Division 2-1

Request:

Please provide a qualitative description for each of the ways that the changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act will affect the benefit-cost analyses included in the PST Books in the rate case filing. Please be specific and describe how the new law would affect:

a. The after-tax weighted average cost of capital.

b. The cost of the specific project, including:
   i. O&M costs
   ii. capital costs
   iii. Any other costs

c. The benefits of the project, including:

   i. avoided energy costs
   ii. avoided generation capacity costs
   iii. avoided transmission and distribution capacity costs
   iv. avoided O&M costs
   v. avoided capital costs
   vi. Any other benefits

Response:

Please see the qualitative descriptions below for each of the ways that the changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act will affect the benefit-cost analyses included in the Power Sector Transformation Plan Books in the rate case filing.

a. The after-tax weighted average cost of capital.

The changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act will not affect the Company's after-tax weighted average cost of capital and, therefore, would not affect the benefit-cost analyses included in the PST Books in the rate case filing.

b. The cost of the specific project, including:

   i. O&M costs

The changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act will not affect the explicit tax assumptions related to the operation and maintenance (O&M) costs included in the benefit-cost analyses of the PST investments. It is possible for the changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act to have broader impacts on other sectors of the economy and affect the prices of equipment and service inputs to the proposed PST projects; however, the cost

assumptions included in the benefit-cost analyses reflect the most accurate cost data available to the Company at this time.

ii. capital costs

The changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act will not affect the explicit tax assumptions related to the capital costs included in the benefit-cost analyses of the PST investments. It is possible for the changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act to have broader impacts on other sectors of the economy and affect the prices of equipment and service inputs to the proposed PST projects; however, the cost assumptions included in the benefit-cost analyses reflect the most accurate cost data available to the Company at this time.

iii. Any other costs

The changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act will not affect the explicit tax assumptions related to any other costs included in the benefit-cost analyses of the PST investments. It is possible for the changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act to have broader impacts on other sectors of the economy and affect the prices of equipment and service inputs to the proposed PST projects; however, the cost assumptions included in the benefit-cost analyses reflect the most accurate cost data available to the Company at this time.

c. The benefits of the project, including:

i. avoided energy costs

It is possible that changes to the tax code made in H.R.-1 The Tax Cuts & Jobs Act could affect the wholesale price of electric energy. However, the avoided energy cost forecast included in the benefit-cost analyses reflects the most accurate data available to the Company at this time.[1]

ii. avoided generation capacity costs

It is possible that changes to the tax code made in H.R.-1 The Tax Cuts & Jobs Act could affect Forward Capacity Market (FCM) prices. However, the avoided generation capacity cost forecast included in the benefit-cost analyses reflects the most accurate data available to the Company at this time.[2]

iii. avoided transmission and distribution capacity costs

[1] The avoided energy cost assumptions included in the benefit-cost analyses are from the Avoided Energy Supply Costs in New England: 2015 Report (*See* Attachment DIV 1-2-3 to Division 1-2, Hornby, Rick et al., Avoided Energy Supply Costs in New England: 2015 Report, March 27, 2015, Revised April 3, 2015); The next update of the AESC will be prepared on behalf of the AESC Study Group by Synapse Energy Economics by March 31, 2018 (*see*, Attachment DIV 2-1-1 to this response, AESC Study Group Request for Proposals, Estimation of Marginal Supply Costs Avoided by Electricity, Natural Gas, Fuel Oil, Biofuels, Propane, Kerosene, and Wood Savings from Program Administrator Energy-Efficiency Activities, at 3).
[2] *Id*.

As reflected in Tables 4-4, 5-6, 6-4, 7-3, and 8-3 and Appendix 2.1 of Company's PST Plan[3], the proposed PST investments do not result in avoided transmission and distribution capacity cost benefits.

iv. avoided O&M costs

There are no explicit tax assumptions related to avoided O&M costs included in the benefit-cost analyses of the PST investments. It is possible for the changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act to have broader impacts on other sectors of the economy and affect the prices of equipment and service inputs to the proposed PST projects; however, the cost assumptions included in the benefit-cost analyses reflect the most accurate cost data available to the Company at this time.

v. avoided capital costs

There are no explicit tax assumptions related to avoided capital costs included in the benefit-cost analyses of the PST investments. It is possible for the changes to the tax code made in H.R.-1 the Tax Cuts & Jobs Act to have broader impacts on other sectors of the economy and affect the prices of equipment and service inputs to the proposed PST projects; however, the cost assumptions included in the benefit-cost analyses reflect the most accurate cost data available to the Company at this time.

vi. Any other benefits

It is possible that changes to the tax code made in H.R.-1 The Tax Cuts & Jobs Act could affect economic drivers of the other benefits assumptions included in the benefit-cost analyses. However, the benefits forecasts included in the benefit-cost analyses reflect the most accurate data available to the Company at this time.[4]

(This response is identical to the Company's response to Division 8-1 in Docket No. 4770.)

[3] The Narragansett Electric Company d/b/a National Grid, Investigation as to the Propriety of the Proposed Tariff Changes, Rhode Island Public Utilities Commission, RIPUC Docket No. 4770, November 27, 2017, Schedule PST-1.

[4] Avoided renewable energy credit (REC) cost assumptions, wholesale market price effects assumptions, avoided greenhouse gas externality costs, and avoided criteria air pollutant and other environmental costs assumptions are from the AESC 2015; AESC 2018 is expected to be completed by March 31, 2018 (*see* footnote 1, above). Avoided non-electric fuel cost assumptions used in the Electric Heat Initiative benefit-cost analysis are from the U.S. Energy Information Administration (EIA) 2017 Annual Energy Outlook (*see*, Attachment DIV 1-2-4 to Division 1-2, U.S. Energy Information Administration, Annual Energy Outlook 2017, Table: Energy Prices by Sector and Source, New England Residential Energy Price Forecast, Reference Case); the 2018 Annual Energy Outlook is expected to be published in January 2018 (*see* Attachment DIV 2-1-2 to this response, U.S. Energy Information Administration, "EIA – Annual Energy Outlook," https://www.eia.gov/outlooks/aeo/index.php (downloaded January 12, 2018)).

Prepared by or under the supervision of: Robert Sheridan

REQUEST FOR PROPOSALS

AVOIDED ENERGY SUPPLY COMPONENTS FOR USE IN ENERGY-EFFICIENCY PROGRAM COST-EFFECTIVENESS ANALYSES IN NEW ENGLAND "2018 AESC STUDY"

Estimation of Marginal Supply Costs

Avoided By Electricity, Natural Gas, Fuel Oil, Biofuels, Propane, Kerosene, and Wood Savings from

Program Administrator Energy-Efficiency Activities

PURPOSE

Energy efficiency and demand-side management[1] programs are being offered to customers throughout New England, generally by electric and gas utilities, as well as by other program administrators (collectively, "administrators"). Ratepayer funds support these programs, which focus on reducing energy consumption and peak demand. To support program planning and development, prioritization prior to and during implementation of those programs, and filings with regulators, program administrators must be able to examine estimated program benefits over the lives of the component measures, and possibly beyond (if post-program benefits can be reasonably assumed). Key benefits derived from these energy efficiency and demand-side management programs are the costs associated with avoided use of electricity and natural gas. In addition, several regulatory bodies permit the inclusion of non-electric and non-gas benefits in these benefit-cost analyses.

[1] In the context of AESC 2018, "demand-side management" programs refer to demand response programs, non-wires alternative ("NWA") programs, behind-the-meter battery storage/other behind-the-meter distributed generation ("DG") programs, load growth programs (strategic electrification, electric vehicle programs, etc…), and voltage reduction/optimization programs. Demand response programs may include a broad array of aggregated active load management and peak load shifting programs.

The Program administrators[2] in the region have chosen to solicit bids from consulting firms to provide projections of avoided energy costs which will support their internal program decision-making and their regulatory filings during 2018, 2019, and 2020. These project sponsors, along with non-utility parties and their consultants, constitute the 2018 Avoided-Energy-Supply-Component ("AESC") Study Group[3]. It will be the Study Group's responsibility to select the Contractor to conduct the study, interact with the Contractor, monitor progress of the study, and ensure that the results satisfy the study goals and provide the necessary factors to facilitate the cost-effectiveness analysis.

This 2018 AESC Study is intended to update and enhance prior studies conducted biennially since 1999 which have been based on various methods including a survey of forecasts of market prices for electricity and fuels, production cost modeling, and actual experience in the energy markets (including the influence of plant retirements and shale gas development, clean energy imports and LNG exports, regional electric and gas infrastructure development, and environmental impacts and regulations), as well as the Forward Capacity Market (FCM) and Regional Greenhouse Gas Initiative ("RGGI") auctions. In the 2015 AESC Study, the Study Group moved to a three year cycle. In this Study, the Study Group intends to keep with a three year cycle with limited annual updates, as described below in Task 6.

The Scope for 2018 is intended to maintain continuity with prior studies and ensure consistent application of study results despite the varied nature of program offerings. At the same time, it will expand upon the scope of previous studies to better reflect the benefits from emerging demand-side management programs in addition to the benefits from the more traditional energy efficiency programs that past studies have focused on. As with past studies, the 2018 scope will also reflect the latest developments in the ISO-New England wholesale power market.

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[2] The sponsors of this project include: Berkshire Gas Company, Cape Light Compact, Liberty Utilities, National Grid USA, New Hampshire Electric Co-op, Columbia Gas of Massachusetts, Eversource (Connecticut Light and Power, NSTAR Electric & Gas Company, Western Massachusetts Electric Company, Public Service Company of New Hampshire, and Yankee Gas), Unitil (Fitchburg Gas and Electric Light Company, Unitil Energy Systems, Inc, and Northern Utilities), United Illuminating, Southern Connecticut Gas and Connecticut Natural Gas, Efficiency Maine, and the State of Vermont.

[3] The following agencies or organizations are represented in the Study Group: Connecticut Department of Energy and Environmental Protection, Connecticut Energy Efficiency Board, Massachusetts Energy Efficiency Advisory Council, Massachusetts Department of Public Utilities, Massachusetts Department of Energy Resources, Massachusetts Attorney General, Massachusetts Low-Income Energy Affordability Network (LEAN), CLF, Environment Northeast, New Hampshire Public Utilities Commission, Rhode Island Division of Public Utilities and Carriers, Rhode Island Energy Efficiency and Resource Management Council, and Vermont Department of Public Service.

This Scope includes a proposed schedule for the project (page 27). The Study Group intends for the Contractor to begin work on the project no later than October 2, 2017 and to complete the final report by March 30, 2018. Keeping these dates in mind, the Study Group will look to the Contractor to be furnished with a detailed timeline, consisting of dates for study milestones and deliverables.

The Study Group strongly emphasizes that the intent of this process is to determine energy supply components that will be applied only for the purposes of energy efficiency and demand-side management program planning, evaluation, and implementation and not be regarded as proxies for the market prices of any commodity.

SCOPE OF SERVICES

The objective of the Study is to update the 2015 AESC Study (see http://www.nationalgridus.com/EnergyEfficiencyReports.asp to view the study) avoided costs for current conditions and current cost projections, beginning with a base year of 2018 and going out 30 years through 2048. There are nine distinct forecasts that are contemplated by the study.

1. Avoided natural gas costs
2. Avoided fuel oil costs
3. Avoided electric commodity costs, this includes the avoided renewable energy credit value
4. Avoided electric capacity value
5. Avoided costs of other fuels
6. Value of compliance with greenhouse gas control regulations that is not embedded in avoided commodity value
7. Value of demand reduction induced price effects (DRIPE) for electricity, electric capacity, natural gas, and cross fuel price effects between gas and electricity.
8. Avoided transmission and distribution costs
9. Value of improved electric reliability

The Study Group expects that the Contractor will, through assumptions and methodologies that will be reviewed by the Study Group, develop the requested forecasts for the period 2018 through 2033 and that escalation assumptions will be used to extrapolate the forecasts through 2048. Different real escalation rates may be used, as appropriate, for different avoided cost components (electric energy, electric capacity, natural gas, oil, and other fuels) to apply to final 2030 forecast values through 2048. All forecasts should be presented in real 2018 dollars. Nominal values and discount rate should be presented for all forecasts for Connecticut zones as well. The Contractor will propose and provide justification for a real discount rate to be used only for the purposes of present valuing in the Study, solely for calculating levelized values and comparing results relative to previous Studies (see Task 3). The Contractor will provide instructions

to ensure avoided costs are used consistently and appropriately. The Contractor will also provide an interactive user interface to guide users in the appropriate use of results. Where levelized values are required, three levelized values should be included: for a 10 year period (2018-2028), a 15 year period (2018-2032), and the full forecast period (2018-2048), using the previously identified real discount rate.

The tasks enumerated below identify the information that is to be developed in the 2018 AESC Study. The tasks below identify component deliverables, as well as the final report and data file deliverables. The Contractor will note that some components are naturally dependent on others, and the independent component must be completed and reviewed before preparing dependent components. Deliverables should be labeled as "Deliverable #," followed by a descriptive name. Component deliverables (and any interim deliverables) should be delivered in a format which will allow for a full review by the Study Group. The Study Group reserves the right, as an outcome of the review of the Contractor's work plan, to request specific interim deliverables as well.

The full final report should be provided both in printed form and electronic form. The final report should include the statement of and documentation for all assumptions in the avoided cost forecasts, even if they have been presented previously in component deliverables or other project documentation.

Final avoided cost tables must be provided in Microsoft Excel spreadsheets, which include an active user interface and are suitable for manipulation and use by the users. The Study Group will work with the Contractor to develop an acceptable format for the tables.

The Study Group expects regular and timely communication with the Contractor in the course of the Study, as described further below.

STUDY MANAGEMENT

Two members of the Study Group will serve as the Study Managers. They will organize and facilitate meetings, handle all intra-Study Group communication, be the primary liaison with the Contractor, and monitor the project budget. All teleconferences and meetings will end with a schedule update and summary of action items. The Contractor will send out the same information electronically at the conclusion of each meeting.

In addition to the tasks outlined below, the Contractor will be responsible for timely communication with the Study Group and for managing the schedule of the project. Time is of the essence in the completion of this project as its results feed into regulatory filings that will be prepared beginning in spring 2018. Contractor must also establish adequate internal quality control procedures for reviewing numeric results prior to sending them to the Study Group.

The Study Group as a whole anticipates taking an active role in the execution of the study, including understanding the workings of any models used for the analyses.

Study Group member feedback is expected to be via email, commented documents, or through project meetings. Study Group members may communicate feedback directly to the Contractor, however Study Group members understand that Contractor will address questions and recommendations through project meetings or group communications. Study Group members will, whenever possible, substantiate recommendations for alternative methodologies or assumptions (see Task 2) with supporting documentation. The Study Group members also commit to providing feedback by the dates developed by the Contractor, and understand that late feedback may not be able to be incorporated into the Study.

There are a few key areas that the Study Group expects to review with particular attention. Based on prior studies, these areas are expected to include the natural gas forecast, the cost of compliance with greenhouse gas control requirements, overall GHG abatement costs, the value of capacity, demand reduction induced price effects (DRIPE), including an analysis of DRIPE with respect to natural gas and cross fuel effects, and the applicability of the avoided cost factors to a broad array of demand-side resources, including traditional energy efficiency programs and emerging demand-side management programs.

The selected Contractor will meet with the Study Group at a Kickoff Meeting, preferably in person, or via conference call if necessary, to resolve any outstanding issues related to costs, deliverables, and the expected study output not addressed in the RFP process or this scope of work. In the course of the Study, we expect there will be a number of meetings or teleconferences to discuss the preparation or review of forecast components and deliverables. Beyond regularly scheduled communications, the Contractor is strongly encouraged to alert the Study Group about any questions or issues it wants to discuss that may arise while they are working on the forecast components. The Contractor should be aware that achieving consensus is an important element in the widespread acceptance of the forecast, and account for group interaction and consensus building in the schedule. In the course of the study, Contractor will be required to respond in a timely manner to Study Group member comments about methodologies and assumptions. Work that is beyond that described in this Scope of Work should be approved by the Study Group.

The Contractor should expect that each deliverable will be reviewed by the Study Group, which may lead to revisions. Clear and complete documentation is expected to allow for a full review. Each Study Group member is responsible for reviewing and, if appropriate, commenting on and providing suggestions regarding input assumptions and methodology. Alternatively, through meetings with Study Group members during the analysis and preparation of deliverables, consensus on various assumptions, etc., may be reached, minimizing the necessity of revision. As part of the Study schedule, which must be approved by the Study Group, the Contractor will propose a date by which all input

must be received from Study Group members, and will alert Study Group to any changes Contractor proposes to make as a result of potential new information.

TASKS

TASK 1. Project Set-up and Kick-Off

A. The Contractor will establish an electronic communication protocol for the Study to facilitate review of project documents. (The Study Group anticipates that this will involve an electronic project site, though other forms will be considered.) The project site should meet the following criteria:

1. Contractor and Study Group members will be subscribers or members.
2. Documents should be posted on the site for download, review, and upload.
3. E-mail notification should be sent every time there was a new posting by the Contractor, either through the project site or outside of it.
4. When the project site is established, the Contractor will distribute instructions for use to the Study Group.

B. Develop a schedule for completion of the Study:

1. The Contractor should propose a study schedule showing, at minimum, estimated start and finish date for all Tasks, dates for all deliverables, and dates by which feedback from Study Members needs to be received by Contractor, and planned conference calls/meetings[4] to meet ultimate final deliverable date of March 30, 2018.
2. The Contractor may propose as part of its schedule, in addition to dates for deliverables, the production and delivery of interim deliverables that would support the preparation and review of a forecast component.
3. The proposed schedule should also indicate the timing for identification of up to three sensitivity analyses that are to be performed as part of Task 4.

C. The Contractor will prepare for and attend a kick-off meeting. At the kickoff meeting, the Contractor will, at a minimum, discuss the following items:

1. Project Schedule, including the timing for the assessment of alternative costing periods identified in Tasks 3A and 3C.

[4] Beyond regularly scheduled communications, the Contractor is strongly encouraged to alert the Study Group about any questions or issues they want us to discuss that may arise while they are working on the forecast.

2. Methodology
3. Areas of special focus, or special attention for Study Group, including key assumptions
4. State-specific or Study Group member input required, if any (for example, costs of compliance with state-specific emissions reduction requirements), and the process for incorporating that input.
5. Application considerations

D. **Task 1 Deliverables**

1. **Electronic Communication Protocol and Instruction for Use**
2. **Proposed Schedule of Deliverables and Meetings**
3. **Kickoff Meeting and Presentation**

TASK 2. Develop assumptions and methodologies for avoided cost study products. In this context, "avoided" means the costs avoided or value created by energy efficiency and demand-side management programs over the forecast horizon. For each of the nine forecast products listed in the Scope of Services, the Contractor will describe the methodology and assumptions they propose to use in preparing the forecast.[5] The Contractor may choose to develop the assumptions and methodologies for each of the nine forecast products in parallel or in sequence but, in all cases, the assumptions and methodologies must be presented to the Study Group for review and comment prior to the development of the forecast based on the assumptions and methodologies. Attachment A describes considerations that should be accounted for in the development of the methodology for each forecast component, and the documentation of methodology and assumptions must include documentation on how each of these considerations is proposed to be addressed.

A. **Task 2 Deliverables**

1. **Forecast Assumptions and Methodology Documents: <u>One for Each Forecast Component</u>.** <u>Before</u> developing the estimates of avoided costs, the Contractor will present the Study Group with a memo documenting the chosen methodology,

[5] If a simulation model is proposed for use, information should be provided on the model which clearly describes the model and the input data in general that will be used, including information about how the model is calibrated to actual market prices. If the model is proprietary and not open to the Study Group to review, Contractor shall provide documentation that the model satisfactorily replicates real market conditions.

all input assumptions including source documents and data, and the actual values of those assumptions which it intends to use. The memo will specifically highlight what the Contractor expects to be key drivers of the forecast. The Study Group will review and comment on this document before the Contractor proceeds with forecast development. In developing the proposed schedule for the Study, the Contractor may stagger the scheduling of the deliverables for this task.

