCO - DC**

Investor-Owned Utility



Washington, DC

249,059 Customers

Distribution Circuits Impacted: **19 (of 779)**

DA Communication Network: Wireless mesh

Total Cost of DA Implementation under SGIG

$8,308,800

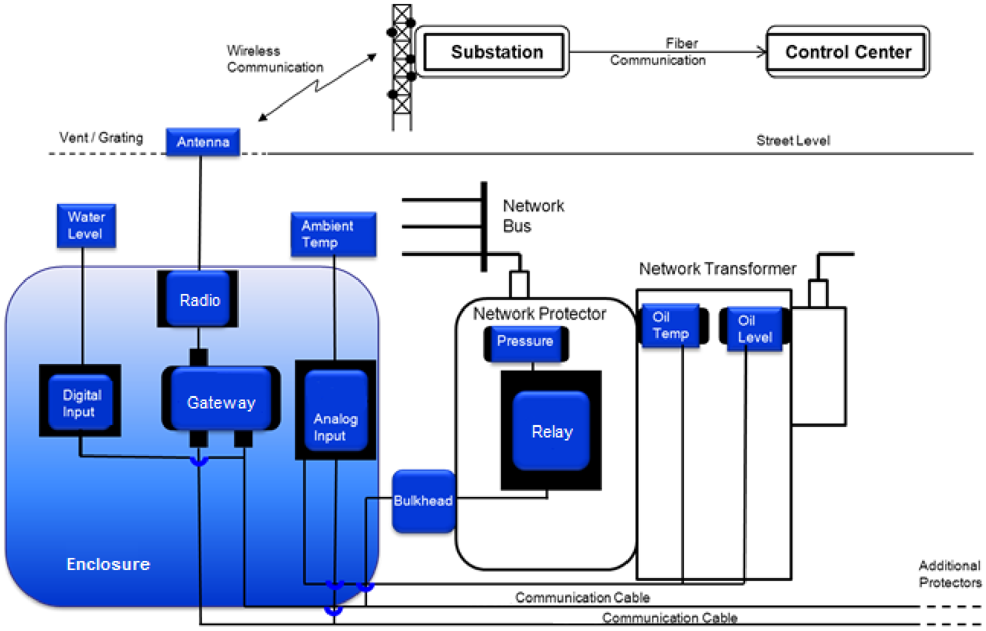
Distribution Automation Devices Deployed					
Automated Feeder Switches	✓	**42**	Remote Fault Indicators	✗	
Automated Capacitors	✗		Transformer Monitors	✓	**41**
Automated Regulators	✗		Smart Relays	✓	**306**
Feeder Monitors	✗		Substation DRTUs	✓	6
Transformer Health Sensors	✓	14	Automated Circuit Reclosers/Switches	✓	64

OMS and GIS Integration Improves Outage Management: In addition to OMS integration with AMI, Pepco's OMS has GIS mapping capabilities that display feeder and switch locations. The system shows operators and field crews the number of customers without power during outage events and the number of customer calls for each event. The system also allows operators to manually ping meters.

RMS and EMS Integration Improves Equipment Health Condition Monitoring: Pepco's remote monitoring system (RMS) is also integrated with the company's overall Energy Management System (EMS), enabling real-time and continuous data flows for operators and maintenance and repair crews to identify and address potential issues that can cause system disturbances. Pepco is also leveraging data from its remote monitoring system to improve its system planning process. It is using loads and voltages telemetry at peak time to verify the accuracy of the network computer model and the sizing of existing network transformers.