2. Request for recommendations on specific research issues. In addition to the comprehensive set of assumptions and methodologies identified above, the Study Group requests that the Contractor also report and recommend on the following specific issues. These may be reported on as part of Task 2 Deliverables, or during the execution of Task 3, as appropriate; in either case, Contractor should explicitly respond to these issues to the Study Group before the completion of work that will be affected by these issues.

    a. The Contractor should recommend, based on a preliminary assessment of its forecast methodology and available data, whether natural gas capacity considerations (see Attachment A) may be properly reflected in the commodity value of natural gas, as in past studies, or whether a separate natural gas capacity value should be developed and introduced into program administrator benefit-cost models.

    b. The Contractor should report on the magnitude of potential variations in source data on natural gas commodity prices and the drivers behind those variations (and some estimate of the probabilities of the various gas prices) that may be used in the preparation of the forecast; this information will inform Study Group's guidance on the development of the natural gas forecast as well as potential sensitivity analyses around the range of natural gas commodity prices.

    c. The Contractor should recommend whether the grades of fuel oil reported in the 2015 AESC (#2, #4, #6, and biofuel blends B5 and B20) are the appropriate categories for use by energy efficiency programs in the current study. This question is being asked because it has been reported that some fuel oil grades have biofuel mixed in.

    d. The Contractor should research and recommend for which zones electric energy and capacity avoided costs should be reported[6]. Any zones should

[6] Avoided electric energy supply components were developed in the 2015 AESC Study for each of the following 9 zones. Zonal boundaries are consistent with ISO-New England definitions:

1. Maine
2. Vermont

be consistent with ISO-NE definitions. Definition of capacity zones should allow for the capture of potential future zonal separation.

i. Contractor will model avoided costs for Connecticut using the following three zones:

1. Connecticut (Statewide)
2. Southwest Connecticut, including Norwalk Stamford
3. Rest of Connecticut (Connecticut excluding Southwest Connecticut)

e. Contractor will examine the ISO-NE load forecast and describe the treatment of energy efficiency and other demand-side management programs in it. Contractor will describe implications of the treatment of energy efficiency and other demand-side resources in the load forecast (i.e., any bias or impact on the avoided cost forecast), as well as the impact on the Installed Capacity Requirement (ICR). Contractor will evaluate whether the impact of energy efficiency and other demand-side resources on the load forecast and ICR varies based on whether or not the resource actively participates in the ISO-NE wholesale markets (capacity, energy, or other), as well as the timing of the impact on future ICR determinations (i.e. whether resources can impact the ICR determination in years beyond the useful measure life). The Contractor will, in consultation with the Study Group, make a recommendation on use or modification of forecast to appropriately account for energy efficiency load reductions for this Study.

f. If a state has identified state regulations or mandates related to reduction of greenhouse gases that are reasonably expected to be enacted and/or enforced in the future that will significantly affect generation prices across New England, but is unable to provide a value for that compliance mandate, the Contractor will assess whether they are able to develop a proposal to develop an estimate of the costs of compliance associated with each of

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3 . New Hampshire
4. Connecticut (Statewide)
5. Massachusetts (Statewide)
6. Rhode Island
7. SEMA (Southeast Massachusetts)
8. WCMA (West-Central Massachusetts)
9. NEMA (Northeast Massachusetts)

In addition, AESC 2013 developed a single capacity value for all New England zones. There were four capacity zones in FCA 7 and FCA 8 (ME, NEMA, CT and Rest of Pool). SEMA and RI were modeled together as an additional separate capacity zone for FCA 9 and FCA 10.

these regulations or mandates for inclusion in the avoided energy forecasts for Task 3D3. Contractor will report on this assessment and may provide a proposal for an addition to the scope of work to develop these value(s) for approval by the Study Group.

g. The Contractor will discuss its proposed methodology for determining the value of all components of DRIPE with the Study Group prior to conducting this analysis, specifically addressing the following aspects of their methodology: (1) treatment of demand reductions from expected future DSM programs, (2) duration of DRIPE, (3) the amount of energy transacted in the market by state that will be subject to the price effect and (4) overlap of price suppression effects among the DRIPE categories (5) consideration of changes in the slope of the FCM demand curve. The Contractor will document its proposed methodology, the components of DRIPE which will be studied, and, if applicable, provide information regarding improvements from the prior forecast methodology(ies).Contractor will also discuss the appropriateness of the proposed methodology with respect to recent empirical market results.

h. The Contractor will examine whether avoided cost components would be expected to differ based on whether or not energy efficiency and other demand-side resources actively participate in the wholesale ISO-NE energy and/or capacity markets. The contractor will discuss with the study group and recommend which, if any, of the avoided cost components should be modeled or reported separately based on the status of wholesale market participation. Contractor will differentiate the modeling of the selected avoided cost components based on the status of participation in the respective ISO-NE markets.

i. The current values for the avoided cost of electric transmission and distribution ("T&D") capacity are utility-specific and are estimated by each program administrator. While a number of the program administrators apply variations of a common T&D avoided cost model, which was developed by ICF Consulting as part of AESC 2005, the methodology for modeling T&D avoided costs may vary for some program administrators. AESC 2018 will seek to evaluate the methodologies that are currently applied by the program administrators to model T&D avoided costs, and will recommend improvements to those methodologies, if applicable.

    i. Contractor will develop a common set of criteria with which to evaluate the methodologies that are currently applied to model T&D avoided costs. Contractor will discuss this set of criteria with Study Group before proceeding to next step.

ii. Contractor will also discuss recommendations regarding the following issues with the study group:

1. The components of electric T&D avoided costs that are applicable to EE and demand-side management programs, including NWA programs (i.e. distribution capacity costs, transmission capacity costs, Regional Network Service charges/other bulk transmission charges, etc…). Contractor will differentiate transmission and distribution capacity as two distinct cost components.
2. The appropriate allocation of avoided pool transmission costs between states/LSEs.
3. Whether the treatment of T&D avoided costs differs for specific technology types and/or program applications, particularly with respect to distributed generation, NWA, and load growth programs.

iii. Following the development of the criteria, Contractor will survey sponsors about the methodology that each program administrator uses to model T&D avoided costs and will provide the survey results, including a description of each methodology that is applied, as a deliverable in Task 2A2i. Contractor will apply the common criteria developed in this task to evaluate the existing methodologies that the program administrators apply to model T&D avoided costs. Contractor will identify any differences between the criteria and the existing modeling methodologies and, if applicable, provide recommendations for improvements to the modeling methodologies. Contractor will discuss recommendations regarding the following issues with the study group:

1. If analysis identifies applicable cost components that are not modeled under the existing methodology, Contractor will recommend a methodology for estimating such cost components and comment on the relative importance of the component to the overall T&D avoided cost estimates. If requested by the study group, Contractor will provide a forecast of the incremental avoided cost components, if applicable, as a deliverable in Task 3H.
2. Applicability of existing methodology to emerging demand-side management programs. If existing models do not appropriately account for the T&D avoided costs from

demand-side management programs, contractor will recommend improvements to the methodology that would appropriately account for the impact of demand-side management programs.

j. The Program Administrators do not currently model an avoided cost for gas Transmission and Distribution (T&D) capacity. Contractor will analyze whether there is an avoided cost of gas transmission and distribution capacity as a result of gas demand reductions and discuss the results of this analysis with the study group. If Contractor's analysis is positive, Contractor will:

   i. Recommend the cost components of gas T&D avoided costs that are applicable to EE and demand-side management programs and comment on the relative importance of each cost component to the overall T&D avoided cost estimates.

   ii. Recommend a methodology for estimating the avoided cost of gas T&D capacity.

   iii. Comment on the applicability of gas T&D avoided costs across the various gas costing periods, as identified in Task 3A3.

   iv. Provide a forecast of the incremental avoided cost components, if requested by the study group, as a deliverable in Task 3H.

k. Contractor will evaluate whether there are incremental benefits of improved electric reliability that occur as a result of energy efficiency and demand-side management programs and are not embedded within the T&D capacity values, as identified in Task 2A2i and 2A2j. If applicable, Contractor will discuss its proposed methodology for estimating incremental reliability benefits with the Study Group prior to conducting this analysis.

l. Contractor should comment on the economic relationship between oil demand in the building and transportation sectors, and, recommend whether changes in the demand for oil within either sector would have a DRIPE impact on oil costs across all sectors. Contractor will discuss the recommendation for Oil DRIPE with the study group and, if applicable, provide an estimate of the value of Oil DRIPE as a deliverable in task 3G.

m. The contractor will discuss its proposed methodology for estimating the avoided cost of wood chips/pellets as a delivered fuel with the study group prior to conducting the analysis outlined in Task 3E1.

TASK 3. Use agreed upon methodology and assumptions to develop forecasts for each of the nine avoided cost components. Prepare and document forecasts

in memo to Study Group. Documentation should reflect the considerations described in Attachment A as well as any resolution of research questions identified in Task 2. For this and all other streams in other deliverables, Contractor should propose and secure consensus from the Study Group about the real and nominal inflation and discounting assumptions used to levelize the stream. Forecast results will be presented in real dollars (2018$) for 2018 through 2048, as well as nominal dollars for Connecticut, in a format acceptable to Sponsors. The forecast will include three levelized costs (10 year, 15 year, and life of forecast) for the stream of avoided costs. Present the forecast values in printed form and in a Microsoft Excel spreadsheet.

A. **Avoided natural gas costs (Deliverable 3A, Regional and Sector-specific Natural Gas Forecasts).** Develop and document the following forecast products for each sector and end use, as specified. This component must be completed before the electric energy forecast component, 3C.

1. Estimates of future natural gas costs[7] avoided by energy efficiency program savings and for the costing periods as specified, for the region as a whole and for each of the six New England States. Results should be provided with and without avoided local distribution company (LDC) margin[8], as in 2015 AESC, and should be stated in all-in $/MMBtu and, depending on the recommendation from Task 2A2b, separated into peak-day $/MMBtu (capacity value) and other $/MMBtu (energy value) for the end use profiles specified as:

   a Electric generation: If necessary for the purposes of the modeling of electric avoided costs, the costs for this sector should be differentiated by season or zone. If by zone, the zones should be mapped to the zones for the electric market defined above in Task 3.

   b Commercial and industrial non-heating

   c Commercial and industrial heating

   d Residential heating

   e Residential water heating

   f Residential non-heating

   g All commercial and industrial

[7] This may be affected by outcome of discussions pursuant to Task 2A2a.

[8] Contractor will request and obtain from sponsoring gas utilities distribution charges applicable from the city gate(s) to the burner tip(s) in the defined regions.

h All residential

i All retail end uses

2. Documentation for this deliverable should also include the following:

   a Wholesale natural gas commodity price projections in $/MMBtu for the region as a whole and for each of the six New England states.

   b Comparison of the commodity price projections and similar projections from the 2013 AESC study through 2015, with some explanation of differences and key drivers;

   c Comparison of the most recent EIA forecast and forecast as represented by the NYMEX futures market.

   d Sector specific end use marginal natural gas commodity costs at the city gate in $/MMBtu for electric generation, commercial, industrial, and residential end uses

3. Contractor will review the gas costing periods applied in the AESC 2015 study, as well as the alternative electric costing period analysis presented in AESC 2015, and expand upon this analysis to assess whether alternative costing period definitions of peak avoided costs may more accurately and reasonably reflect the seasonal and hourly variation of marginal energy costs, in comparison to the definitions presented in 3A1. Contractor's analysis will include an assessment of the applicability of alternative definitions of peak avoided costing periods to traditional energy efficiency programs, as well as emerging demand-side management programs such as demand response and active demand management. If the assessment is affirmative, then Contractor will develop a recommendation, in consultation with the Study Group, for alternative definition(s) of peak avoided costing periods. This assessment and recommendation should be included in Deliverable 3A. Contractor's analysis will include an assessment of the following:

   a The applicability of alternative definitions of peak avoided costing periods to traditional energy efficiency programs, as well as emerging demand-side management programs.

   b The applicability of the alternative electric peak avoided costing periods to the determination of gas cross DRIPE.

   c Programmatic (i.e. contractual, voluntary, etc..) and timing (i.e. real time, day-ahead, seasonal, etc…) conditions necessary for active gas demand management programs to create cross-fuel energy and capacity DRIPE avoided costs.

d Vermont-specific avoided gas costs should be presented for the following time-of-use costing periods, which were applied to the Vermont avoided cost results in AESC 2015:

- Design day
- Peak Period
- Remaining Winter
- Rest of Year

B. Avoided fuel oil costs (Deliverable 3B, Sector-specific Fuel Oil Forecast for the New England Region). Develop and document forecast of New England regional oil prices.

1. Develop forecasts of oil prices, in $MMBtu, used by the following four sectors: electric generation, residential, commercial, and industrial in each state.
2. Develop end use prices for fuel avoided costs separated into the following categories:
   a By grade: #2, #4, #6, B5 and B20 (biofuel blends).
   b By sector: generation, commercial and industrial applications, residential heating applications. The prices for the commercial, industrial, and residential sectors should be those that would be avoided by the installation of oil-saving energy efficiency measures.
3. Contractor should also provide the value associated with mitigation of significant pollutants achieved through fuel oil energy efficiency at the end use level and the emission rates of significant pollutants from fuel oil in lbs/MMBtu.

Documentation for this deliverable should also describe how the forecast compares to the alternative forecasts. The forecast should be compared by grade with the most recent EIA forecast, a forecast as represented by the NYMEX futures market, and other external forecasts that the Contractor may identify. Identify the strengths and weakness of these forecasts, if possible. Also discuss the relative consistency of oil forecast with the natural gas forecast because of fuel substitution effects.

C. Avoided electric commodity costs; this includes the avoided renewable energy credit value (Deliverable 3C, New England Electric Avoided Cost Forecast and Zonal Electricity Avoided Cost Forecasts by Costing Period)

1. Develop and document regional (New England-wide) marginal electric energy costs avoided by energy efficiency and demand-side management savings for the

New England region throughout the projected period. For each of the following costing period components as outlined below, provide streams of energy[9] values for all of New England in $/kWh. The energy price should be the hub price, reflecting congestion and losses. This will provide continuity with future AESC studies.

a summer on peak energy in $/kWh

b summer off-peak energy in $/kWh

c winter on-peak energy in $/kWh

d winter off-peak energy in $/kWh

e hourly[10] energy in $/kWh

2. Documentation for the New England-wide avoided costs should include the following:

   a An explanation of any apparent price spikes and key variables that affect the results.

   b Provide the following analyses of the forecast developed in subtask (1)

   - A comparison to the prior AESC forecast through 2035 (2015 Study, Exhibits 1-2 and 1-6).
   - A comparison of the forecast to a trend of actual monthly prices (real time) from ISO-NE for 2016-17.
   - A comparison of the wholesale price projection with (i) the most recent EIA forecast, (ii) a forecast as represented by the NYMEX futures market, and (iii) other external forecasts that the Contractor may identify, if possible.

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[9] The forecast analyses defined in Subtask 3C should be developed using the following definitions of seasons and costing periods:
Electric Energy Costing Periods: For all zones, Summer On-peak is as defined by ISO-NE, June-Sep., weekdays 7 am to 11 pm; Off-peak is 11 pm to 7 am weekdays, plus weekends, and holidays. Winter period is the remaining 8 months with the same diurnal time divisions, weekends and holidays. The holidays are defined by ISO-New England at http://www.iso-ne.com/stlmnts/holidays/

[10] Hourly energy avoided costs should be provided for all hours in each year, assuming 8760 hours per year. Additionally, Contractor will provide hourly values for the additional parameters that are determined to affect the energy avoided costs (i.e. system load, temperature, humidity, etc…) and the associated marginal electric generation emission rates. Contractor should provide hourly avoided costs and associated parameters in electronic format only.

- A high level discussion of reasons for differences identified in the comparisons in the above bullets, without a detailed re-examination of assumptions made in the 2015 Study.

3. Develop and document marginal electric energy costs avoided by energy efficiency savings, for each of the four electricity components identified above in subpart (1). These will be estimates of future electric supply costs avoided by energy-efficiency and demand-side management program savings at the delivery point to the transmission system for New England as a whole and for each of the regions and zones determined following Task 2A2d, factoring in applicable locational differences such as fuel costs, emissions regulations, and congestion, including generation energy and capacity losses. The avoided costs should also be submitted in a Microsoft Excel workbook with one spreadsheet for each zone.

   a As part of these avoided costs, explicitly show the additions to those prices from the inclusion of

      - Renewable Portfolio Standard ("RPS") compliance,
      - internalized costs of greenhouse gas compliance (separated into compliance currently enforced, enacted or mandated but not yet in effect, and reasonably expected to be enacted); see Considerations in Attachment A for additional information relevant to this component,
      - reserve margin multiplier,
      - wholesale risk premium, and
      - Pool Transmission Facility (PTF) energy and/or capacity losses, if conducive to the Contractor's forecast method. Contractor must inform sponsors whether and which PTF losses are included in the results (see Task 3H below). Local distribution energy and capacity losses should not be included.

   b Contractor will review results of the alternative costing period analysis (the four-hour peak period) presented in the AESC 2015 study and expand upon this analysis to assess whether alternative costing period definitions of peak avoided costs may more accurately and reasonably reflect the seasonal and hourly variation of marginal energy costs, in comparison to the definitions presented in 3C1. Contractor's assessment will explore whether peak pricing avoided costs periods may be more accurately defined by using additional parameters such as weather conditions (e.g., temperature and humidity), system load, etc. Contractor's analysis will include an assessment of the applicability of alternative definitions of peak avoided costing periods to traditional energy efficiency programs, as well as emerging demand-side

management programs such as demand response and active demand management. If the assessment is affirmative, then Contractor will develop recommendations, in consultation with the Study Group, for alternative definition(s) of peak avoided costing periods. This assessment and recommendation should be included in Deliverable 3C.

D. Avoided electric capacity value (Deliverable 3D, Avoided Electric Generation Capacity Value)

1. Develop and document marginal electric capacity costs avoided through energy efficiency and demand-side management savings throughout the projected period. These will be estimates of future electric capacity supply costs avoided at the delivery point to the transmission system for New England or sub-zones determined following Task 2A2d, appropriate for load reduction, and reflecting the payment rate for existing and new capacity resources, zonal clearing prices, rest-of-pool prices, and allocation of Capacity Transfer Rights. Modeling of the avoided capacity costs should also consider the impact of EE and other demand-side resources on the ICR following the recommendations in Task 2A2e. Capacity costs for each capacity zone will be developed in $/kW-year.
2. Provide streams of capacity[11] values for each capacity zone in $/kW-year. The avoided costs should also be submitted in a Microsoft Excel workbook with one spreadsheet for each zone.
   a As part of these avoided capacity costs, explicitly show the additions, if any, to those prices from the inclusion of
      - reserve margin multiplier,
      - wholesale risk premium, and
      - Pool Transmission Facility (PTF) energy and/or capacity losses, if conducive to the Contractor's forecast method. Contractor must inform sponsors whether and which PTF losses are included in the results (see Task 3H below). Local distribution energy and capacity losses should not be included.

   b Contractor will differentiate these avoided capacity costs, if applicable based on Contractor's analysis in Task 2A2h, for the status of participation in the ISO-NE wholesale markets.

[11] Capacity value should be defined consistently with ISO-New England's FCM.

3. Documentation for this deliverable should include the following:
   a Provide the following analyses of the forecast developed in subtask (1)
   - A comparison to the prior AESC forecast through 2032 (2015 Study, Exhibits 1-2 and 1-6).
   - A high level discussion of reasons for differences identified in the comparisons, without a detailed re-examination of assumptions made in the 2015 Study.

E. Avoided costs of other fuels (Deliverable 3E, Other Fuels Forecast)

1. Develop and document avoided costs for other fuels used in residential heating applications for 2018 through 2048; develop these by state, if supported by research. Determine what sources for price projections are available; identify what portions of costs are avoidable; and develop, and implement a methodology for projecting price, by state, of:
   a Cord Wood; in $/MMBtu
   b Wood chips; in $/MMBtu
   c Wood pellets; in $/MMBtu
   d Kerosene; in $/MMBtu
   e Propane; in $/MMBtu
2. Contractor should also provide the value associated with mitigation of significant pollutants achieved through other fuel energy efficiency at the end use level and the emission rates of significant pollutants from other fuels in lbs/MMBtu.

F. Value of non-embedded costs associated with greenhouse gases and other emissions (Deliverable 3F, Non-Embedded Costs and Indices)

1. Develop and document the carbon and NOx mitigation values of energy efficiency as follows:
   a Determine an appropriate dollar value to use for embedded avoided carbon and NOx emissions when screening DSM programs. The values should be developed in $/kWh and $/MMBtu (a range of values would be acceptable; if a range is provided a central point estimate should be provided as well) for 2018 through 2048, and should be consistent with the values included in Task 3C and 3D.
   b Identify and recommend the total value associated with mitigation of carbon and, to the extent necessary, NOx, through electric and gas energy efficiency. The Contractor will further identify what portion, if any, of these values are

embedded in the avoided electricity and natural gas costs and what portions are not embedded, consistent with the categories of embedded values and the values included in Task 3C and 3D.

c Determine an appropriate dollar value of non-embedded costs associated with carbon and NOx emissions (damage costs or abatement costs). The values should be developed in $/kWh and $/MMBtu (a range of values would be acceptable) for 2018 through 2048.

d Determine and quantify indices for embedded carbon and NOx reduction benefits which correspond to energy efficiency reductions, in lbs/MWh and lbs/MMBtu, respectively, during each costing period. These values should be consistent with the assumptions used to develop the avoided electricity costs, i.e., heat rates, fuel sources, and emissions of carbon and NOx in the 2018 base year during each of the energy and capacity costing periods as defined in Tasks 3C and 3D.

G. Value of demand reduction induced price effects (DRIPE) for electricity, electric capacity, and natural gas (Deliverable 3G, DRIPE Values)

1. Develop and document Demand Reduction Induced Price Effects (DRIPE): The Contractor will estimate the effect on wholesale market electric energy and capacity prices resulting from reductions in energy demand on the ISO-NE system due to energy-efficiency savings for 2018 through 2048. The analysis should be consistent with the costing periods as defined above in Tasks 3C and 3D. The results will reflect price effects that may be attributed to the Sponsors' energy efficiency programs. Contractor will differentiate the DRIPE impact, if applicable based on Contractor's analysis in Task 2A2h based on whether or not demand resources participate in the ISO-NE wholesale markets. Results should be presented for intrastate DRIPE (effects confined to state boundaries) and regional DRIPE (where cross-boundary impacts are included as well). Contractor will retrospectively apply the capacity DRIPE methodology to validate the results of the model against recent empirical FCM results. The Contractor will express results of this analysis in $/kW and $/kWh. The forecast will include three levelized costs for the stream of avoided costs, including the assumptions used to levelize the stream.

2. The Contractor will estimate the effect on gas energy prices resulting from reductions in gas energy demand due to energy-efficiency savings for 2018 through 2048. The analysis should be consistent with the costing periods as defined above in Task 3A. The results will reflect price effects that may be attributed to the Sponsors' energy efficiency programs. The Contractor will express results of this analysis in $/MMBtu. The forecast will include three

levelized costs for the stream of avoided costs, including the assumptions used to levelize the stream.

3. The Contractor will estimate the effect, if any, on gas energy prices resulting from reductions in electric energy demand and on electric energy prices resulting from reductions in gas energy demand due to energy-efficiency savings for 2018 through 2048. The analysis should be consistent with the costing periods as defined above in Task 3A. The results will reflect price effects that may be attributed to the Sponsors' energy efficiency programs. The Contractor will express results of this analysis in $/kWh and $/MMBtu, as appropriate. The forecast will include three levelized costs for the stream of avoided costs, including the assumptions used to levelize the stream.
4. Documentation for this deliverable should include a narrative description of the methodology as well as a comparison of the methodology and results to previous AESC studies. Contractor should also compare its methodology and results to similar work on the subject. In addition, the Contractor should provide guidance about how, in the future, users of the DRIPE forecast values developed may assess and confirm their accuracy.
5. Contractor will estimate the effect on oil energy prices resulting from reductions in oil demand due to energy efficiency savings for 2018 through 2048, if applicable based on Contractor's recommendation in Task 2A2l. The results will reflect price effects that may be attributed to the Sponsors' energy efficiency and demand side management programs. Contractor will express results of this analysis in $/MMBtu. The forecast will include three levelized costs for the stream of avoided costs, including the assumptions used to levelize the stream.

H. **Avoided Transmission and Distribution Costs (Deliverable 3H, T&D Avoided Capacity Values)**

1. Electric T&D Avoided Cost Components: Contractor will develop and document the value of incremental electric T&D avoided cost components, if applicable, which were identified in Contractor's analysis in Task 2A2i. Contractor will present the avoided electric T&D cost components in $/kW-year, $/kWh, or another appropriate format, as applicable based on the avoided cost component modeled. If additional electric T&D cost components are utility-specific, Contractor will provide excel-based models to sponsors in order to facilitate utility-specific estimates of the respective avoided cost components.
2. Gas T&D Avoided Cost Components: Contractor will develop and document the value of gas T&D avoided cost components, if applicable, which were identified in Contractor's analysis in Task 2A2j. Contractor will present the avoided gas

T&D cost components in $/MMBtu, or another appropriate format, as applicable based on the avoided cost component modeled. If additional gas T&D cost components are utility-specific, Contractor will provide excel-based models to sponsors in order to facilitate utility-specific estimates of the respective avoided cost components.

3. Losses: If electric transmission energy or capacity losses are included in the forecasts prepared in Task 3D, the Contractor should prepare a summary of the embedded loss factors by costing period by zone. Sponsors will compare these values to their own utility-specific loss factors for reasonableness.

I. **Value of Improved Electric and Gas Reliability (Deliverable 3I, Reliability Values)**

1. Contractor will develop and document the incremental reliability benefits of energy efficiency and other demand-side management programs: Contractor will estimate the value of improved customer reliability for electricity service resulting from reductions in demand or from behind-the-meter generation that are driven by energy efficiency and other demand-side management programs and are not embedded in the existing T&D avoided costs, as identified in Task 2A2j. Contractor will evaluate the impact that different demand-side management technologies have on electric reliability and, to the extent that benefits vary for different technologies, will differentiate the values by technology type. The value of reliability should consider improvements both at the grid level and for individual customers as a result of onsite backup generation. Values should be developed in $/kW-year. The analysis should be consistent with the costing periods as defined above in Tasks 3C and 3D.

TASK 4. Other Report Components to be included in draft final report

A. Sensitivity Analyses (this task should be performed after Task 3A):

1. The Study group requests that sensitivity analyses be performed to provide information on how major changes to key assumptions may affect electric avoided costs. Sensitivity analyses will be performed around no more than three issues for electric avoided costs, one of which will be natural gas pipeline capacity and commodity costs[12] (others might be, for example, loads or net loads, capacity resources, and plant retirements). The exact parameters of the sensitivity will be

[12] Contractor will analyze this as a two-part sensitivity scenario, considering sensitivities around (a) natural gas pipeline capacity and (b) natural gas commodity costs.

determined as the study progresses. The results of the sensitivity analysis should be included in the final report, including key figures and summary tables for which the sensitivity results are particularly informative. Subject to the parameters of the chosen sensitivity analyses, the Study Group expects that the results will be presented relative to the New England Basic Avoided Cost forecast for electric avoided costs (see Tasks 3C and 3D and the regional wholesale natural gas commodity price projections (see Task 3A), and not at a further disaggregated level.

B. Instructions for Proper Use of Avoided Cost Forecasts:

1. Develop a set of application instructions to which Sponsors and others may refer to ensure proper use of avoided cost tables (similar to Appendix A of the 2015 AESC Study). Instructions should include, but not be limited to:

   a guidance on the estimation of savings by costing period and season to match avoided costs developed in the study

   b illustrative equations on the calculation of value, e.g., savings x avoided cost x loss factor x reserve margin, for each of the avoided cost components

   c indication of what types of savings may or may not be eligible for certain components of value

   d instruction on how to develop levelized values from the stream of avoided costs provided for time periods other than the three periods for which levelized values are presented

   e A reminder that all avoided costs are in real 2018 dollars and what steps must be taken if it is desired to convert them to nominal dollars for states other than Connecticut.

C. Avoided Cost User Interface

1. Develop an excel-based user interface appropriate for the detail and flexibility of the final avoided cost results. This task will only be required if changes are made to costing periods (determined in Tasks 3A, 3C, 3D). If changes are made, the tool will be developed to manipulate the results to the costing period required by the user. The interface should:

   a use simple excel functionality, such as drop downs, simple logic, and/or macros

   b allow user to specify state and PA as initial inputs

   c allow user to specify costing period of interest based on current or alternative costing periods pursued in the study (hourly, system load, weather, etc.)

d generate tables of avoided costs based on user specific information

e be self-contained and transparent, including definitions and directions as necessary

f provide shortcut or default settings to current costing period results

D. **TASK 4 DELIVERABLES**

1. **Sensitivity Analysis**
2. **Usage Instructions**
3. **8760 Avoided Cost User Interface**

TASK 5. Presentation and Follow-Up:

a. **DRAFT FINAL DELIVERABLE.** Submit a draft final report to all Study Group members by February 23, 2018 in an electronic format suitable for reviewing and testing. The draft final report will include:

i. An executive summary including the following:

- An overview of the study, methodological processes, and key findings and interpretations.
- The following tables comparing the results of the 2018 AESC and the present study:
  a. Comparison of 15 year levelized avoided cost of natural gas delivered to retail customers by end use by state
  b. Comparison of 15 year levelized avoided natural gas capacity costs by state (if Study Group has instructed Contractor to prepare this separately)
  c. Comparison of 15 year avoided electric energy costs by costing period for New England overall and by zone
  d. Comparison of 15 year levelized avoided electric capacity costs by state
  e. A single "all-in" 15 year stream of avoided electric avoided costs for New England in $/kWh, combining electric energy and capacity and specifying the assumptions used to combine various values and create the stream.
- Additional tables to summarize the following results:

a. Illustrative calculation of differential in avoided energy costs for 2018 versus 2015
b. Summary of electric DRIPE results by state
c. Summary of natural gas DRIPE results by state
d. Summary of other fuel results
e. Summary of emissions values, embedded and non-embedded, by fuel

ii. A section for each of the nine forecast components outlined above. Each section should contain a complete and detailed description of methodology and assumptions supporting the final results, as well as the results themselves. To make the final report a standalone document, the sections should contain relevant information that had been previously presented and documented in component deliverables. Each section should specifically address which key assumptions affect the results for that component, and a general indication of the magnitude of their influence. Previous studies should be referenced if necessary or useful. The final report should also include the results of any follow-up analyses.

- The Draft Final Deliverable of natural gas and electric energy avoided costs should include the Contractor's assessment of alternative costing period definitions and, if directed by the Study Group, the recommended alternatives. The project sponsors will review the results of the assessment and decide whether to request that the Contractor develop and report in the Final Report an additional set of avoided energy cost data disaggregated according to an alternative formulation of costing periods.

iii. A section including the items requested in Task 4 (e.g., PTF losses, user interface, and usage instructions).

iv. Appendices with the developed avoided energy supply costs by zone for easy application by Program Administrators.

v. All avoided energy supply costs presented in the draft final report shall be in real 2018 dollars, covering the period 2018 through 2048. Three levelized values should be included: for a 10 year period (2018-2028), a 15 year period, (2018-2032) and the full forecast period (2018-2048), using the previously identified real discount rate.

vi. All numeric results should be provided electronically as well.

b. At an appropriate interval after delivery of the draft final report, on or around March 16, 2018, there will be a meeting at which presentation and discussion of the results of Tasks 3 and 4 will occur.

i. Following the oral presentation, the Study Group members will submit outstanding written comments on the draft final report to the Study Managers and the Contractor.[13] The Contractor will revise and resubmit per the oral discussion and written Study Group comments. Following an opportunity for further communication between the Contractor and Study Group, the report will be declared final upon a consensus finding by the Study Group.

ii. **FINAL DELIVERABLE.** The final report will be delivered via one hard copy in a three ring binder and electronically in Word and PDF format to all distinct parties represented in the Study Group by March 30, 2018. Final avoided cost tables will be submitted in the specified formats in Excel and PDF format as well. All avoided energy supply costs presented in the final report shall be in real 2018 dollars (and nominal and real dollars for Connecticut zones), covering the period 2018 through 2048. Three levelized values should be included, for the 10 year, 15 year, and full forecast period, as described above, using the previously identified real discount rate.

c. Following delivery of the final report, the Contractor will work with the Study Managers (along with any other interested Study Group member) to:

i. Review and revise this scope of work for possible use in the anticipated 2021 update of the AESC study.

ii. Identify potential process improvements for future updates of the AESC Study.

The Study Managers will disseminate a summary of this work to the Study Group.

d. The Contractor may be called upon for a period of time until a new Study is underway, or a date agreed upon by the Study Group members and Contractor, to do follow-up Program Administrator (PA)-specific analyses for individual Study Group members. The Contractor may also be called upon to provide testimony during briefings or regulatory proceedings whenever the results of the Study are relied upon in a PA Energy Efficiency docket. Hours for this follow-up work should not be included in the proposal, but a billing rate should be provided, as noted below in "Proposal Requirements."

i. If revisions are created as a result of this follow-up work, a revised electronic version of the follow-up work should be sent to all members of the Study Group, with an accompanying memo highlighting the changes and identifying the affected pages of the final report.

[13] The format of the transmission of the final set of comments may change depending on the experience with the electronic project site.

TASK 6. 2019 UPDATE OF AESC 2018:

a. At the beginning of 2019, the Contractor will prepare a list of key inputs of the 2018 Study that have a significant influence on forecast of avoided cost components and for which an update since the publication of the 2018 Study report has been issued or created. Such list will include, but need not be limited to a natural gas commodity forecast, ISO-NE load forecast and the FCM auction results. In collaboration with the Study Managers, no later than the end of February in 2019, a memo will be prepared and forwarded to the Study Group containing this list, Contractor's high level estimate of the change in the input parameter from that incorporated into the 2018 AESC Study (for example, "the clearing price for FCA 13 was X% lower than the clearing price for FCA 12") and Contractor's qualitative assessment about how this change may affect the affected avoided cost component over the forecast horizon.

b. Meet with the Study Group to review and discuss the list of key inputs under consideration for updating.

   i. Study Group will select a limited list (between 2 and 5) of these inputs for updating

   ii. Study Group states will decide whether or not to participate in the Update

   iii. Contractor will develop and present a price estimate and proposed schedule for the Update based on the selected update parameters and participating states for review and approval by participating Sponsors

c. Contractor will update the 2018 AESC forecast with the selected revised inputs. No changes to methodologies or models are expected.

d. Contractor will provide a draft Study Supplement to the participating states, containing documentation for the updated inputs and their sources, and a revised full set of tables for all forecast components (even those unaffected by updated inputs).

e. Participating Study Group members will have the opportunity to review and comment on the draft Study Supplement prior to a Final Study Supplement being issued

f. Contractor will provide a Final Study Supplement to participating Study Group members.

PROPOSAL REQUIREMENTS

Bidder's responses must include:

1) Methodology:
   a) A description of the bidder's proposed electronic communication protocol, per Task 1.
   b) Identification and descriptions of any data sources, methodology(ies), and work plan that the bidder proposes to use to prepare direct estimates of future gas, oil, marginal electricity supply, electric DRIPE, gas DRIPE, other fuel costs, and embedded and non-embedded costs of environmental impacts of fuel consumption avoided by energy-efficiency programs (as described in Tasks 2 and 3, and Attachment A).
   c) A detailed description of all models expected to be used, including the extent to which they are transparent and can be reviewed by the project sponsors. Detailed reporting on past experience with these models in approximating actual prices, costs, other outputs, or other modeled factors should be included.
2) Project Management:
   a) A proposed schedule, including a date for each of the intermediate deliverables as well as the final report.
   b) Written assurance that the proposed work will be provided by the due date specified below.
   c) A description of the bidder's proposed internal quality control procedures.
3) Experience and Qualifications:
   a) Descriptions of projects that demonstrate relevant experience.
   b) Names of the principal personnel that will be responsible for performing the work and preparing the deliverables, plus a brief statement of their qualifications including their participation in the projects cited as relevant experience.
   c) References for relevant work performed in the last three years.
4) Costs:
   a) The total cost for each of Tasks 1 through 5, and total costs summed up across all tasks, along with the hours and hourly rates listed separately for all projected management, professional, analytical, and support personnel. Contractor will break out the incremental cost for all tasks, if applicable, for the work associated

with expanding the scope of the study beyond traditional energy efficiency programs to include emerging demand-side management programs[14].

b) An hourly and daily billing rate that will be charged for additional work in the course of the project and for any and all follow-up work requested by the Study Group or individual sponsors, including Annual Updates, for a period of approximately three years following delivery of the final report.

c) An estimated cost for performing Task 6 in 2019, assuming that (1) the update in both years is limited to the natural gas commodity forecast, new FCM results, and a new ISO-NE load forecast; (2) that Study Group input is limited as described and (3) that four states will desire a Supplemental report. In their proposals, bidders are invited to discuss other factors or assumptions that affected the pricing for this task.

5) Conflict of Interest disclosure. The Study Group requests that all bidders disclose similar work performed for another party currently or in the past twelve months that would potentially influence or inhibit the bidder's ability to perform the AESC work as defined by the Scope of Work and directed by the Study Group. Bidders are requested to complete Attachment B and return it with their proposal.

Responses may further include:

1) Any questions, concerns or issues, comments or relevant suggestions on the study as described in the Scope of Work for discussions at the initial meeting with the Study Group

Responses, not including resumes or supporting documentation of relevant similar work, should not exceed 30 pages.

PROPOSED SCHEDULE

Kickoff Meeting, week of October 3, 2017, location TBD

Mid Study update meeting, January 2018.

[14] Contractor will list incremental costs associated with the modeling of demand-side management programs only where there is an incremental cost beyond that for the modeling of traditional energy efficiency programs. Contractor will identify the specific deliverables and cost components where the modeling of demand-side management programs results in an incremental cost.

Final Draft Deliverable, February 23, 2018

Report Presentation, March 16, 2018

Final Report, March 30, 2018

CONTRACT ISSUES

Contracts with the Contractor will be executed with each of the sponsoring entities. Sponsor's Terms and Conditions are attached. The Contractor will bill each sponsor individually according to their percentage of the project cost. Sponsors will process invoices in a timely manner. These percentages will be provided at the time of project Kickoff.

Bidders should note that, because state agencies are among the Sponsors of this project, all material that will be shared with the Study Group should be considered to be in the public domain.

It is expected that project Sponsors will be billed for work completed in association with completed deliverables, with payments capped at the total proposed bid for Tasks 1 through 5. Annual Supplement will be billed separately as completed.

ATTACHMENT A.