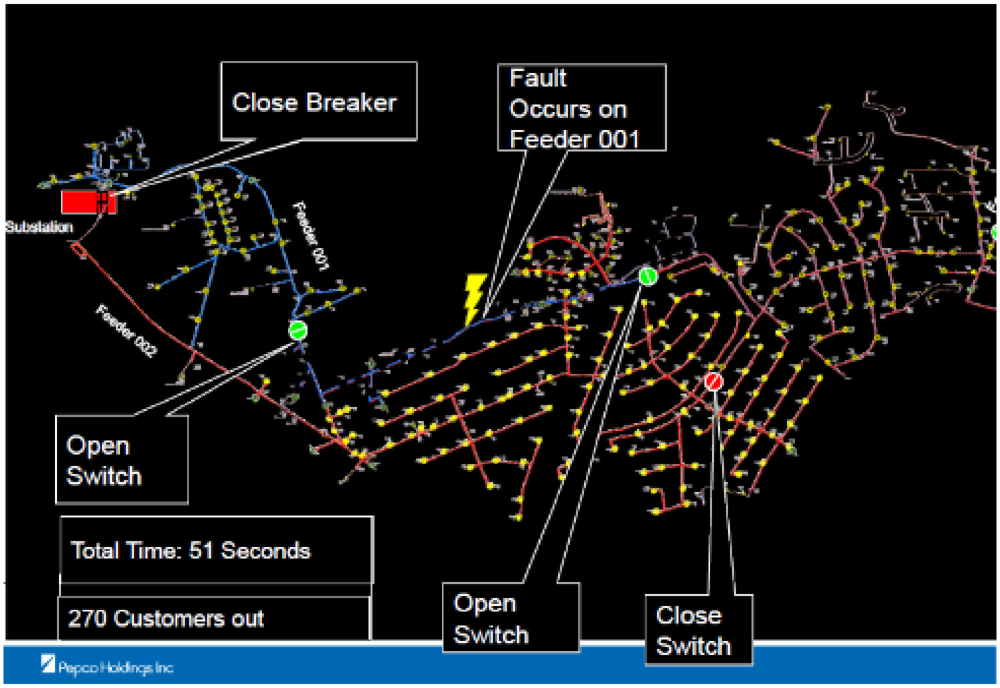
Figure 24 shows an example of how equipment health condition monitoring technologies and systems work together to implement actions. Pepco's approach focuses on transformers, and collects data such as oil level, oil temperature, and protector pressure (text in blue boxes without round corners), which is transmitted using radio communication to substations, and then is transmitted back to control centers using fiber-optic communications backhaul.

Figure 24. Illustration of Pepco's System for Equipment Health Condition Monitoring



Automatic Sectionalizing & Restoration Schemes Enable FLISR Operations: Pepco implements FLISR operations through its Automatic Sectionalizing & Restoration (ASR) schemes, which segment feeders into two, three, or four sections using closed remote-controlled switches or automatic circuit reclosers in the field. For any fault in one section, ASR first opens closed switches to isolate the faulted section. Then, it restores the non-faulted sections by reclosing feeder breakers and/or closing open tie switches to other feeders. Figure 25 shows a screen shot of Pepco's ASR operations.

Figure 25. Screenshot of Pepco's Demonstration of FLISR Operations



Remote Software/Firmware Upgrades Reduce Time in Field: Pepco is moving toward remote, "over-the-air" upgrade capabilities to reduce the amount of time needed to implement changes in the field when new software versions become available.

DERMS Enabled Testing of Solar Systems Integration Revealed Challenges: Pepco developed a DERMS and measured voltage fluctuations from an 18 megawatt photovoltaic array connected to the distribution grid. The system simulated voltage levels that ranged from about 124 volts when the system was off to about 126 volts when system was set with a 0.97 leading power factor, and about 127 volts when the system was set with a 0.97 lagging power factor. With voltage level requirements set at 115.2 – 124.8 volts (+/- 4 percent of 120 volts), inverters were able to provide voltage management that reduced voltage fluctuations, and helped prevent voltage sags or collapses if large amounts of solar were to trip off line at one time. Pepco's photovoltaic system caused reverse flows on a few low load days, resulting in high voltage on the feeder and some damage to some customer equipment.