1. Electric Energy and Capacity Forecast considerations:

- Current and expected ISO-NE and Federal Energy Regulatory Commission ("FERC") rules and procedures governing the structure and operation of the electricity market in New England, including implementation of the two-settlement design in the FCM (also referred to as "Pay for Performance"), the integration of Demand Response into the ISO-NE energy and reserve markets, and the NEPOOL Integrating Markets and Public Policy (IMAPP) project.
- Known or forecast generation retirements
- Most recent ISO-NE load forecast, transmission system projects, and capacity additions and retirement assumptions reflected in the 2018 Capacity, Energy, Loads and Transmission ("CELT") report, 2017 Regional System Plan ("RSP"), and recent work by ISO-NE's Energy Efficiency Forecast Working Group.
- Four categories of costs related to emissions control pursuant to federal, regional, and state emissions control requirements for NOx (including high electric demand days), SOx, carbon/CO_2 equivalent, and mercury:

  1. currently enforced, such as, but not limited to, RGGI; Contractor should consider available data, for example, including results of RGGI auctions to date and projections for future RGGI auctions;
  2. enacted, but not yet in effect;
  3. reasonably expected to be enacted. Contractor will recommend, in consultation with the study group, state and federal regulations, which are expected to be enacted within the forecast period, to be included in the forecast.
  4. non-embedded costs associated with greenhouse gases and other emissions.

  In this Study, the first three categories should be considered to be "embedded" in avoided costs, and should be assessed and separately identified in the avoided energy cost forecast. See Attachment A, Section 6, below for considerations about the costs that are not embedded in generation costs.

  If there is some component of compliance with federal and/or state-specific regulations or climate plans, that directly impacts generators, that are reasonably expected to be enacted and/or enforced in the future, which can be quantified and credibly supported, and which will have a significant impact on other states in the region, it should be included in one of the three categories included in the avoided energy cost forecast. Study Group members from each state will inform the

Contractor of requirements that fall into the first two categories. Other than expected RGGI values, Study Group members will provide a quantitative valuation of the cost of complying with the requirements in the first two categories. **Contractor should inform Study Group at what point in schedule this information will be needed**. Contractor will determine how to include all embedded costs in its development of avoided energy costs and to ensure there is no double counting of the values of the various compliance values.

If no value has been provided by a state, the Study Group may authorize the Contractor to develop a value as additional work. Because of the nature of the regional market, the costs of complying with one state's law may also affect avoided costs in other states in the NE market. However, Contractor would not be asked to determine value of full compliance with these plans, laws, or regulations or the impact of energy efficiency on other sectors that may also be covered by them, such as transportation or industry, in achieving the overall objectives of the plan, law or regulation (in the case of GWSA, these costs may be developed in a broader stakeholder process per Massachusetts Department of Public Utilities order in Dockets 11-120 or 14-86).

- Results of Forward Capacity Auctions and Regional Greenhouse Gas Initiative auctions.
- Renewable portfolio standards ("RPS") and alternative portfolio standards ("APS"). All New England states have adopted some form of renewable portfolio standard. Contractor will examine the relevant RPS regulations, make an assessment of non-compliance with the standards, and account for the standards—as well as non-compliance—in the resource mix for generation. The Contractor will estimate the costs to comply with applicable renewable energy requirements in each state for 2018 through 2048. This cost shall then be presented as a cost saved per retail kWh avoided. Additionally, Contractor will evaluate whether there is an incremental direct benefit to certain technology types from the generation of RPS or APS credits (for example heat pumps may be eligible to earn APS credits in some states) and, if applicable, will present this benefit in an appropriate unit (i.e. $/kWh generated, $/kW, etc…).
- Active market participation: Contractor will identify whether the avoided cost factors would differ based on whether or not the resource actively sells energy and/or capacity products in the ISO-NE wholesale markets.
- Other factors that will influence market prices including, but not limited to: Current and projected values of market-based locational marginal prices, other locational factors that may differentiate prices between zones as defined by ISO-NE, zonal capacity prices, congestion charges, and operating reserves.

- Current and projected values of any avoidable costs not internalized in the market prices going forward (such as the cost of reliability must run generating plants and renewable energy credit purchases avoided by generators or load servers[15]).
- Other recent market developments including, but not limited to, short and long term supply of, demand for, and price of natural gas infrastructure and electric generation to the New England region.
- Market fuel prices applicable to marginal sources. These values should be consistent with generation-related gas and fuel oil price projections provided under Task 3.
- Fixed and variable O&M costs (excluding fuel) of marginal units.
- Heat rate, marginal fuel mix, and capital cost of new generation additions.
- Load growth by regions or zones.
- Major transmission projects that are currently planned to be in service during the planning period. Certain projects may have major implications not only for avoided T&D costs, but also for locational marginal prices, zonal capacity prices, congestion charges, operating reserves, super-peak, and other costs.
- Wholesale Risk Premium: The Contractor will develop a wholesale risk premium for energy and capacity, as applicable, to reflect the premium that generators may include in their wholesale contract prices over and above the cost of generation. The premium, expressed as a percentage addition to avoided costs, should reflect only that portion of generation prices that would be avoided by the implementation of energy efficiency. The contractor will substantiate the wholesale risk premium assumption by conducting an empirical analysis of historical supply rates as compared to wholesale prices for electric energy and capacity.
- Reserve Margin Multiplier: Energy efficiency capacity reductions create value by reducing reserve requirements. The reserve margin multiplier is the number by which generation capacity value should be multiplied to incorporate the reserve margin benefit. The Contractor should research the methodology currently used by ISO-NE to develop its reserve margin, consider factors that may influence it over the forecast horizon, and make a recommendation for a single reserve margin multiplier for application over the entire forecast horizon.

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[15] The cost of compliance with renewable portfolio standards should be included in the cost of generation (see Task 3D3). In addition, energy efficiency reduces the need for generation; therefore load serving entities may avoid purchase of some Renewable Energy Credits. Both effects of RPS should be included in the avoided costs.

2. Natural Gas Forecast Considerations

- Commodity
    - Sources of commodity, basis, and supporting assumptions.
    - Assumptions on new supply that may be avoided by energy efficiency and the incorporation of this new supply in the forecast.
    - Assumptions made regarding the impact of shale gas on the price and demand for natural gas in New England. Also consider impact of potential regulation of hydraulic fracturing techniques to the extent that such regulation is known and documentable.
    - Methods used for the gas commodity forecast for each state, as appropriate.
- The forecast method should address the issue of long-term volatility and/or uncertainty and price spikes of gas prices.
- Capacity
    - Wholesale demand/capacity cost projections for the region as a whole and for each state.
    - Timing and cost of new transportation, storage, and peak shaving projects that will be available to serve the region in the future, both short and long term.
    - Wellhead, transportation, storage, and peak-shaving costs and characteristics for natural gas available to the region.
    - Major gas transmission projects that are currently proposed for the region including costs and expected increased capacity. Assess the need and avoided cost of new pipeline transmission capacity for natural gas as a result of the EE programs. This would essentially involve reviewing proposals for new pipelines to determine costs, reviewing the current high demand days for natural gas on LDC systems and the current high demand days for natural gas generation to determine how much, if any additional transmission pipeline capacity may be needed, and overlaying projected natural gas EE measures on these high demand days to determine the impact. This might end up largely tracking some of the variables in Tasks 3C and 3D on avoided electric capacity.
- Combination of commodity and capacity

- Determine those gas supply sources likely to serve as marginal resources in the New England region during appropriate seasonal and peak day costing periods for the period 2018 through 2048, based on:
  - Current and projected wellhead, transportation, storage, and peak-shaving characteristics for natural gas available to the region.
  - Consideration of how firm vs. interruptible supply is handled for generation.
  - Expected regional sales volumes and demand levels.
  - Costing period definitions that reflect measures that save natural gas 12 months per year and those that save during the heating season only.
- A reasonable, clearly stated, and transparent method of matching anticipated resources and loads for determining marginal supply sources (which need not involve through-put simulation).
- Projected gas wellhead prices and transportation tariffs to the city gate for each identified geographical division applicable to marginal sources (using secondary sources if desired).
- Conversion of peak day sendout prices, loss factors, fuel price escalation rates, allocation of load shapes to end uses, contract provisions, stated transportation/compression losses.

- Examine the value of gas and electric EE and demand-side management programs reducing gas demand and thereby reducing the probability of constraints on the reliable supply of natural gas for electric generation and/or heating (reliability may be a natural gas DRIPE consideration as well, but should not be double counted, and should reflect the monetary value of reliability on natural gas avoided costs, as opposed to a non-energy impact).
- Environmental impacts of natural gas efficiency: There is an environmental benefit from reduced combustion of natural gas due to natural gas energy efficiency programs. The Contractor will consider the various pollutants created by the combustion of natural gas, assess whether they are significant and internalized into the cost of natural gas. For each pollutant determined by Contractor to be significant, the Contractor will present the value associated with mitigation of that pollutant through natural gas energy efficiency. They will further identify what portion, if any, of this value is be internalized in the avoided natural gas costs and what portion should be treated as a non-embedded cost. This

should also consider whether natural gas EE programs will have a positive impact on reducing leaks on the system.

3. Fuel Oil Forecast Considerations

- Penetration assumptions used to weight grade specific fuel oil costs into sector specific costs.
- Whether and how fuel oil incorporates a certain amount of biofuel
- How the forecast method addresses the issue of volatility and/or uncertainty of oil prices.
- What portions of the fuel costs are avoidable and how that is reflected in the avoided costs.
- Sector specific characteristics, such as typical contract provisions, transportation charges
- Environmental impacts of fuel oil. There is an environmental benefit from reduced combustion of fuel oil due to energy efficiency programs. The Contractor will consider the various pollutants created by the combustion of fuel oil, assess whether they are significant and internalized into the cost of fuel oil. For each pollutant determined by Contractor to be significant, the Contractor will present the value associated with mitigation of that pollutant through fuel energy efficiency. They will further identify what portion, if any, of this value may be internalized in the avoided fuel costs and what portion should be treated as a non-embedded cost.
- Contractor should also provide the value associated with mitigation of significant pollutants achieved through fuel oil energy efficiency and the emission rates of significant pollutants from fuel oil in lbs/MMBtu.
- Other key drivers to the forecast.

4. Demand Reduction Induced Price Effect (DRIPE) Forecast Considerations

- Demand reduction induced price effects refers to the price effects seen by customers as a result of demand savings.
- The Contractor will conduct their analysis of price effects following the Study Group's consideration of the methodological proposal identified in Task 2.
- Information regarding the existence of demand reduction induced price effects for gas (gas DRIPE), and the method the Contractor would use to provide forecasted

values of gas DRIPE by state. This must include a close look at the increased reliance on natural gas for electric generation and the impacts that natural gas EE will have on reducing demand during peak heating season.

- In addition to examining the interaction between gas supply and the generation market, examination of natural gas DRIPE should also consider energy efficiency's impact on the following aspects of the natural gas market, including
    - reliability of LDC supply of natural gas
    - volatility of natural gas prices
    - the use of transmission pipeline that is used to supply both generators and distribution customers
    - the availability of distribution capacity and commodity
- Develop an assessment of the impact of natural gas energy efficiency programs on reliability and capacity during peak heating season to support evaluation of DRIPE for natural gas. This should take into account the effect of increased reliance on natural gas for electric generation, and may introduce some cross fuel DRIPE effects, while ensuring that DRIPE is not double-counted.

5. Other Fuels Forecast Considerations

- Environmental impacts of other fuels. There is an environmental benefit from reduced combustion of other fuels (e.g., kerosene, wood) due to energy efficiency programs. The Contractor will consider the various pollutants created by the combustion of other fuels assess whether they are significant and internalized into the cost of these other fuels. For each pollutant determined by Contractor to be significant, the Contractor will present the value associated with mitigation of that pollutant through energy efficiency. They will further identify what portion, if any, of this value may be embedded in the avoided other fuel costs and what portion is not embedded.

6. Considerations about non-embedded costs associated with greenhouse gases and other emissions

- There are believed to be costs associated with the emission of greenhouse gases and other emissions that are not currently reflected or anticipated to be reflected in the market prices for energy. These could be the cost of abatement to reach a desired level of a pollutant in the atmosphere or the cost of the damage to society.
- There is an abundance of literature and information about what these costs might be. Contractor should provide a sound theoretical explanation of the values

recommended, using data from existing studies, or other information developed by the Contractor.

- The non-embedded costs should be identified relative to the total costs of abatement or damage, minus the costs for compliance included in the avoided energy costs
- The total damage or abatement values should be generally applicable to all states.
- Contractor is not being asked to provide state-specific recommendations on how to use these values.
- For natural gas, also consider the costs of mitigating pipeline leakage which introduces methane into the atmosphere.

7. Considerations about non-embedded economic benefits

- There have been efforts in RI to model "economic benefits" that are not embedded in the AESC avoided costs. Such "economic benefits" have been modeled to show increases in state domestic product that result from energy efficiency program spending and the associated benefits to end use customers.
- Contractor will consult with the study group and comment on whether the wholesale avoided cost forecasts account for such "economic benefits." Contractor is not expected to model the "economic benefits," rather to provide a theoretical explanation of whether or not some portion of those benefits would be embedded within the avoided costs presented in this study.

Attachment B

ORGANIZATIONAL CONFLICTS OF INTEREST

DISCLOSURE STATEMENT

Solicitation Name/ Number: _____

Check all appropriate boxes, sign and return as part of your solicitation response.

On behalf of my organization, I represent that it (1) is not currently providing, and has not provided in the last 12 months, services to any other client relating in whole or in part to the same subject matter as the AESC solicitation; (2) has no actual or potential conflict of interest with respect to the subject matter of the AESC solicitation; and (3) is able to render impartial and objective services to the AESC sponsors.

On behalf of my organization, I represent that it is able to render impartial and objective services to the AESC sponsors even though it may have an actual or potential conflict of interest in that it is currently providing, or has provided in the last 12 months, services to other clients relating in whole or in part to the same subject matter as the AESC solicitation.

If this box is checked, please submit sufficiently detailed information, including an explanation as to how any actual or potential conflict of interest will be mitigated, to allow a meaningful evaluation of the potential effect of the interest on the performance of the AESC scope of work. Failure to provide sufficiently detailed information may result in the organization being determined ineligible for award of the solicitation.

The AESC Study Group will determine in their sole discretion whether the disclosed interests are likely to affect the integrity of the AESC scope of work. Information provided on the statement will constitute a material representation as to the award of this contract. The AESC Sponsors, in their sole discretion, reserve the right to cancel or amend the resulting contract if the organization fails to disclose an actual or potential

organizational conflict of interest, which it knew or should have known about, or if the organization provided information on the statement that is materially false or misleading.

On behalf of my organization, I represent that, if, after submission of this disclosure statement, the organization becomes aware of any additional actual or potential conflicts of interest with respect to the subject matter of the AESC solicitation, it will disclose the relevant facts as part of a revised disclosure statement.

Organization: _____

Signature: _____

Name: _____

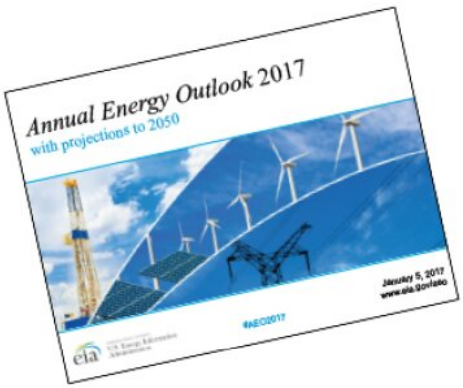
Title: _____

Date: _____

U.S. Energy Information Administration

Annual Energy Outlook 2017

Full Release Date: January 5, 2017 | **Next Release Date:** January 2018 |
correction
|
full report



Annual Energy Outlook 2017

presents yearly modeled projections
and analysis of energy topics
Download

The *Annual Energy Outlook* provides modeled projections of domestic energy markets through 2050, and includes cases with different assumptions of macroeconomic growth, world oil prices, technological progress, and energy policies. With strong domestic production and relatively flat demand, the United States becomes a net energy exporter over the projection period in most cases.

The Annual Energy Outlook provides long-term energy projections for the United States

- Projections in the *Annual Energy Outlook 2017* (AEO2017) are not predictions of what will happen, but rather modeled projections of what may happen given certain assumptions and methodologies.
- The AEO is developed using the National Energy Modeling System (NEMS), an integrated model that aims to capture various interactions of economic changes and energy supply, demand, and prices.
- Energy market projections are subject to much uncertainty, as many of the events that shape energy markets and future developments in technologies, demographics, and resources cannot be foreseen with certainty.
- More information about the assumptions used in developing these projections is available shortly after the release of each AEO.
- The AEO is published pursuant to the Department of Energy Organization Act of 1977, which requires the U.S. Energy Information Administration (EIA) Administrator to prepare annual reports on trends and projections for energy use and supply.

Division 2-2

Request:

For each of the benefit-cost analyses included in the PST Books in the rate case filing, please recalculate the analysis to account for all the effects of the changes to the tax code made in H.R.-1 The Tax Cuts & Jobs Act. Please explain how your answers to the previous question affected each of the benefit-cost analyses. Please provide all workpapers, workbooks, and calculations in machine-readable format with formulas intact.

Response:

The Company has not recalculated the benefit-cost analyses of the proposed investments described in Chapters 4 through 8 of its Power Sector Transformation (PST) Plan (Bates Pages 68-160 of PST Book 1) to account for effects of the changes to the tax code made in H.R. 1 The Tax Cuts & Jobs Act. As described in the Company's response to Division 2-1, the changes to the tax code made in H.R. 1 The Tax Cuts & Jobs Act will not affect the after-tax weighted average cost of capital or the explicit tax assumptions included in the benefit-cost analyses of the proposed PST investments. As further described in the Company's response to Division 2-1, although it is possible that the changes to the tax code will have broader economic impacts affecting the costs and benefits of the proposed PST investments, the assumptions included in the benefit-cost analyses reflect the most accurate data available to the Company at this time.

(This response is identical to the Company's response to Division 8-2 in Docket No. 4770.)

Prepared by or under the supervision of: Robert Sheridan

Division 2-3

Request:

Regarding the Grid Modernization investments described in Schedule PST-1, Chapter 3, except for the AMF initiative, please describe in detail the methodology that the Company used in the best-fit/least cost assessment.

Response:

As presented in the Department of Energy Modern Distribution Grid Report (Volume III, page 40) [1], the most practical approach to evaluating core platform investments involves the following best-fit/least cost methodology:

The first step is to assess the "fit" against the "need" as defined in a related grid architecture and design that satisfy the functional needs aligned to the pre-determined customer and policy objectives. This best-fit assessment is applied to certain grid technology solutions to narrow the potential options. Afterwards, the least-cost can be assessed through various means. Most typically, this determination is the result of a competitive procurement. It should be noted that states have varying approaches to least-cost, best-fit that may also alternatively be assessed as best combination of expected cost and risk.

The Company has proposed the projects in Chapter 3 to progress the Company's vision that aligns with the state-level policies and objectives identified in Chapter, 1 Section 4, and the Docket 4600 goals discussed in Chapter 2, Section 2 of the Power Sector Transformation Plan.

The Company uses several methods to identify appropriate solutions and considers their relative fitness to address the needs and objectives, including industry research, benchmarking, and equipment demonstrations and testing. Similarly, the Company uses several methods to procure and deliver selected solutions at the lowest reasonable cost, including competitive solicitations, standardization, and leveraging synergies when possible across projects and affiliated companies. The Company also employs a robust project governance process that ensures the scope, cost, and schedule of projects are reviewed and approved at the appropriate management levels prior to procurement or any project expenditure.

(This response is identical to the Company's response to Division 8-3 in Docket No. 4770.)

[1] U.S. Department of Energy, Office of Electricity Delivery & Energy Reliability, *Modern Distribution Grid, Decision Guide*, Volume III, June 28, 2017. Available at: http://doe-dspx.org/sample-page/modern-distribution-grid-report/.