Future FLISR Deployments Planned: Pepco plans to continue its automatic sectionalizing and restoration deployments with the goal of reaching 15 percent of its systems, including expansion into areas covered by Delmarva Power, which was not part of its SGIG project.

READ MORE ABOUT PEPCO'S PROJECT ON SMARTGRID.GOV:

Note: Pepco Holdings, Inc. had three utilities with SGIG projects. Links to all three projects are included here.

Pepco Project Page

Pepco Holdings, Inc.—DC Project Description – *September 2015*

Pepco-MD Smart Grid Project Interim Report – *August 2013*

Atlantic City Electric Project Page

Atlantic City Electric Project Description – *September 2015*

3 Major Findings: Voltage and Reactive Power Management

Voltage monitoring and control and automated power factor correction enabled 38 SGIG utilities to reduce peak demands, efficiently utilize existing assets, and improve power quality.

Table 14. Voltage and Reactive Power Management Results from DA Investments

Primary Aim	• Reduced wear and tear on capital assets • Lower capital and operating costs to keep rates affordable for consumers • Protect sensitive electronic equipment—in utility and customer systems—from voltage and other power quality issues that can damage or limit equipment performance			
Smart Grid Function	Integrated volt/volt-ampere reactive controls (IVVC)	Automated voltage regulation	Conservation voltage reduction (CVR)	Automated power factor correction
Description	IVVC enables automated and greater control of voltages and reactive power levels to improve feeder power factors and reduce line losses.	Enables utilities to monitor voltages, determine optimal control signals, and use manual or automated controls to regulate voltage levels on particular feeders	Monitoring and automated controls enable utilities to reduce feeder voltage levels to reduce electricity use, primarily during peak periods.	By monitoring voltages and using automated capacitor banks, utilities accomplish power factor corrections to improve energy efficiency and reduce energy requirements for electricity delivery
Key Impacts & Benefits	• Reduced line losses to improve energy efficiency and capacity management • Reduced peak demand • Improved reliability and reduced outage costs • Energy savings to reduce emissions and customer bills • Improved voltage management capabilities and power system measurement • Reduced reactive power consumption • Generation fuel supply and cost savings • Reduced damage to customer-side electronic equipment		38 utilities employed conservation voltage reduction to **reduce peak demands by 1%–3%** on average per event. One utility reduced annual system energy losses by an estimated 4,500 MWh, resulting in: • $0.34 million in **annual energy savings** • **Reduced CO_2 emissions** by about 340 metric tons Several utilities **improved power factors to near unity** (where power factors equal 1). One utility in particular: • **Reduced reactive power requirements by about 10%–13%** over a one-year test period • **Increased power factors by 1%–2%**	

Historically, the size and placement of LTCs, voltage regulators, and capacitors were typically based on off-line modeling of peak- and light-load conditions, as well as operating experience. Most utilities did not monitor loads and voltages on the distribution system. For the last several decades, SCADA systems have been used by many utilities for distribution system monitoring, but these reach only substations and do not monitor feeder conditions from substations to customers. The lack of operating visibility on distribution feeders has historically required utilities to design and operate their systems in a relatively conservative manner to accommodate worst case scenarios. There has been little opportunity to optimize voltage and reactive power levels for constantly changing load conditions.

With the introduction of smart sensors, communications, and controls, utilities are now able to implement automated approaches to monitor and regulate voltage levels and reactive power levels, and to perform conservation voltage reduction and power factor correction to improve power quality. Many of the SGIG utilities pursued pilot-scale implementation of DA technologies for voltage monitoring and control to test the ability to improve efficiency and/or peak demand management.

As weather and climate conditions influence electricity demands, electricity generation and delivery assets are sized to serve demand when it reaches its highest levels, even though peak levels only occur less than 10 percent of the year. Because peak demand is one the most significant drivers of electricity costs, utilities attempt to reduce peak demands to improve asset utilization. This can result in lower capital requirements and operations and maintenance costs. Through rate cases and other proceedings, reduced peak demand can ultimately translate into lower electricity rates for consumers.

In addition, the use of digital electronics and computer controls in homes, offices, and factories is on the rise, enabling the nation's electricity consumers to operate more efficiently and expand capabilities for improving productivity, economic performance, and quality of life for consumers at home. However, changes from purely electro-mechanical to power-electronic-based components affect power quality requirements and other aspects of grid operations. For example, growing use of electronic, variable-speed-drive industrial motors can affect the inertial balance of the grid, which would impact the stability of local power systems. The changes in power quality requirements boost the need for addressing power quality issues on distribution systems.

Table 15 shows the impacts that result from the application of automated voltage controls.

Table 15. Utility and Customer Impacts from Voltage Management for Asset Utilization

Impacts	How Impacts are Accomplished
Utility Impacts	
Improved energy efficiency through reduced line losses and improved power factors	Feeder and substation sensors provide voltage and phase data to grid operators and/or DMS. Automated controls trigger voltage regulators and capacitor bank switching to optimize performance through conservation voltage reduction.
Reductions in peak demand	Smart meters and feeder sensors provide voltage data to grid operators and/or DMS. Automated controls implement conservation voltage reduction during peak periods which lower peak demands.

Impacts	How Impacts are Accomplished
Reductions in labor requirements	If automated volt/VAR control devices are replacing manually switched legacy equipment, this could result in avoided field visits for operations and maintenance of the devices without degrading the performance of the distribution system.
Improved reliability	Applications of conservation voltage reduction and real-time load balancing during peak periods reduces peak demands, risks for equipment overloads and the frequency of power disruptions.
Customer Impacts	
Energy savings and bill reductions	Applications of conservation voltage reduction reduce power consumption for affected customers and produces energy savings and lower bills.
Outage cost reductions	Reductions in the number of power disruptions reduce economic losses from outages for customers.

3.1 Integrated Volt/VAR Controls (IVVC) and Automated Voltage Regulation

Integrated volt/VAR technologies and systems provide new capabilities for grid operations to automate voltage controls and reactive power management. The SGIG DA utilities that implemented integrated volt/VAR controls employed a variety of techniques but all involved a common set of functions that began with data collection and telemetry for feeder voltage levels, feeder loads (real power in watts), and feeder reactive power (in VARs). Automated volt/VAR control devices (e.g., capacitor banks and voltage regulators) also report on their operational status (e.g., tap position of voltage regulators) to the utility's SCADA system.

The SCADA system collects the data and delivers it to utility back office systems and also typically to the DMS. In these cases, the DMS uses inputs from other grid assets and monitoring devices to continuously update models of electric distribution system operations. DMS models are used to estimate the effects of various grid elements on power flows and voltage profiles, including interconnected distributed generators such as rooftop photovoltaic or fossil-fuel fired gen sets. Given the available inputs and modeling capabilities, the DMS is used to determine optimal, coordinated volt/VAR control actions that are appropriate for given operational needs.

Once the optimal control actions are determined, the DMS sends switching commands to each volt/VAR control device through the SCADA system, which passes the commands to individual devices, such as switching capacitor banks and adjusting load tap changer and voltage regulator set points. If desired, grid operators can choose to manually override control actions determined by the DMS.

Grid operators can monitor, control, and optimize voltage from substations, along feeders, and all the way to customer premises using DA. Voltage level data at the customer from smart meters is sent to grid operators and DMS for use in optimizing grid performance. Voltage regulation down to the customer level is an important complementary objective for utilities implementing more comprehensive volt/VAR controls, like CVR (see more below).