Prepared by or under the supervision of: Robert Sheridan

Division 2-4

Request:

Regarding the Grid Modernization investments described in Schedule PST-1, Chapter 3, except for the AMF initiative, please provide all results of the best-fit/least cost assessment. Please provide all workpapers, workbooks, and calculations in machine-readable format with formulas intact. Please provide the assessments separately for:

a. The system data portal

b. Feeder monitoring sensors

c. Control center enhancements

d. Operational data management

e. Telecommunications

f. Cybersecurity

Response:

The Company does not have results of the best-fit/least cost assessment for each of the grid modernization initiatives. The best-fit/least cost assessment does not lend itself to a simple result. Rather, with respect to each proposed investment, the Company assesses the type of solution that best accomplishes the goals of implementing the solution by taking advantage of industry expertise in each area. Then, the Company takes steps to ensure that the best-fit solution can be accomplished at the least cost by employing cost control measures. In addition, the proposed projects are currently in the conceptual stage of development and are not scheduled to commence until the Company's Fiscal Year 2020. At this point, these projects will continue to be refined through stakeholder engagement associated with this proceeding and similar proceedings in other jurisdictions before they reach their final form and are ready for implementation.

Best-Fit: The Company's principal goals in developing its grid modernization proposals are the efficient integration of high penetrations of distributed energy resources through a more granular management of the distribution system. To ensure that the proposals it has developed are a best fit with achieving these goals, the Company gathered subject matter experts from across the organization to consider the impacts of state policy objectives and customer and stakeholder expectations. These subject matter experts worked collaboratively, and engaged with third-party consultants when appropriate, considered industry research, and reviewed the grid modernization projects implemented by other utilities to determine the best fit projects for the Company.

Prepared by or under the supervision of Robert Sheridan

Least Cost: The costs the Company has calculated to date are conceptual. They are based on Requests for Information or Request for Proposals on similar projects in other jurisdictions, costs of previous projects, and input from subject matter experts. The Company used this information to determine whether it was worthwhile to expend additional effort and resources to progress each project through detailed design. The Company intends to develop more detailed plans and present those plans to the Rhode Island Public Utilities Commission (PUC) in the annual Power Sector Transformation (PST) Plan filings proposed in the Company's testimony.[1] When and if the Company moves forward with any particular investment, the Company will use its standard process for procuring solutions. It will conduct open, fair, and competitive procurement events to engage external vendors. It will evaluate vendors on understanding of technical and business requirements, quality performance, support capability and financial cost. It will select vendors to submit competitive pricing options and to conduct final interviews, in which the Company will evaluate the vendor's ability against established criteria.

Although the Company's grid modernization proposals are still in the conceptual phase, the Company has already taken several concrete steps to ensure best-fit/least cost for each of them:

a. System data portal: The concept for the system data portal stems from a publicly accessible website created for the Company's New York affiliate, Niagara Mohawk Power Corporation (Niagara Mohawk), which makes a large amount of information available for the benefit of distributed energy resource providers. In New York, the system data portal locates this information in a common place to make accessing it simple for external stakeholders. The existing Niagara Mohawk portal has been well received by stakeholders.

   In Rhode Island, the Company proposes to leverage the existing framework in New York and build on the lessons learned from that implementation to minimize project costs. The Company's plan is to develop the portal using technology already in use. Additionally, the incremental costs for the information system upgrades necessary for the proposed Rhode Island portal would be limited because the existing portal uses a cloud-based server and requires limited expansion of the Company's existing software licenses. The majority of the expected costs for the portal are for the development and management of the data contained within it. In addition, the portal is designed to evolve in an economical and timely manner as new information is made available.

   Please see Attachment DIV 2-4-1 for the workpapers, workbooks, and calculations associated with the system data portal proposal.

[1] The Narragansett Electric Company d/b/a National Grid, Investigation as to the Propriety of the Proposed Tariff Changes, Rhode Island Public Utilities Commission, RIPUC Docket No. 4770, November 27, 2017, Schedule PST-1, Chapter 10: Funding the Transformation.

b. Feeder monitoring sensors: In developing this program, the Company investigated sensors from three different vendors and considered critical issues, including technical capabilities, equipment costs, installation requirements, telecommunications capability, and on-going data costs. The Company has completed pilot installations to test the capabilities of the preferred sensor. The costs represented in this plan are based on previous deployments of dozens of the preferred sensors across jurisdictions.

   Please see Attachment DIV 2-4-1 for the workpapers, workbooks, and calculations associated with the feeder monitoring sensors proposal.

c. Control center enhancements: The Company has taken several steps to ensure the best-fit/least cost for the Distribution Supervisory Control and Data Acquisition (DSCADA) system and Advanced Distribution Management System (ADMS) proposal in the PST Plan. Since 2009, National Grid has taken the following steps:

   - Performed a Request for Information and Request for Proposal procurement process to design and implement an Outage Management System (OMS) and ADMS, and selected a vendor through that process.

   - Commissioned a third party consultant, Accenture, to develop a technology roadmap for the Company's New England and New York Control Centers, which identified synergies and benefits associated with leveraging the selected vendor for the proposed ADMS/DSCADA systems, such as:

     - Maintaining a single network model and GIS system extract;

     - Establishing a single user interface for operators for OMS and ADMS;

     - Reducing ongoing maintenance by using a vendor-supplied interface between common SCADA and ADMS platforms, which can reduce ongoing maintenance; and

     - Reducing training requirements for both user and administrative support.

   - Carried out a pilot project with ADMS software supplied by ABB Ltd. to verify that the ADMS functionality was still a fit for National Grid and to investigate the maturity and usability of the presently licensed ABB ADMS advanced applications. The pilot also assessed what additional real time data and GIS network data is required for the increasingly complex ADMS application models. The lessons learned from the pilot have shaped the scope of the associated GIS project proposed in the PST Plan. The pilot team also surveyed multiple utilities and gathered information on their implementation and use of the ADMS.

The work performed and lessons learned in both the Control Center Roadmap exercise and ADMS Pilot Project will help to ensure that National Grid is prepared to undertake these control center software projects in the most efficient and cost effective manner possible. As National Grid moves forward additional potential cost savings can be achieved by implementing a common platform across multiple jurisdictions.

Please see Attachment DIV 2-4-1 and the following individual Excel files in Attachment DIV 2-4-2 Confidential for the workpapers, workbooks, and calculations associated with the control center enhancements proposal: "509 ADMS NewEngland from NiMO.Timeline2.xls" and "512 GIS Not_Scaleable.Timeline2.xls".

d. Operational data management: National Grid's information system architecture team worked with subject matter experts in planning, operations, and advanced analytics to develop an information architecture to support the development and evolution of modern grid applications. Elements of this architecture include the enterprise service bus, data lake, cloud computing, and advanced analytics platform. With this architecture in mind, National Grid identified projects of an appropriate scale considering the scope and timing of the portfolio of modern grid projects under consideration in each of its jurisdictions.

   In advance of developing the PST Plan, the Company contracted with Accenture to further develop the information system proposals from National Grid's Distribution System Implementation Plan in New York to estimate the scope and cost of similar project proposals in Rhode Island. Accenture provided additional subject matter expert support to develop project scope and cost estimates.

   Please see the following individual Excel files in Attachment DIV 2-4-2 Confidential for the workpapers, workbooks, and calculations associated with the operational data management proposal: "514 ESB_RI_and_NY.Timeline2.xls", "514 ESB_RI_ONLY.Timeline2.xls", "517 Data Lake Cloud Hosting RI_and_NY.Timeline2.xls", "517 Data Lake Cloud Hosting RI_Only.Timeline2.xls", "515 PI Historian_Not_Scaleable.Timeline2.Rev5.xls", "516 Information Management RI_and_NY.Timeline2.xls", and "516 Information Management RI_Only.Timeline2.xls".

e. Telecommunications: The same process described in part d. above is applicable to the back-office telecommunications project.

   Please see the following individual Excel files in Attachment DIV 2-4-2 Confidential for the workpapers, workbooks, and calculations associated with the telecommunications proposal: "513 Telecom NY_and RI.Timeline2-NoRTU.xls" and "513 Telecom RI_Only.Timeline2.xls".

f. Cyber security: In conjunction with Accenture, National Grid developed a Cyber Security Services Estimation model to refine cost estimates associated with the cyber security domains recommended to secure the various initiatives being delivered as part of the Company's New Reforming the Energy Vision (REV) filing in New York. The model delivered an estimation methodology based on high level guidance from National Grid, National Institute of Standards and Technology Interagency/Internal Report 7628 Guidance, and Accenture's experience in delivering or consulting on similar projects. The model identified and defined detailed cost factors that comprised the necessary inputs and calculations for each cyber security service domain.

The model was based on interviews and document reviews from National Grid, industry good practice, industry benchmarking, consultation with Accenture Subject Matter Advisors (SMAs), and open source research. Several steps were taken to rationalize and justify the costs in the model including, but not limited to the following:

- Developing estimates based on industry benchmarking estimates from analogous smart grid projects;
- Conducting multiple interviews with National Grid stakeholders where available in pertinent areas including with Telecommunications, Strategy Planning, Security Operations Center, and Network Security leads;
- Reviewing National Grid security and IS documentation;
- Coordinating with the Accenture IT Operations Project team to review IT costs across three New York Distributed System Implementation Plan projects;
- Conducting interviews with Accenture Utility Security SMAs, including a former Chief Information Security Officer of a major utility with operations similar to National Grid;
- Reviewing Gartner Group and other research reports on smart grid security strategy and tactics; and
- Reviewing open source information available from Accenture internal research and publicly available research publications.

National Grid also accounted for the fact that it already has cyber security infrastructure, applications, systems, staff, and operations. The cyber security proposal seeks to 1) *enhance existing capabilities* and 2) *extend capabilities* where necessary. The model was then aligned with the known objectives for Rhode Island grid modernization.

National Grid based its cost estimates on either the meter ratio between Rhode Island and New York or, in circumstances where meter ratios were inappropriate, a cost sharing model. National Grid also prepared a standalone model for Rhode Island that assumed the Company would not benefit from any synergies with other jurisdictions. The proposal is subject to change based on the evolving threat surrounding IT/OT and as new technologies begin to emerge.

When preparing this PST Plan, National Grid used proxies for technologies the Company might use based on Accenture experience with, or knowledge of, those products. Before implementing any of the cyber security solutions, National Grid would undertake additional architectural development and perform a product selection process (competitive procurement event) to ensure the best-fit/least cost solution. When the Company obtains approval for the investments, it will conduct an open, fair, and competitive procurement event to engage external vendors.

Please see the following individual Excel files in Attachment DIV 2-4-2 Confidential for the workpapers, workbooks, and calculations associated with the cyber security proposal: "NG_Cybersecurity_Cost_Activity_Model_20170302_vF - RI + NY.Timeline2.xls" and "NG_Cybersecurity_Cost_Activity_Model_20170302_vF - RI Alone.Timeline2.xls".

(This response is identical to the Company's response to Division 8-4 in Docket No. 4770.)

Prepared by or under the supervision of Robert Sheridan

System Data Portal Cash Flow

Description	FY19	FY20	FY21	FY22	FY23
Data Portal - Labor					
Capital	$ -	$ -	$ -	$ -	$ -
Expense	$ 69,000	$ 690,000	$ 690,000	$ 690,000	$ -
Data Portal - Website Setup & Hosting					
Capital	$ -	$ -	$ -	$ -	$ -
Expense	$ 10,000	$ 10,000	$ 10,000	$ 10,000	$ -
System Data Portal Cash Flow, $M					
CAPEX	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
O&M	**0.08**	**0.70**	**0.70**	**0.70**	**0.00**
Filing / Recover Mechanism	2018 SRP	PST Provision	PST Provision	PST Provision	

Labor information matched to OPEX rate case method
Data Portal website costs were based on NY Data Portal setup and maintenance

SYSTEM DATA PORTAL LABOR DETAILS
Narragansett Electric Rate Case - PST Provision
Incremental FTE Information Required for Revenue Requirement Impact

										SRP 2018				PST Provision Yr 1			
Line #	Work stream	Job Title	Mgmt Band	Labor Type (Union or Management)	Employment Start Date	HIRING Company	Function/Initiative (Link to Testimony)	Driver for FTE	L04 Receiving Cost Center	FTE	$ Salary (No burdens)	$ Burdens	$ Total (Salary + Burden)	FTE	$ Salary (No burdens)	$ Burdens	$ Total (Salary + Burden)
1	Power Sector Transformation	Distribution Asset Management	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Planner - NWA Engineer	Electric Process & Engineering				**$0**	1.00	$115,000	$115,000	**$230,000**
2	Power Sector Transformation	Distribution Asset Management	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Planner - Regulatory Lead / Data Portal	Electric Process & Engineering				**$0**	1.00	$115,000	$115,000	**$230,000**
3	Power Sector Transformation	Asset Data & Analytics	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Analyst - Data Portal Development	Electric Process & Engineering				**$0**	1.00	$115,000	$115,000	**$230,000**
	The following is not to be included in Rate Case / PST Provision. The following is proposed within the 2018 SRP																
4	Power Sector Transformation	Distribution Asset Management	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Planner - Regulatory Lead / Data Portal	Electric Process & Engineering	0.15	$17,250	$17,250	**$34,500**				**$0**
5	Power Sector Transformation	Asset Data & Analytics	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Analyst - Data Portal Development	Electric Process & Engineering	0.15	$17,250	$17,250	**$34,500**				**$0**
									Total	**0.30**	**$34,500**	**$34,500**	**$69,000**	**3.00**	**$345,000**	**$345,000**	**$690,000**

SYSTEM DATA PORTAL LABOR DETAILS
Narragansett Electric Rate Case - PST Provision
Incremental FTE Information Required for Revenue Requirement Impact

										PST Provision Yr 2				PST Provision Yr 3				Total FTE's			
Line #	Work stream	Job Title	Mgmt Band	Labor Type (Union or Management)	Employment Start Date	HIRING Company	Function/Initiative (Link to Testimony)	Driver for FTE	L04 Receiving Cost Center	FTE	$ Salary (No burdens)	$ Burdens	$ Total (Salary + Burden)	FTE	$ Salary (No burdens)	$ Burdens	$ Total (Salary + Burden)	FTE	$ Salary (No burdens)	$ Burdens	$ Total (Salary + Burden)
1	Power Sector Transformation	Distribution Asset Management	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Planner - NWA Engineer	Electric Process & Engineering		$115,000	$115,000	**$230,000**		$115,000	$115,000	**$230,000**	1.00	$345,000	$345,000	**$690,000**
2	Power Sector Transformation	Distribution Asset Management	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Planner - Regulatory Lead / Data Portal	Electric Process & Engineering		$115,000	$115,000	**$230,000**		$115,000	$115,000	**$230,000**	1.00	$345,000	$345,000	**$690,000**
3	Power Sector Transformation	Asset Data & Analytics	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Analyst - Data Portal Development	Electric Process & Engineering		$115,000	$115,000	**$230,000**		$115,000	$115,000	**$230,000**	1.00	$345,000	$345,000	**$690,000**
	The following is not to be included in Rate Case / PST Provision. The following is proposed within the 2018 SRP																				
4	Power Sector Transformation	Distribution Asset Management	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Planner - Regulatory Lead / Data Portal	Electric Process & Engineering				**$0**				**$0**	0.15	$17,250	$17,250	**$34,500**
5	Power Sector Transformation	Asset Data & Analytics	D/E	Management	9/1/18	NEPSCO	DER Integration / PST - Data Portal	Analyst - Data Portal Development	Electric Process & Engineering				**$0**				**$0**	0.15	$17,250	$17,250	**$34,500**
									Total	**-**	**$345,000**	**$345,000**	**$690,000**	**-**	**$345,000**	**$345,000**	**$690,000**	**3.30**	**$1,069,500**	**$1,069,500**	**$2,139,000**

Feeder Monitoring Sensors Cash Flow

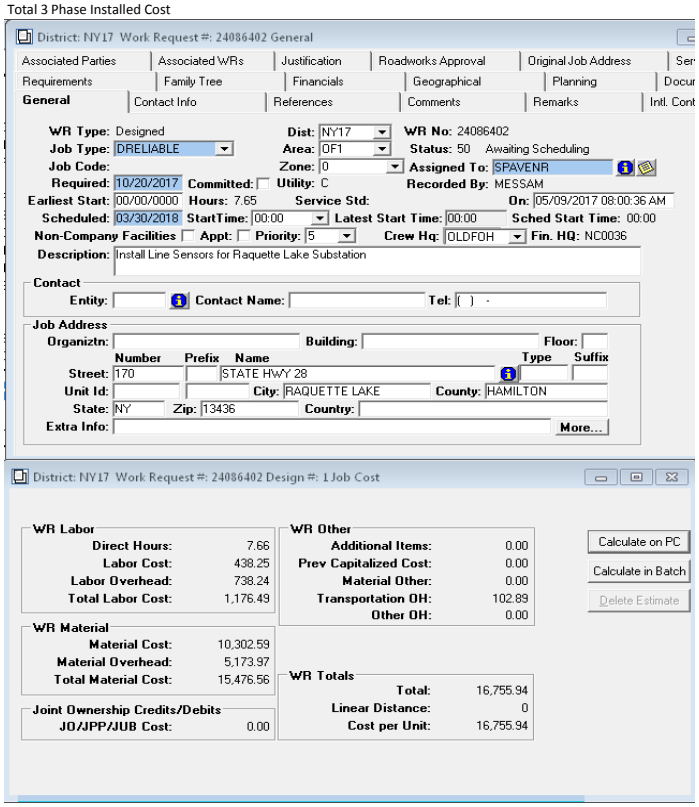
Description				FY19	FY20	FY21	FY22	FY23
Rhode Island Deployment				0%	20%	20%	20%	20%
Circuits				0	26	26	26	26
Sensors	Unit Cost	Count	Total Cost					
Feeder Monitor / Sensors (Installed Cost)	$ 16,700	133	$ 2,221,100	$ -	$ 434,200	$ 434,200	$ 434,200	$ 434,200
Communications Equipment	$ 800	133	$ 106,400	$ -	$ 20,800	$ 20,800	$ 20,800	$ 20,800
Capex - Total	$ 17,500		$ 2,327,500	$ -	$ 455,000	$ 455,000	$ 455,000	$ 455,000
Opex				$ -	$ -	$ 5,000	$ 10,000	

Sensors Cash Flow, $M

CAPEX	**0.00**	**0.46**	**0.46**	**0.46**	**0.46**
O&M	**0.00**	**0.00**	**0.01**	**0.01**	**0.00**
Total	**0.00**	**0.46**	**0.46**	**0.47**	**0.46**

Feeder Monitor / Sensors (Installed Cost)

Total 3 Phase Installed Cost



Communication Equipment

nationalgrid

Bill Of Material **WR#: 24086402**

Header Info

WR Type: DESG **Division:** NY17 **WR #:** 24086402 **Recorded Date:** 05/09/2017 08:00
Job Type: DRELIABLE **Area:** OF1 **Planner/Engineer:** **Required Date:** 10/20/2017 00:00
Job Code: **Crew HQ:** OLDFOH **Assigned To:** SPAVENR **Ext. Job No:**
Description: Install Line Sensors for Raquette Lake Substation

Company Code	Project	Work Order	WP Crew Class	Activity	Description
36	C069688	10024086402	E2	1068	ED OH, PRIM & SEC CONDUCTOR I/R/M
			EO	1145	ED OH, DOWN GROUND/GROUND SYSTEM INSTALL
			TC	1067	ED, RADIO/ANTENNA I/R/M
			TC	1068	ED OH, PRIM & SEC CONDUCTOR I/R/M

Communications Technician - TC

Material Items

Quantity	UOM	Material ID	Material Description	Unit Price	Total Cost
1	EA	9389708	KIT, ANTENNA, INSTALLATION, VERIZON, FOR 4G LTE-4G/3G C	$180.6900	$180.69
1	EA	9389636	MODEM, VERIZON, 4G LTE-4G/3G, CELLULAR RADIO, FOR COMMU	$642.8300	$642.83

"MUST GO" Please deliver to Utica Stores by 10/20/17

Work Packet Total: **$823.52**

RTU Separation Cash Flow

Description				FY19	FY20	FY21	FY22	FY23
Rhode Island Deployment				0%	33%	56%	11%	0%
RTU Separation	Unit Cost	Count	Total Cost					
New RTU	$ 374,000	3	$ 1,122,000	$ -	$ 373,626	$ 623,832	$ 124,542	$ -
RTU Reconfiguration	$ 10,000	59	$ 590,000	$ -	$ 196,470	$ 328,040	$ 65,490	$ -
Capex - Total			$ 1,712,000	$ -	$ 570,096	$ 951,872	$ 190,032	$ -
Opex				$ -	$ 60,000	$ 60,000	$ 60,000	$ -

* Unit Costs from NY rate case analysis

RTU Separation Cash Flow, $M					
CAPEX	**0.000**	**0.570**	**0.952**	**0.190**	**0.000**
O&M	**0.000**	**0.060**	**0.060**	**0.060**	**0.000**
Total	**0.000**	**0.630**	**1.012**	**0.250**	**0.000**

GIS Data Enhancement (Non-IS) Cash Flow ($M)

Description	FY19	FY20	FY21	FY22	FY23
Rhode Island Deployment	0%	0%	33%	33%	33%
Capex - Total	$ -	$ -	$ -	$ -	$ -
Opex	$ -	$ -	$ 1.03	$ 1.03	$ 1.03

Data Improvement	Description	RI Estimate (* using revised estimate data 2017)
DG	This effort will focus on the DG data model and functionality in GIS to ensure that the system will be capable of supplying the information required by DSIP investments. Beyond the system review and development, full population of DG locations and attributes will be completed.	$32,778
General Data Collection	This effort is focused on improving data quality of existing data through leveraging issues found during model builds, operating knowledge and known areas of concern. The intent of this effort is to eliminate errors related to network topology, attribute level inconsistencies and to apply additional system validations to drive improved data quality moving forward.	$1,060,102
New Attributes	Will be made available and where it will be stored will be developed and migration or creation of this data will be completed. Additionally, validations and cross system keys will be established to drive quality and synchronization.	$454,365
Networks	To address known needs related to modelling downtown GIS networks this effort would focus on creating an underground focused data model, population of available data (including potential field checks) and integration of inspections with GIS for enhancing data quality moving forward.	$845,169
Secondary	GIS currently does not fully model secondary systems. This effort would be a multi-year effort to fully populate the system. Additional considerations will be updating connect model export techniques to get the data to downstream systems, including ADMS.	$481,865
Substation Modelling	Substation assets are kept in the Cascade system but only peripherally modelled in GIS. This effort would interface these systems – creating a GIS substation data model that incorporates network connectivity considerations between Transmission and Distribution to provide data that will be used to inform ADMS and load flow planning models	$93,737
Connected Model Export	This effort will seek to replace or enhance current capabilities utilized to export information from GIS to downstream systems including CYME, OMS and ADMS. The current process is highly customized but very use specific and does not meet emerging and future needs.	$114,751
Total		**$3,082,767**

Division 2-5

Request:

Regarding the Grid Modernization investments described in Schedule PST-1, Chapter 3, please describe in detail how the best-fit/least cost assessment approach is consistent with the Commission's cost-effectiveness guidelines provided in docket 4600.