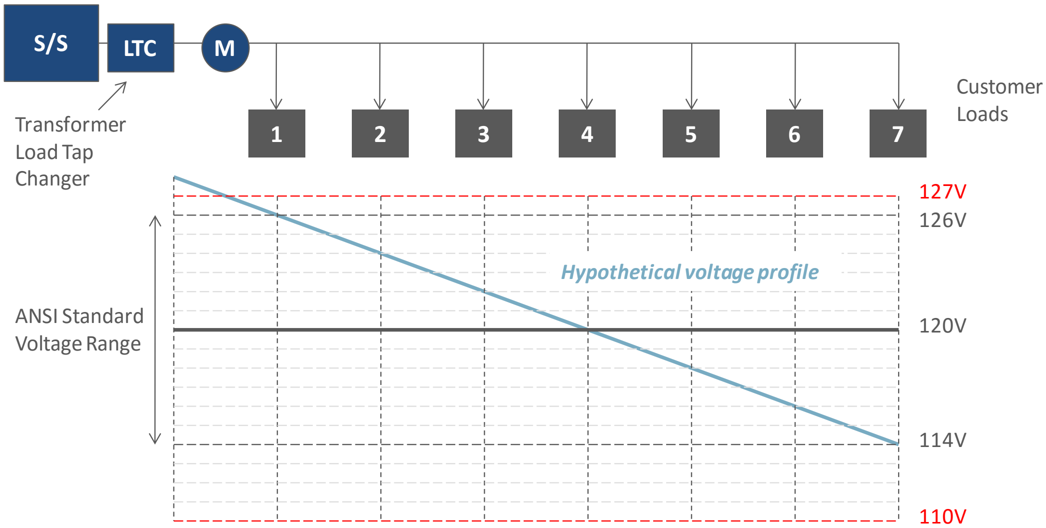
3.2 Conservation Voltage Reduction (CVR)

CVR optimizes distribution asset utilization by using monitoring and automated controls to reduce feeder voltage levels, improve the efficiency of distribution systems, and reduce energy consumption during peak periods or for longer-duration operations. Typical objectives of CVR include:

- Management of peak demands through service voltage level reductions, which can reduce electricity consumption of end-use appliances and equipment and reduce customer bills. Reduction in electricity consumption is on the order of 1–3 percent. When implemented during peak hours, CVR actions can supplement traditional demand-side management programs such as direct load controls, time-based rates, and incentive based programs. Duke Energy refers to its CVR actions as “Distribution System Demand Response” for this reason.
- Line loss reductions through feeder voltage level reductions and reactive power management results in lower electric resistance, which improves system energy efficiency and saves energy.

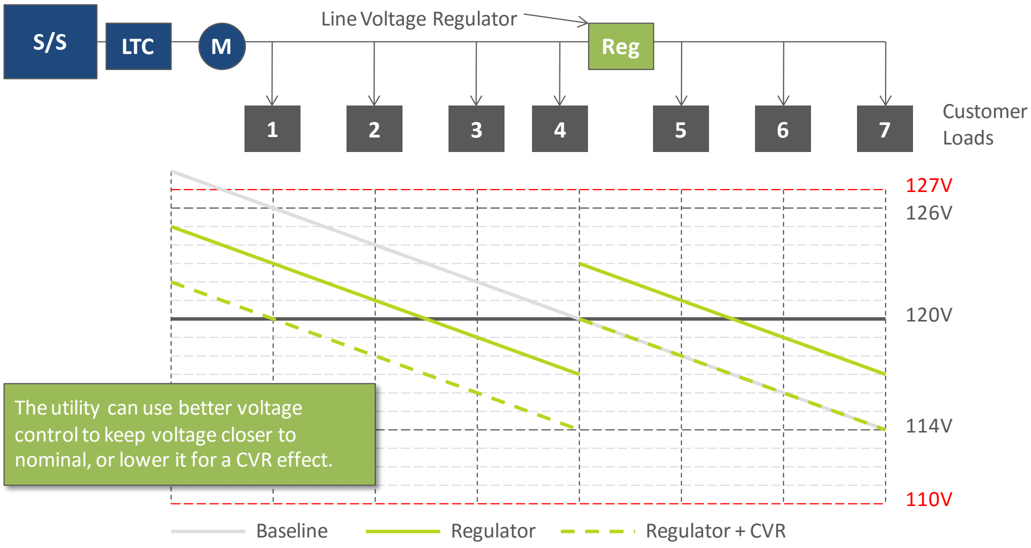
Operators use LTCs and voltage regulators to make small adjustments to voltage as load changes. Figure 26 and Figure 27 show the effects of LTCs and voltage regulators on a hypothetical distribution feeder voltage profile.