Response:

The Company has proposed using the best-fit/least cost assessment approach for those investments in the Power Sector Transformation Plan for which specific benefits cannot be quantified. Often, these investments provide foundational capabilities. In the Public Utilities Commission's Guidance on Goals, Principles and Values for Matters Involving The Narragansett Electric Company d/b/a National Grid in Docket No. 4600 (Docket 4600 Guidance Document), it is recognized that there is significant work remaining to be completed for the Benefit-Cost Framework to be applied in a fully quantitative manner. However, the Benefit-Cost Framework can now and should be used to provide the basis for qualitative assessments of proposals.

The Company's best-fit/least cost assessment involves first narrowing its potential solution options by assessing the "fit" against the "need" with respect to pre-determined customer and policy objectives. The "needs" these projects intend to directly align with the goals of the Docket 4600 Guidance Document. In Schedule PST-1, Chapter 3, Table 3-22 (Bates Page 64 of PST Book 1), the Company presents a summary of the "fit" with respect to the goals of the Docket 4600 Guidance Document.

During the deployment of each project, the Company determines how to deliver the project at the lowest reasonable cost using a competitive procurement, cost/risk assessment, or some other means. The approach will vary depending on the solution type and complexity and the impact it might have on the Company's ability to deliver electric services.

(This response is identical to the Company's response to Division 8-5 in Docket No. 4770.)

Prepared by or under the supervision of: Robert Sheridan

Division 2-6

Request:

Regarding the Grid Modernization investments described in Schedule PST-1, Chapter 3, except for the AMF initiative, for each initiative that has both stand-alone and shared scenarios, please describe in detail any reasons why the Company might not be able to pursue the shared scenario.

Response:
The Company would look to pursue shared scenarios to the greatest extent possible to realize cost-sharing efficiencies and develop common work practices.

Investments in Schedule PST-1, Chapter 3, except for AMF, in which potential synergies have been identified include: Distribution Supervisory Control and Data Acquisition, Advanced Distribution Management System, Geographic Information System, Enterprise Service Bus, Data Lake, PI Historian, Advanced Analytics, Telecommunications, and Cyber Security.

Reasons why a shared scenario may not be realized or the degree of synergy impacts reduced include: not receiving authorization to proceed in another jurisdiction; a revision in scope or change in functionality that may be a condition of any approval; or a project implementation schedule that reduces cost-sharing opportunity.

(This response is identical to the Company's response to Division 8-6 in Docket No. 4770.)

Prepared by or under the supervision of: Robert Sheridan

Division 2-7

Request:

Regarding the Grid Modernization investments described in Schedule PST-1, Chapter 3, except for the AMF initiative, for each initiative that has both stand-alone and shared scenarios:

a. Please provide the Company's best estimate of probability of each scenario occurring.

b. Please use the probabilities provided in response to (a) to estimate the expected value of the cost of the initiative.

c. Please provide the Company's best estimate of when it will be able to determine whether the investment will be stand-alone or shared.

Response:

Investments in Schedule PST-1, Chapter 3, except for AMF, in which potential synergies have been identified include: Distribution Supervisory Control and Data Acquisition; Advanced Distribution Management System; Geographic Information System; Enterprise Service Bus; Data Lake; PI Historian; Advanced Analytics; Telecommunications; and Cyber Security.

a. In developing the Power Sector Transformation Plan, the Company took into account the current status of the associated regulatory proceeding of its Massachusetts and Upstate New York affiliates. In Massachusetts, all testimony and briefs have been filed and a ruling on the Massachusetts Electric Company and the Nantucket Electric Company's Grid Modernization Plan is pending with the Massachusetts Department of Public Utilities in Docket No. D.P.U. 15-120. In New York, Niagara Mohawk Power Corporation filed a Joint Proposal setting forth the terms and conditions for a comprehensive three-year rate plan on January 19, 2018 in Cases 17-E-0238 and 17-G-0239. The Joint Proposal is subject to Commission approval, which is expected to occur in March or April 2018. The Company is not in a position at this time to estimate the probability of each initiative being approved by the Massachusetts Department of Public Utilities and the New York Public Service Commission.

b. As stated in the Company's response to part a. above, the Company is not in a position to estimate the expected value of the costs of each initiative as it is not in a position to estimate the probability of each initiative being approved by the Massachusetts Department of Public Utilities and the New York Public Service Commission.

c. The Company expects to receive an Order in the Niagara Mohawk Power Corporation rate case in March or April 2018. There is no statutory requirement for the

Prepared by or under the supervision of: Robert Sheridan

Massachusetts Department of Public Utilities to render a decision in the Massachusetts proceeding within a specific period of time.

(This response is identical to the Company's response to Division 8-7 in Docket No. 4770.)

Prepared by or under the supervision of: Robert Sheridan

Division 2-8

Request:

Regarding the AMF investments described in Schedule PST-1, Chapter 4:

a. Has the New York Public Service Commission approved a proposal for AMF or AMI investments by Niagara Mohawk? If so, please provide any related commission orders.

b. Please describe how the Niagara Mohawk AMF or AMI proposal compares with, and differs from, the AMF proposal in this docket.

Response:

a. Not at this time. In a Joint Proposal filed on January 19, 2018 with the New York State Public Service Commission (NYPSC) in Cases 17-E-0238 and 17-G-0239, Niagara Mohawk Power Corporation (Niagara Mohawk) agreed to convene a collaborative to refine and update its AMI business case. Thereafter, Niagara Mohawk will file its updated AMI business case by October 1, 2018 for NYPSC review and approval. Although there is no required timetable for the NYPSC to act on the filing, Niagara Mohawk is hopeful to obtain direction in early 2019. The Company notes that this is a similar process that was followed for approval of Consolidated Edison's AMI program in New York.

b. Niagara Mohawk's AMI proposal, submitted as Attachment DIV 6-19-2 to the Company's response to Division 6-19 (in Docket 4770), was filed as part of its April 2017 rate case (Cases 17-E-0238 and 17-G-0239), and as modified in the rebuttal testimony, submitted as Attachment DIV 2-8 to this response, of the Advanced Metering Infrastructure Panel filed on September 15, 2017 (Niagara Mohawk AMI Proposal), is largely consistent with the Company's AMF proposal in RIPUC Docket No. 4780. The Niagara Mohawk AMI Proposal served as the baseline from which adjustments were made to the Company's AMF proposal to account for the specific Rhode Island Docket 4600 goals and AMF guidelines provided in the Power Sector Transformation Phase One Report.

The following is a description of the key similarities:

i. Both proposals include full territory-wide electric and gas AMF implementation.

ii. Both proposals include a similar time period of two-and-one-half years for detailed planning, procurement, and back-office systems implementation

Prepared by or under the supervision of: John Leana

activities prior to AMF electric and gas ERT deployment. There is an opportunity to align the timeline for these activities for Niagara Mohawk and the Company pending the outcome of the associated regulatory cases.

iii. Both proposals provide time during the detailed planning and procurement phase for additional regulatory and stakeholder engagement regarding the design of the AMF program.

iv. Both proposals include common cost elements and estimation methodologies for the standalone Company-only and Niagara Mohawk-only scenarios with the exception of the few items noted in item ii. below.

v. Both proposals include common benefit elements and estimation methodologies with the exception of the items noted in item iii. below

The following is a description of the key differences:

i. The Niagara Mohawk AMI Proposal includes a concurrent, coordinated deployment of AMI electric meters and gas ERTs over a four-year period while the Company AMF proposal deploys electric AMF meters and gas ERTs separately over an 18-month and estimated 11-year period, respectively. The difference in deployments is driven largely by the estimated useful life of the ERTs in Niagara Mohawk and the Company's service territories. Niagara Mohawk's AMR gas ERTs are being replaced over the same time period as the electric AMR meters because the vast majority of Niagara Mohawk's AMR gas ERTs are approaching their 20-year battery life. In contrast, the Company's AMR gas ERTs are not approaching their useful life *en masse* and therefore are proposed to be replaced separate from the electric meters over an estimated 11-year period.

ii. The Company AMF Proposal does not include the cost of AMF gas ERT installation because the gas ERTs will be replaced on their normal replacement cycle. In addition, the customer engagement component and associated costs of the Company AMF Proposal were refined and enhanced from the Niagara Mohawk AMI Proposal.

iii. The Company AMF Proposal identifies an electromechanical meter benefit from the enhanced accuracy resulting from replacing electromechanical meters with solid state electric AMF meters. Niagara Mohawk has already achieved these benefits as its existing AMR electric meters are solid state devices.

iv. Based on the timing of the two filings, only the Company AMF Proposal includes a joint Company and Niagara Mohawk AMF implementation scenario. To develop this scenario, cost synergy assumptions and estimation methodologies were developed for equipment costs, project management, and information technology cost areas.

(This response is identical to the Company's response to Division 8-8 in Docket No. 4770.)

Prepared by or under the supervision of: John Leana

Niagara Mohawk Power Corporation
d/b/a National Grid

PROCEEDING ON MOTION OF THE COMMISSION AS TO THE RATES, CHARGES, RULES AND REGULATIONS OF NIAGARA MOHAWK POWER CORPORATION FOR ELECTRIC AND GAS SERVICE

Rebuttal Testimony and Exhibits of:

Advanced Metering Infrastructure Panel
(REDACTED)

Book 4

September 15, 2017

Submitted to:
New York State Public Service Commission
Case 17-E-0238
Case 17-G-0239

Submitted by:
Niagara Mohawk Power Corporation

nationalgrid

Before the Public Service Commission

NIAGARA MOHAWK POWER CORPORATION d/b/a NATIONAL GRID

Rebuttal Testimony

Of

The Advanced Metering Infrastructure Panel

Dated: September 15, 2017

Case 17-E-0238
Case 17-G-0239

Rebuttal Testimony of The Advanced Metering Infrastructure Panel

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Rebuttal Testimony of The Advanced Metering Infrastructure Panel

I. Introduction

Q. Please introduce the members of the Advanced Metering Infrastructure Panel (the "Panel").

A. The Panel consists of John O. Leana, James M. Molloy, and Pamela I. Echenique (Dise).

Q. Is this the same AMI Panel that previously submitted direct testimony in these proceedings?

A. Yes. The terms defined in the Panel's direct testimony have the same definitions here.

II. Purpose of Testimony

Q. What is the purpose of the Panel's rebuttal testimony?

A. The purpose of the Panel's rebuttal testimony is to respond to certain recommendations of the Department of Public Service Staff ("Staff") Advanced Meter Infrastructure Panel ("Staff AMI Panel"), the Utility Intervention Unit's AMI Panel ("UIU AMI Panel"), and Pace Energy and Climate Center's Advanced Metering Infrastructure Metrics Panel ("PACE AMI Metrics Panel"). Specifically, the Panel will address the following topics:

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Rebuttal Testimony of The Advanced Metering Infrastructure Panel

(i) The Staff and UIU AMI Panel's comments and recommendations regarding delaying the Company's AMI program;

(ii) The Staff and UIU AMI Panel's comments and recommendations regarding the estimation of the Company's AMI Business Case costs;

(ii) The Staff and UIU AMI Panel's comments and recommendations regarding the estimation of the Company's AMI Business Case benefits;

(iii) Revisions to the Company's AMI Business Case benefit-cost analysis ("BCA") to reflect adjustments to estimated costs and benefits; and

(iv) The Staff AMI Panel's and PACE AMI Metrics Panel's comments and recommendations regarding AMI program metrics.

Q. Does the Panel sponsor any exhibits as part of its rebuttal testimony?

A. Yes, the Panel sponsors the following exhibits that were prepared under our direction and supervision:

- Exhibit __(AMI-1R) provides a utility benchmark comparison of the Company's estimated AMI deployment costs on a cost per meter basis;
- Exhibit __(AMI-2R) contains the Company's responses to various Information Requests;

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Rebuttal Testimony of The Advanced Metering Infrastructure Panel

- Exhibit __ (AMI-3R) contains an analysis of dynamic pricing by The Brattle Group economists Ahmad Faruqui and Jenny Palmer;
- Exhibit __ (AMI-4R) contains an analysis of the Staff AMI Panel's five percent meter replacement recommendation;
- Exhibit __ (AMI-5R) contains the electric meter AMR and gas ERT replacement schedules used to calculate avoided AMR costs;
- Exhibit __ (AMI-6R Confidential) contains a comparison of the ESAI Energy LLC ("ESAI") and the Staff AMI Panel's ICAP forecast; and
- Exhibit __ (AMI-7R) contains the updated BCA results for changes to costs and benefits and the ICAP forecast sensitivity.

III. Overview and Impact of Delaying the AMI Program

Q. Please briefly summarize the recommendations of the Staff (at 6-8) and the UIU AMI Panels (at 3-4) concerning the Company's proposal to implement AMI.

A. The Staff AMI Panel recommends that the Commission not adopt the Company's AMI program at this time. Expressing concern that the costs of AMI could outweigh the benefits, the Staff AMI Panel recommends that the Company refine its AMI Business Case and BCA to provide a clearer picture of the benefits and costs of AMI. The Staff AMI Panel removes all AMI costs

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from the revenue requirement, but proposes to include project management costs to allow the Company to continue developing its Business Case and BCA. The UIU AMI Panel makes similar recommendations.

Q. Does the Panel have any comments about these recommendations?

A. The Panel disagrees with the Staff and the UIU AMI Panels' recommendations to postpone AMI. The Panel sees minimal to no-value in such an approach. The end result would be more costs to customers to achieve a result that would be substantially similar to the updated BCA submitted in Exhibit ___ (AMI-7R), and would only serve to further delay the benefits to customers that AMI will provide.

One of the key takeaways from the public statement hearings attended by members of the Panel was that customers were frustrated because they were conserving energy but not seeing lower energy bills. AMI, if implemented, will help change this because, among other benefits, it will allow the Company to implement new time-varying pricing programs that will provide price signals to customers to help them shift their energy consumption. These programs have been demonstrated to provide customer bill savings and will help respond to the concerns we heard at the public statement hearings.

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Further, a delay will only result in additional costs to customers. The gas ERT component of the AMI program cannot be postponed because the battery life of the ERT is nearing its end and must be replaced. As such, the cost efficiency of simultaneously replacing the gas ERTs and electric meters of customers taking both gas and electric service – estimated to be 16 percent of the AMI installation cost – will be lost if the AMI program is delayed. The Panel estimates that AMI deployment costs would increase $13.81 million on a net present value ("NPV") basis if the Staff and the UIU AMI Panels' recommendations were adopted. In addition, delaying AMI deployment would result in capital costs of approximately $19.24 million and O&M costs of $1.27 million in Data Year 2 for gas ERT replacements.

Delaying AMI deployment will also hinder the Company's ability to achieve the Commission's Reforming the Energy Vision ("REV") goals and transition to the role of the Distribution System Platform ("DSP") provider. The Commission specifically recognized that AMI deployment "will be an important contribution to enabling utilities to assume the role of the DSP" (*see* "Order Adopting Distributed System Implementation Plan ("DSIP") Guidance" in Case 14-M-0101 (at 58)). Moreover, as the Staff AMI Panel acknowledges (at 8), postponing AMI will not allow the Company to

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effectuate the distributed energy resources ("DER") compensation schemes envisioned in the Commission's Value of DER proceeding in Case 15-E-0751. Nevertheless, the Staff AMI Panel states (at 8-9) that the Company will need to find an alternative solution to obtain hourly data to comply with the requirements from this proceeding. At this time, the only alternative solution would be the installation of cellular AMI meters using the AMI solution that was developed for the Company's Clifton Park demonstration project. These meters, however, are approximately two and a half times more expensive than, and have half the useful life of, a mesh network AMI meter that would be deployed as part of the Company's proposed AMI program. The end result would be more costs to customers without realizing the broader benefits envisioned by the REV proceeding.

Q. Please describe, in general, the process the Company utilized to develop its Business Case and BCA.

A. The AMI program was part of an iterative process that dates back to the Company's initial DSIP filing in 2016 in which the Company filed an initial business case and BCA that evaluated multiple deployment strategies. Based on the results of that initial effort, the Company refined its Business Case and BCA, utilizing the assistance of Accenture, a consultant with experience

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developing AMI programs. The Company also incorporated lessons learned from its Massachusetts affiliate's Worcester Pilot.

Throughout, the Company engaged in a thorough, careful, and deliberate process to consider implementation options and costs and benefits. That process resulted in refinements to the program, and informed the Company's decision to propose a phased implementation schedule that would allow for further refinements to the model based on stakeholder feedback during the initial 18-month Phase 1 of the AMI plan, as well as learnings developed from the Company's Clifton Park demonstration project.

Q. Does the Panel agree with the Staff AMI Panel's contention that the BCA does not provide a strong case for AMI at this time?

A. No, we do not. For the most part, the Staff AMI Panel did not indicate disagreement with the estimate of AMI costs. Indeed, as shown in Exhibit ___ (AMI-1R), the Company's estimated cost of AMI deployment on a cost per meter basis of $247 (*see* Exhibit ___ (AMI-2), Page 8 of 52) is in line with industry benchmarks – and, in fact, on the low end – which range between $237 and $339. While specific costs elements will be refined through detailed design and procurement in Phase 1 of the project, the combined cost of the

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Rebuttal Testimony of The Advanced Metering Infrastructure Panel

AMI program is expected to remain consistent with the Company's current estimate and industry benchmarks.

The major difference between the Company and the Staff AMI Panel concerns the benefit calculations for the BCA. The Staff AMI Panel made adjustments to certain benefits and, for other benefits (*e.g.*, outage management), recommended that the Company quantify and include them in a revised BCA. Admittedly, the Panel was conservative in its approach to estimating benefits. There are some benefits, such as outage management, that upon further reflection the Company agrees should be considered. In other areas, the Company disagrees with adjustments proposed by the Staff AMI Panel. These areas are discussed below.

Q. Has the Panel prepared an updated BCA and, if so, what are the results?

A. The Panel prepared an updated BCA that incorporates some of the Staff AMI Panel's recommendations. As discussed below, the results of the updated BCA continue to indicate a positive Societal Cost Test for all but the opt-in low savings scenario. The net Societal Cost Test benefits are substantial, ranging between $83 million to $112 million for the opt-in high scenario and $232 million to $322 million for the opt-out high scenario (*see* Exhibit ___

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(AMI-7R)). The updated BCA fully supports the advancement of AMI for the Company and its 1.7 million customers. The Panel recommends that its proposal be adopted.

IV. Cost Estimates

Q. Did the Staff AMI Panel recommend any adjustments to the costs estimates in the Company's AMI Business Case?

A. Yes. The Staff AMI Panel recommended (at 42-43) removing the cost of Green Button Connect and the E-Commerce Marketplace from the BCA. No other cost adjustments were recommended. The Panel agrees with this recommendation.

Q. Does the Panel agree with the UIU AMI Panel's recommendation (at 3) to add multiple, category-specific cost contingency factors to the BCA based on the concern that some costs may be under estimated.

A. No. The impact of adding multiple contingency factors would result in an over estimation of AMI costs. While estimates by their nature can be high or low, the Company, with the support of Accenture, expended significant resources to develop robust cost estimates based on a detailed scope of work and data from a number of sources. The reasonableness of the Company's

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total AMI Business Case cost is validated when compared to utility benchmarks, as discussed above and shown in Exhibit ___ (AMI-1R).

V. Benefit Estimates

Q. Did the Staff AMI Panel recommend any changes to the calculation of benefits in the Company's AMI Business Case?

A. Yes. The Staff AMI Panel recommended calculation changes for the following benefit areas: (i) Time-Varying Pricing ("TVP"); (ii) avoided AMR costs; (iii) Volt-VAR Optimization ("VVO"); and (iv) the Energy Management Portal.

A. TVP

Q. Please summarize the Staff AMI Panel's recommended changes to the Company's TVP calculations.

A. The Company's AMI Business Case includes four TVP and Critical Peak Pricing ("CPP") scenarios based on the number of customers enrolled in TVPs and their response to price signals:

- Opt-in with low savings from reductions to load and energy (Scenario 1)
- Opt-in with high savings from reductions to load and energy (Scenario 2)

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- Opt-out with low savings from reductions to load and energy (Scenario 3)
- Opt-out with high savings from reductions to load and energy (Scenario 4)

The Staff AMI Panel proposed changes to the (i) opt-in and opt-out customer participation rates, (ii) high and low scenario CPP peak load reduction rates, (iii) high and low scenario time-of-use ("TOU") on-peak energy reduction rates, and (iv) the capacity price forecast. The Panel disagrees with most of the proposed changes as they are overly conservative.

Q. The Staff AMI Panel first recommends (at 29-30) reducing the customer participation opt-in rate (Scenarios 1 and 2) from 20 percent (as proposed by the Company) to 15 percent. Please comment on Staff's recommendation.

A. The recommendation is based on a Department of Energy ("DOE") report (Exhibit ___ (SAIMP-5) that considered ten utility rate pilots that were conducted over two to three years. The report found that opt-in programs had an average participation rate of 15 percent. However, the Panel believes that it is overly simplistic to look at the simple average of the opt-in results reported by DOE. Indeed, Figure 2 to the DOE report shows that the 15 percent simple average is skewed by several TVP programs that achieved

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minimal customer participation levels while several other programs achieved opt-in TVP participation levels well in excess of 20 percent (*see* Exhibit ___ (SAMIP-5), Page 38 of 85). A full-scale AMI deployment with extensive and sustained TVP customer marketing, education, and outreach in New York State is more likely to achieve participation levels at the higher end of the DOE study distribution of results.

In addition, the Panel believes it is overly conservative to use the results from two to three year pilot studies to gauge the potential outcome of a full-scale AMI deployment over a 20-year time period. This is particularly true considering the long-term objectives of the REV proceeding.

Q. The Staff AMI Panel next recommends (at 29-30) increasing customer participation in an opt-out rate (Scenarios 3 and 4) from 80 percent (as proposed by the Company) to 85 percent. Does the Panel agree with this recommendation?

A. Yes. The results from the Worcester Pilot program that implemented a CPP and TOU price design supports a higher participation rate in an opt-out scenario. The Worcester Pilot's initial TVP customer opt-out rate was less than 10 percent and achieved a 98 percent retention rate over two years.

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Q. The Staff AMI Panel further recommends (at 29-30) decreasing the CPP peak load reduction rates for the opt-in high scenario (Scenario 2) from 18 percent to 16 percent, and for the opt-out low and high scenarios (Scenarios 3 and 4) from eight percent to four percent, and 18 percent to eight percent, respectively. Does the Panel agree with these recommendations?

A. No. The Staff AMI Panel presents no evidence that the opt-in high scenario rate should be decreased from 18 percent to 16 percent. To the contrary, the Staff AMI Panel (at 28) cites savings levels from the DOE report for one utility of 24 percent and 22 percent that are higher than the Company's 18 percent assumption. In addition, Exhibit __ (AMI-3R) contains an analysis of pricing pilots that indicate that an 18 percent peak reduction is achievable assuming a sufficient peak to off-peak price ratio. The Company's peak to off-peak ratio in its CPP illustrative tariff design is 28:2, which the Company believes is a sufficient ratio to achieve an 18 percent peak reduction. Lastly, the Worcester Pilot achieved over an 18 percent peak reduction in year two for the customer segments that were most engaged and assumed representative of opt-in customers. The Worcester Pilot CPP peak to off-peak ratio was just below 6.0 to 1.

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With respect to the opt-out high and low scenarios, the Staff AMI Panel recommends reducing the rates by 50 percent. The only basis for this reduction is the findings from the DOE report that customers opting-in are more engaged and therefore their demand reduction would be greater than that of opt-out customers. While the Panel agrees that the peak load reduction rates should be lower for the opt-out versus opt-in programs, the Staff AMI Panel's proposed rates of four percent and eight percent are overly conservative. The Worcester Pilot achieved a seven percent overall peak reduction in the second year of the program and the Staff AMI Panel's testimony cites savings of 12 percent and 14 percent for one utility program (at 28). In addition, as mentioned above, the Panel believes that it is reasonable to assume results from two to three year pilot studies are conservative as compared to what can be achieved over a 20-year time period. These factors support a reduction to the opt-out rates proposed by the Company by 25 percent versus the 50 percent reduction proposed by the Staff AMI Panel. This would mean a CPP peak load reduction percentage of six percent for the opt-out low scenario (Scenario 3) and 13.5 percent for the opt-out high scenario (Scenario 4).

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Q. The Staff AMI Panel also recommends (at 28-29) decreasing the TOU on-peak energy reduction rates for the opt-in low and high savings scenarios (Scenarios 1 and 2) from four percent to three percent, and eight percent to six percent, respectively. Does the Panel agree with these recommendations?

A. No. The Staff AMI Panel testimony cites the Company's illustrative TOU on-peak to off-peak price design ratio of 1.7:1 as the primary basis for its proposed reductions. While the Panel agrees that a higher ratio would be required to support the Company's TOU on-peak reduction rates, the rates presented in the AMI Business Case are illustrative. Indeed, the Company's AMI Business Case states that "a revenue-neutral adjustment could be made to the retail rates to develop OnPeak and OffPeak rates that meet acceptable design objectives around the peak/off-peak price ratio" (*see* Exhibit __ (AMI-2), Page 39 of 52).

The Staff AMI Panel cites savings for one utility of 11 percent and 13 percent. In addition, active customers in the Worcester Pilot achieved on-peak energy savings of 6.4 percent in year two of the TVP program. The above results and the fact that the TOU price design is illustrative support maintaining the Company's estimates.

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Q. Does the Panel agree with the Staff AMI Panel's recommendation (at 30) to calculate the opt-out TOU on-peak energy reduction rates by multiplying the opt-in rates for the same scenarios by 50 percent?

A. No. The Staff AMI Panel recommends that the opt-out on-peak energy reduction rates be calculated by factoring their proposed opt-in on-peak energy reduction rates by 50 percent based on the DOE report. The Panel agrees with the Staff AMI Panel that the on-peak energy reduction rates should be lower for the opt-out versus opt-in program design; however, the proposed rates of 1.5 percent and 3.0 percent are overly conservative. The Staff AMI Panel testimony cites savings of six percent for one utility program (at 29). In addition, it is reasonable to assume results from two to three year pilot studies are conservative as compared to what can be achieved over a 20 year time period. These factors support a reduction to the opt-in rates proposed by the Company by 25 percent versus the reduction proposed by the Staff AMI Panel of 50 percent. Using the Company's originally proposed rates of four percent for the opt-out low scenario (Scenario 3) and eight percent for the opt-out high scenario (Scenario 4), the Company's new proposed rates would be three percent and six percent, respectively.

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B. Avoided AMR Costs

Q. The Staff AMI Panel recommends (at 19-20) that the avoided AMR benefits be calculated assuming a five percent annual replacement rate for AMR electric meters and gas ERTs instead of the Company's assumption that the AMR meters and ERTS are replaced at the same rate as the AMI program. Does the Panel agree with this recommendation?

A. No. The Panel agrees that the ERT replacement schedule can vary from the proposed AMI schedule; however, the five percent rate proposed by the Staff AMI Panel is insufficient to replace over 400,000 gas ERTs that will reach the end of their 20-year useful battery life beginning in 2021. A schedule of gas ERTs in service by vintage is included as Exhibit __ (AMI-2R, Page 161 of 253). The Panel's updated BCA (discussed below) utilized a revised ERT replacement schedule that replaces the ERTs as they reach 19 to 20 years of age. The revised replacement schedule is included as Exhibit (AMI-5R).

Similarly, the Panel agrees that the electric AMR meter replacement schedule can vary from the proposed AMI schedule; however, the five percent rate proposed by the Staff AMI Panel is insufficient based on the age of the in-service electric AMR meters. A schedule of electric AMR meters in service

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by vintage is included as Exhibit __ (AMI-2R, Page 162 of 253). An analysis of the Staff AMI Panel's five percent meter replacement recommendation is included as Exhibit __ (AMI-4R) and indicates that after ten years of meter replacement, 35.5 percent of the meters will be 25 years or older, and after 15 years of meter replacement, 10.5 percent of the meters will be 30 years or older. To avoid significantly exceeding the manufacturer's specified meter life of 20 years, the Panel's updated BCA (discussed below) utilized a revised electric AMR replacement schedule that replaces the original equipment when it reaches 20 years of age. The revised replacement schedule is included as Exhibit __ (AMI-5R).

C. VVO

Q. Does the Panel agree with the Staff AMI Panel's recommendation (at 22-23) to reduce the AMI enabled VVO benefit rate from 0.75 percent to 0.5 percent, representing a shift from the mid-point to the low end of the estimated savings range?

A. Yes. With no Company or New York utility-specific empirical evidence available, the Company accepts the more conservative savings assumption.

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Q. Does the Panel agree with the Staff AMI Panel's recommendation (at 31) that the BCA benefits include a carbon dioxide benefit for VVO?

A. Yes.

D. Energy Management Portal

Q. Does the Panel agree with the Staff AMI Panel's comments (at 25) that the Panel's estimate of savings for the Energy Management Portal may be overly conservative?

A. The Panel agrees that there is a range of potential savings. The Panel's estimate assumes that 50 percent of residential and small commercial customers use the portal and save one percent of sales. The one percent represents the low end of the one percent to three percent savings range that OPower states can be achieved by empowering customers with personalized insights (See Exhibit __ (AMI-2), Page 35 of 52). The Staff AMI Panel cites an EPRI report (at 25) that indicates savings for pilot projects range from zero to 25 percent. Figure 5-2 of the EPRI report indicates a considerable range of results for 35 pilots for which only two included more than 500 customers.

To address the potential uncertainty of the benefit estimate for the Energy Management Portal, the Company has calculated a low and high benefit at one

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percent and three percent, respectively. The low savings estimate will be included with the low TVP pricing options and the high savings with the high TVP pricing options in the Company's revised BCA analysis.

Q. The UIU AMI Panel states (at 22-23) that the Company should provide a sensitivity analysis for unpredictable benefit estimates. Does the Panel have any comment on this proposal?

A. Yes. The sensitivity analysis approach taken by the Company for the Energy Management Portal addresses the UIU AMI Panel's concern. The Company took this same approach to address capacity price uncertainty, as will be discussed below.

E. <u>Additional Benefits</u>

Q. Has the Panel considered the Staff AMI Panel's recommendation (at 33-35) to incorporate additional benefits into the AMI Business Case?

A. Yes. The Panel has considered the benefits areas recommended by the Staff AMI Panel and has calculated additional benefits for the followings areas: (i) outage management; (ii) interval meter reading; and (iii) and electric vehicle integration. The Panel describes each benefit below. The calculated savings from each are explained in the BCA section of the testimony.

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Q. Please describe how the Panel estimated outage management benefits.

A. AMI will enable O&M savings from enhancements to the outage management process. To estimate savings, the Panel assumed a one percent reduction in annual average storm costs over the period 2014 through 2016.

Q. Please describe the Company's estimate of interval meter reading benefits.

A. The AMI system will replace the current MV90 system. The MV90 system currently supports electric interval metering reading for Niagara Mohawk, Massachusetts Electric, and Narragansett Electric. A benefit has been developed and allocated to Niagara Mohawk for the costs that will be avoided, including MV90 licensing and IS support, and avoided field visit costs.

Q. Please describe how the Company estimated electric vehicle integration benefits.

A. The Company expects the introduction of AMI and TVP to enable demand savings and avoided energy charges. The estimate for the electric vehicle integration benefit assumes a certain percentage of electric vehicle charging is done during peak periods and can be displaced, thereby generating both

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system demand (kw) reductions/savings and avoided energy costs by charging at off-peak versus peak rates.

Q. Please describe if there were any benefit areas suggested by the Staff AMI Panel that were not included in the updated BCA and, if so, please explain why they were not included?

A. The Panel did not estimate benefits for the following areas suggested by the Staff AMI Panel – call center labor savings, demand response programs, distribution transformer savings, mobile workforce management, and automated feeder switching. These benefits were not calculated because:

- The Panel does not anticipate decreased call center costs as a result of AMI deployment because the Company has already achieved the benefits of accurate and timely meter reading with the implementation of AMR. The Panel has estimated and included incremental call center costs to support AMI meter deployment and TVP pricing implementation.
- Mobile workforce management and automated feeder switching benefits, which were included in Massachusetts Electric's Grid Modernization BCA, were for a combined AMI and grid modernization proposal and are not applicable to an AMI-only BCA.

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- The benefits of demand response programs are assumed to be included in the TVP benefits as demand response programs support the achievement of TVP savings.
- The Company does not expect that AMI will support distribution transformer savings by reducing transformer failures. An asset management program associated with AMI monitoring of transformers may actually increase the spending for an overloaded transformer program as overloaded units are identified more precisely. Notwithstanding, assuming cost savings are possible, they would be extremely low as the Company experiences just over 100 transformer failures annually on an installed base of approximately 400,000.

VI. Benefit-Cost Analysis

Q. Has the Panel updated the BCA based on the changes to the costs and benefits described above?

A. Yes.

Q. Please summarize the changes made to the BCA.

A. The following changes were made to the AMI BCA: the value of carbon dioxide was updated to reflect the auction price of Renewable Energy Credits;

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the value of capacity was updated to the most recent BCA Handbook forecast; the AMR replacement schedule was updated to match ERT battery life and electric meter 20-year life; the VVO savings rate was adjusted from 0.75 percent to 0.5 percent; a new benefit was added for VVO carbon dioxide reduction; TVP assumptions were updated; the Energy Monitoring Portal savings include a savings sensitivity of one percent and three percent; a new interval meter reading benefit was added; a new outage management benefit was added; a new electric vehicle integration benefit was added; and Green Button and E-Commerce Marketplace costs were removed.

Q. Does the Panel agree with the Staff AMI Panel's proposal (at 37) that the BCA use the Staff Finance Panel's recommended after-tax discount rate of 6.17 percent?

A. No. The Panel believes the BCA should continue to utilize the 6.85 percent discount rate consistent with the Company's filing until such time as a new discount rate is formally adopted.

Q. Does the revised BCA include input updates consistent with the BCA Order and Handbook since the original filing was made, as recommended by the Staff AMI Panel (at 37)?

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A. Yes. The value of the Clean Energy Standard ("CES") Tier 1 Renewable Energy Credits ("RECs"), now available, was used to calculate the societal benefits of carbon reductions. The value of demand reductions in the revised BCA utilizes the updated forecast of ICAP values submitted as a BCA ICAP Spreadsheet Model update in Case 14-M-0101 on August 15, 2017.

Q. **What is the effect of updating the value of carbon dioxide to reflect the auction price of RECs?**

A. The average Tier 1 RECs cost, now available from the New York State Energy Research and Development Authority, is $21.16 per MWH. This value is updated from the Staff AMI Panel's value of $24.24 and is lower than the 2018 value of $25 per MWH included in the Company's BCA. Accordingly, updating the value lowers the societal benefits calculated in the BCA.

Q. What is the effect of updating the value of capacity to reflect the Staff AMI Panel's current installed capacity ("ICAP") forecast?

A. The Staff AMI Panel's updated ICAP forecast is on average approximately 40 percent lower annually than the prior BCA handbook forecast used in the

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Company's BCA. Accordingly, this change reduces the customer benefits calculated for the TVP and electric vehicle integration areas.

Q. What is the basis for the significant change in the Staff AMI Panel's ICAP forecast?

A. The Staff AMI Panel states (at 40-41) that the changes in the ICAP forecast are driven by adjustments to the New York Independent System Operator's ("NYISO") supply forecast based on upstate nuclear plants remaining in service and the announcement of the retirement of Indian Point.

Q. Does the Panel believe capacity price forecasts are highly uncertain as demonstrated by the change in the Staff AMI Panel's recent forecast and other available market forecasts?

A. Yes. There is significant capacity price forecast uncertainty today as the supply market transitions to achieve New York State's clean energy goals. Generation retirements and additions and changes to market mechanisms are difficult to predict. As a result, assumption-driven, long-term capacity price forecasts vary widely. For example, a capacity price forecast provided to the Company by ESAI varies significantly from the Staff AMI Panel's forecast, as illustrated in Exhibit __ (AMI-6R Confidential).

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ESAI is a market consulting firm that prepares forecasts of capacity prices, provides analysis on recent emissions, transmissions happenings, and performs other services for clients, including the Company. ESAI developed the forecast for NYISO ROS UCAP and ICAP prices as of September 5, 2017 through 2040.

Q. To address capacity price uncertainty, did the Company include a sensitivity analysis in its updated BCA?

A. Yes. The Company performed a sensitivity analysis utilizing the ESAI capacity price forecast. The approach addresses the UIU AMI Panel's recommendation that additional BCA sensitivity analysis should be undertaken.

Q. What is the effect of updating the AMR replacement schedules for the avoided AMR cost benefit?

A. The updated schedules extend the replacement to reflect a more precise 20-year useful life replacement program for AMR gas ERTs and electric meters. The change results in a decrease of $12.56 million in benefits from the Company's prior estimate of $275.6 million on a Societal Cost Test 20-year net present value basis.