Figure 26. Hypothetical Feeder Voltage Profile with a Load Tap Changer



In Figure 27, the LTC can adjust the voltage at the head of the feeder to keep the profile within the acceptable voltage range, while voltage regulators placed mid-way along the feeder add a control point to raise or lower the downstream voltage levels.

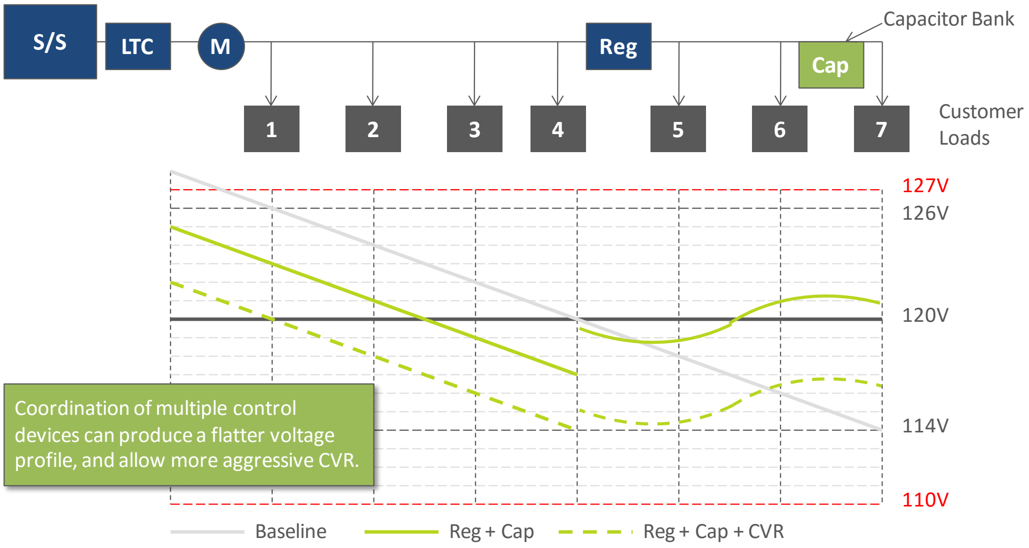
Figure 27. Hypothetical Feeder Voltage Profile with a Load Tap Changer and Voltage Regulator



The utility can use better voltage control to keep voltage closer to nominal, or lower it for a CVR effect.

Operators can also use capacitors to compensate for reactive power caused by inductive loads. Figure 28 shows how capacitor banks placed along a feeder supports voltage profiles both downstream and upstream. The combined effect of the three types of equipment is to help utilities to keep overall profiles closer to desired levels under a variety of load conditions.

Figure 28. Hypothetical Feeder Voltage Profile with a Load Tap Changer, Voltage Regulator, and Capacitor Bank



Coordination of multiple control devices can produce a flatter voltage profile, and allow more aggressive CVR.

Table 16 provides a summary of the equipment for voltage support and reactive power control.

Table 16. Summary of Voltage Control Equipment, Functions, and Location

Equipment	Function	Area Impacted
Load tap changer	Raise or lower voltage	Entire feeders
Voltage regulator	Raise or lower voltage	Downstream of connection point
Capacitor banks	Compensate reactive load	Entire feeder with greatest effect closer to the load
	Support voltage	Upstream and downstream of connection point with greatest effect closer to the connection point

Historically, CVR often faced competing operational objectives. For instance, many utilities are subject to obligations and penalties with transmission operators for not maintaining reactive power levels within certain ranges (although CVR can also improve power factor to help meet transmission system objectives). In addition, reactive power management can also be operated for voltage support rather than line loss reductions, and in these instances, overcompensation is possible, in which voltages can increase.

DA can now provide operators with access to real-time voltage information to help reduce voltage while ensuring that voltage levels do not fall below acceptable levels. Remote, automated control of grid devices enables utilities to maintain reactive power level without overcompensating power factors. Smart meter data on voltages down to the customer level can be an important aspect of CVR to monitor voltage conditions and verify the performance of CVR operations.

Several DA utilities leveraged smart grid technologies in a selection of feeders to implement automated volt/VAR control. Central Lincoln Public Utilities District's case study provides an example of an innovative CVR system design combining distribution planning analytics, real-time management and control, and AMI.

Key Result: System Efficiency Improvements and Fuel Savings

SGIG DA utilities used conservation voltage reductions during peak and off-peak periods to improve system efficiencies. **Several utilities found that CVR could result in savings of 2-4 percent on affected feeders—a change that seems minor, but when applied system-wide, could result in comparable energy savings** and hundreds of thousands of dollars in energy costs.

Central Lincoln Public Utilities District, Wisconsin Power and Light (WPL), Duke Energy, and Glendale Water and Power (GWP) each saw improved feeder efficiencies on that scale due to CVR. Based on GWP's CVR pilot, it estimates a full-scale, five-year program could net power costs savings **of $470,000 to $1.2 million per year.**

→ See **Case Study:** Glendale Water and Power (page 81)

→ See **Case Study**: Wisconsin Power and Light (page 63)

The utilities used different analysis approaches to estimate energy savings and efficiency improvements due to CVR and volt/VAR controls, and applied pilots at different scales:

- Duke Energy estimates saving about 39,000 MWh over more than a year. The utility's rigorous business case assessment found that O&M savings from CVR formed the largest portion of the 20-year business case by far, with a net-present value of more than $155 million.
- Avista used model-based analysis of historical and current feeder loads to estimate an energy savings of about 42,000 MWh in 2014.
- Con Edison estimated annual energy loss reductions of about 4,500 MWh with estimated annual energy savings of about $340,000.

→ See **Case Study:** Duke Energy (page 40)

→ See Case Study: **Avista Utilities** (page 65)

→ See **Case Study:** Consolidated Edison (page 44)

Key Result: Reduced Peak Demand

CVR was also used by several of the SGIG DA utilities to achieve reductions in peak demands.

- Oklahoma Gas and Electric estimated peak demand reductions of about 2.3 percent on 22 circuits in 2012.
- Sacramento Municipal Utility District estimated a 2.5 percent reduction of peak demand in one pilot substation in summer 2011, and estimated a 1 percent average load reduction across 14 substations throughout the program.
- Southern Company used CVR to shave peak load during extreme weather, reducing the voltage level by 5 percent for approximately 5 hours, resulting in 300 MW of peak reduction.

→ See **Case Study:** Sacramento Municipal Utility District (page 67)

→ See **Case Study**: Southern Company (page 61)

3.3 Automated Power Factor Correction

Automated power factor correction provides grid operators with new capabilities for managing reactive power flows. Measurement devices provide grid operators and DMS with data on voltages and reactive power levels. Using this information, operators and DMS determine optimal control signals which trigger the switching of capacitor banks. When necessary, distribution operators can manually override commands generated by DMS.

Utility objectives for reactive power compensation include improving power factors and reducing line losses. Accomplishing these objectives potentially leads to significant cost savings due to lower energy and fuel requirements. Electric distribution systems operate most efficiently when power factors are equal to 1.