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Q. What is the effect of changing the VVO savings rate from 0.75 percent to 0.5 percent?

A. The VVO benefit is reduced by $7.25 million from the Company's prior estimate of $21.76 million on a Societal Cost Test 20-year net present value basis.

Q. What is the effect of changes to the TVP assumptions?

A. Increasing the customer participation rate for the opt-out options (Scenarios 3 and 4) from 80 percent to 85 percent will increase the customer benefits. Decreasing the opt-out CPP peak load reduction and TOU on-peak energy reduction percentages by 25 percent will decrease the customer benefits for the opt-out options.

Q. What is the effect of the change to include a savings range from one percent to three percent for the energy insights/high usage alerts benefit?

A. The one percent savings rate is included in the benefit calculation for the opt-in low and opt-out low BCA scenarios resulting in no benefit change for those scenarios. The three percent savings rate is included in the benefit calculation for the opt-in high (Scenario 2) and opt-out high (Scenario 4) BCA scenarios, resulting in a tripling of the customer benefits for those scenarios.

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Q. What is the effect of the additional new benefit areas on the BCA?

A. The total value of the additional benefits is $19.03 million on a Societal Cost Benefit 20-year net present basis representing 2.26 percent to 3.46 percent of total benefits for the BCA scenarios.

- VVO carbon reduction societal benefit is $4.28 million
- Interval meter reading avoided O&M benefit is $1.11 million
- Outage management avoided O&M benefit is $2.83 million
- Electric vehicle integration customer benefit is $10.81 million

Q. What is the effect of removing the cost of Green Button and E-Commerce Marketplace on the BCA?

A. The total cost reduction is $14.14 million on a Societal Cost Test 20-year net present basis.

Q. What is the effect of all of these changes on the BCA?

A. Overall, the effect of all of these changes results in a Societal Cost Test BCA ratio range of 0.90 to 1.39 across the four scenarios evaluated. For the sensitivity case that utilizes the Company's higher ICAP forecast, the Societal Cost Test BCA range is 0.92 to 1.54 across the four scenarios evaluated. The

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overall results are presented in Exhibit __ (AMI-7R). The revised BCA fully supports the advancement of AMI.

VII. Metrics

Q. Does the Company agree with the Staff AMI Panel's recommendation to consider additional customer engagement metrics such as those included in Con Edison's AMI Scorecard shown in Exhibit __ (SAMIP-8)?

A. Yes. The Company plans to develop the detailed AMI program metrics as part of the development of the detailed customer engagement plan to be conducted in Phase 1 of the Company's AMI program. The Company will consider the Con Edison metrics as well as those developed in the Worcester Pilot and the Clifton Park demonstration project, which are included in Exhibit __ (AMI-2R, Pages 1-160 and 163-253 of 253).

Q. Does the Company agree with the Pace AMI Metrics Panel's recommendation (at 4) that the Company adopt Con Edison's AMI Scorecard?

A. No. Con Edison's scorecard is unique to Con Edison. As discussed above, the Company plans to engage stakeholders to provide input to metric development as part of the development of the detailed customer engagement

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plan during Phase 1 of the AMI program. The Company will consider the Con Edison AMI Scorecard metrics as part of the process.

Q. Does the Company agree with the Pace AMI Metrics Panel's recommendation (at 4) to include additional metrics beyond those included in the Con Edison Scorecard including DER AMI related customer surveys, DER penetration metrics, increases in AMI enabled hosting capacity, and metrics related to the increased integration and utilization of DER?

A. No. These proposed metrics go well beyond the scope of the benefits to be realized through the deployment of AMI.

Q. Does this conclude the Panel's rebuttal testimony?

A. Yes, it does.

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Exhibit ___ (AMI-1R)	Utility Benchmark comparison of the Company's estimated AMI deployment cost on a cost per meter basis
Exhibit ___ (AMI-2R)	Company's responses to various Information Requests
Exhibit ___ (AMI-3R)	Analysis of dynamic pricing by The Brattle Group economists Ahmad Faruqui and Jenny Palmer
Exhibit ___ (AMI-4R)	Analysis of the Staff AMI Panel's five percent meter replacement recommendation
Exhibit ___ (AMI-5R)	Electric meter AMR and gas ERT replacement schedules used to calculate avoided AMR costs
Exhibit ___ (AMI-6R Confidential)	Comparison of the ESAI Energy LLC ("ESAI") and the Staff AMI Panel's ICAP forecast
Exhibit ___ (AMI-7R)	Updated BCA results for changes to costs and benefits and the ICAP forecast sensitivity

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Exhibit ___ (AMI-1R)
Utility Benchmark comparison of the Company's estimated AMI deployment cost on a cost per meter basis

REDACTED

Exhibit___(AMI-1R)
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AMI Deployment Cost Utility Benchmarks

Average AMI Deployment Cost Per Meter (Greater than 500,000 Customers)*

Utility	State/Jurisdiction	Implementation Type	Total Customers	Meters Installed	AMI Implementation Cost	Cost Per Meter
Centerpoint	Texas	Full	2,320,256	2,130,737	$ 514,519,057.00	$ 241.00
Oklahoma Gas and Electric	Oklahoma and Arkansas	Full	843,914	818,415	$ 277,716,012.00	$ 339.00
Central Maine Power	Maine	Full	622,380	622,380	$ 180,474,628.00	$ 290.00
Sacramento Municipal Utility District	California	Full	672,860	617,502	$ 146,373,708.00	$ 237.00

*United States Department of Energy. (September 26, 2016). *AMI and Customer Systems: Results from the SGIG Program* . Retrieved from:
https://energy.gov/sites/prod/files/2016/12/f34/AMI%20Summary%20Report_09-26-16.pdf

Avangrid AMI Deployment Cost Per Meter*

Utility	State/Jurisdiction	Implementation Type	Total Customers	Meters Installed	AMI Implementation Cost	Cost Per Meter
Avangrid	New York	Full	1,794,155	1,794,155	$ 503,800,000.00	$ 281.00

*Combined AMI Business Panel Exhibits, (December 20, 2016)
http://documents.dps.ny.gov/public/MatterManagement/CaseMaster.aspx?MatterSeq=48159

Exhibit ___ (AMI-2R)

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Exhibit ___ (AMI-2R)

Company's responses to various Information Requests

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:
John O. Leana

Date of Reply:
June 1, 2017

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National Grid Smart Energy Solutions Pilot

Final Evaluation Report

Prepared for:

National Grid

nationalgrid

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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

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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.

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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

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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.

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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

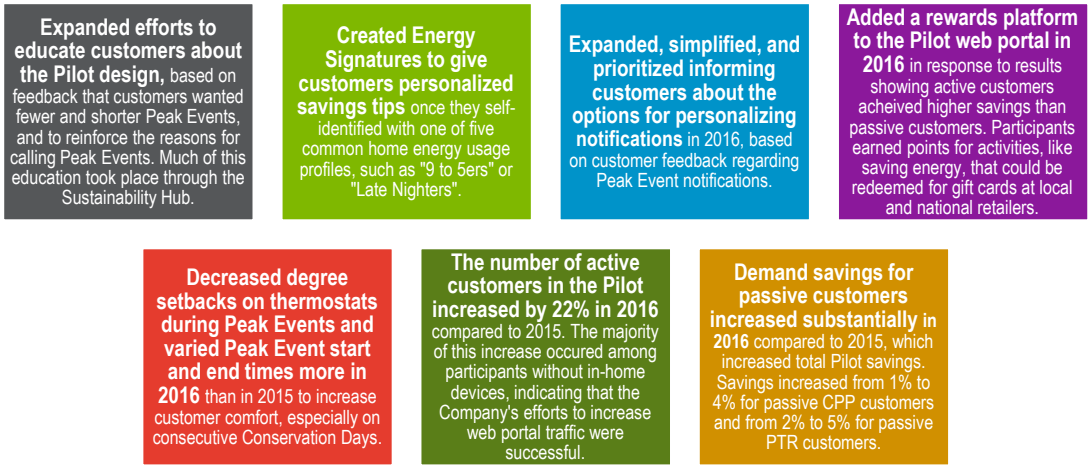
Source: Navigant analysis
Note: CPP refers to Critical Peak Pricing and PTR refers to Peak Time Rebate.

[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



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.

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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.

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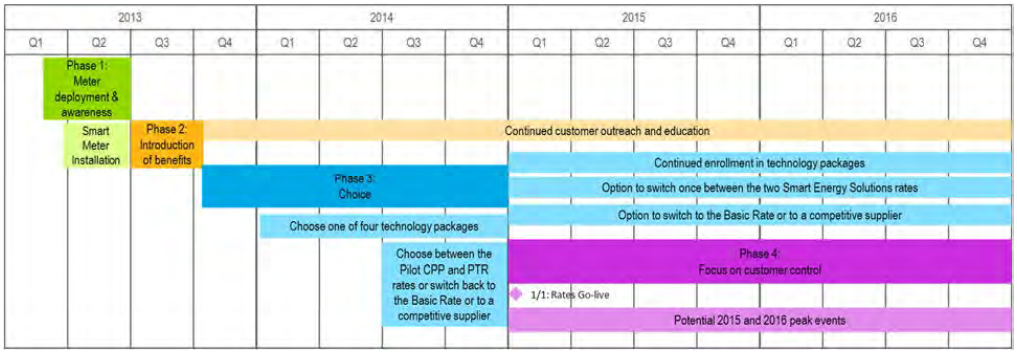
Figure E-3. Four-Phase Rollout of Smart Energy Solutions



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.

[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.

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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.

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

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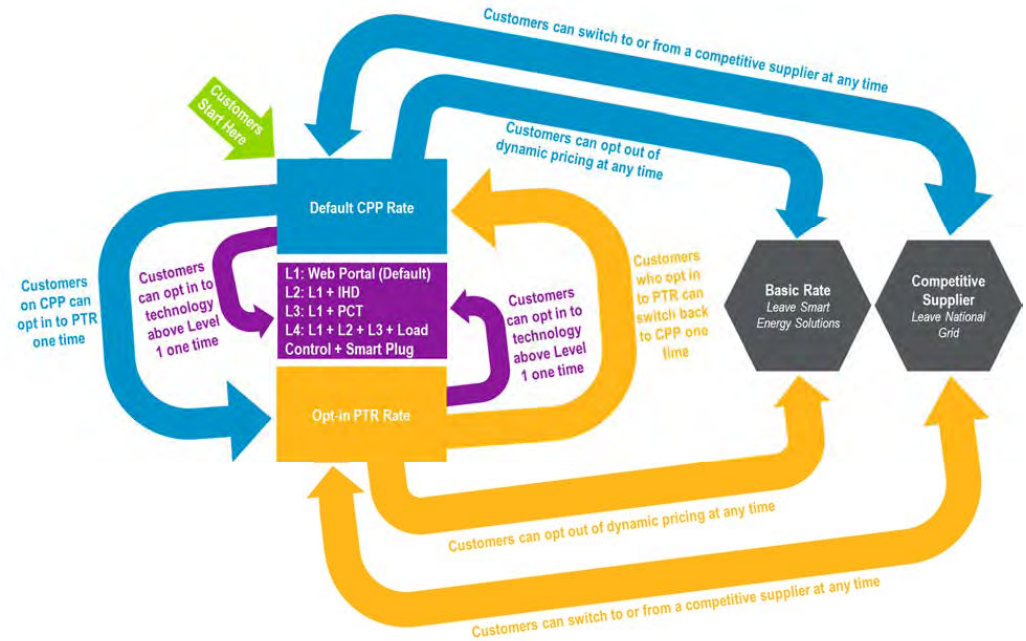
Figure E-4. Smart Energy Solutions Customer Decision Points



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:

[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

[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.

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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			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.

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

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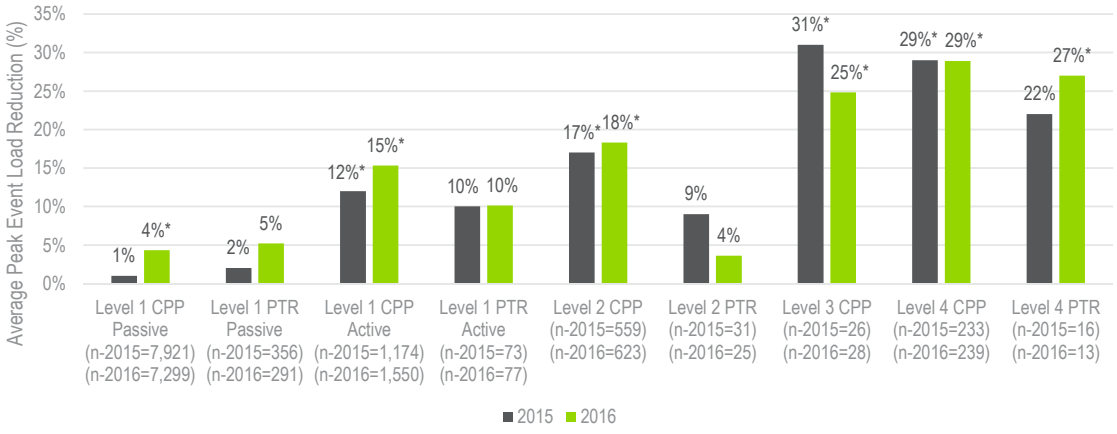
The Pilot was developed to meet the GCA goal of achieving peak and average load reductions of 5% or greater for the active customers in the Pilot. In Navigant's analysis, peak load reduction was examined in the demand analysis and average load reduction in the energy analysis. In both 2015 and 2016, 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.

[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.

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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]

[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.

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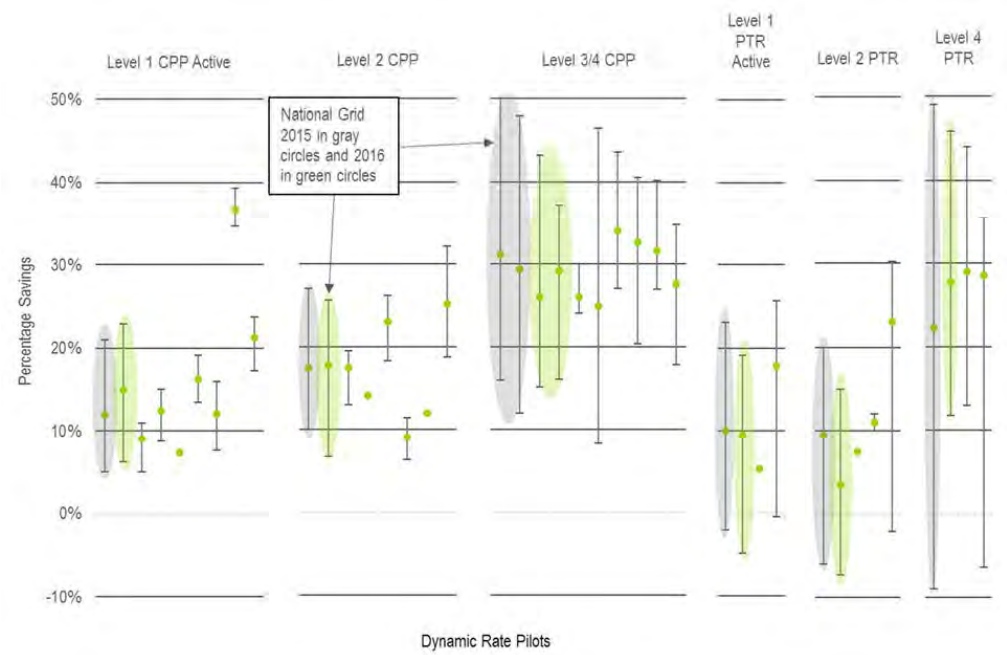
Figure E-6. Peak Event Impacts Percentage Comparisons to Other Utilities



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.

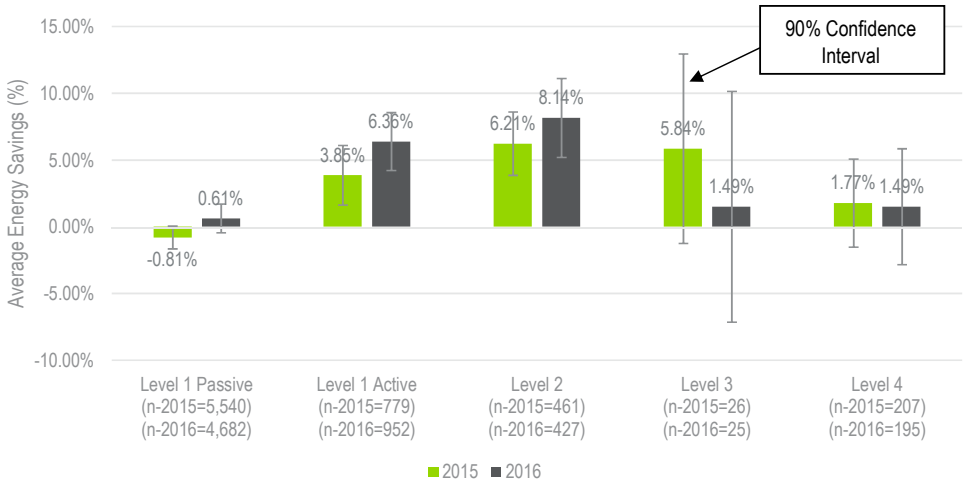
CPP customers achieved average energy savings of up to 8% over the two years of the Pilot.

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

[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

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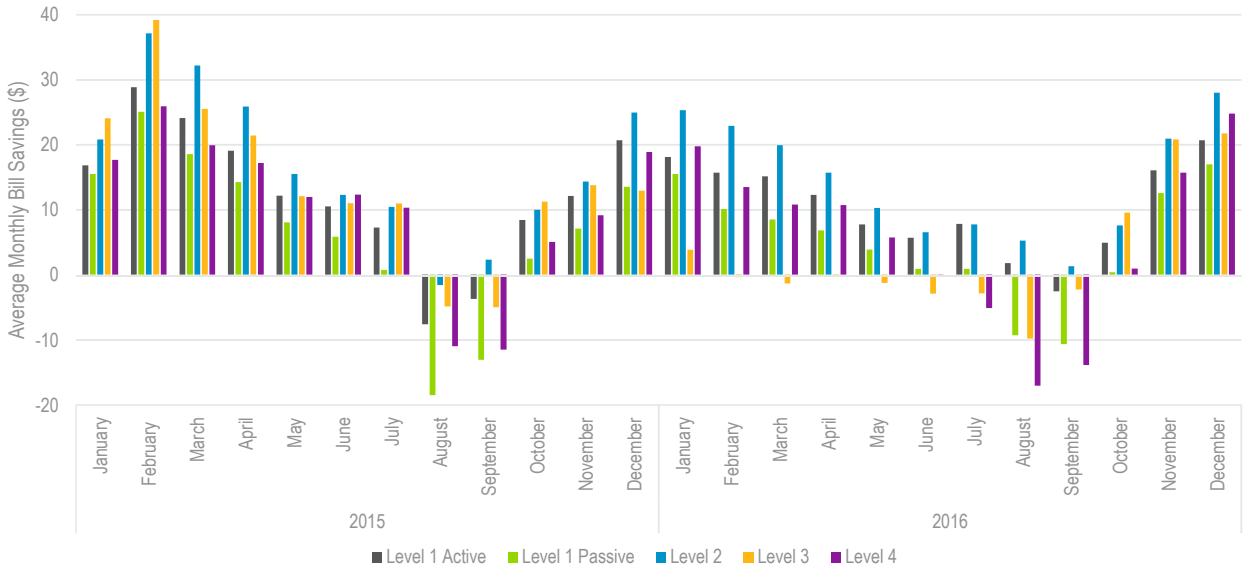
necessarily produce increases in bill savings because of the high price during Peak Events. For example, the highest energy savings occurred in July 2016, but that did not produce high bill savings in that month because eleven Peak Events were called, increasing bills in that month for many customers.

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).

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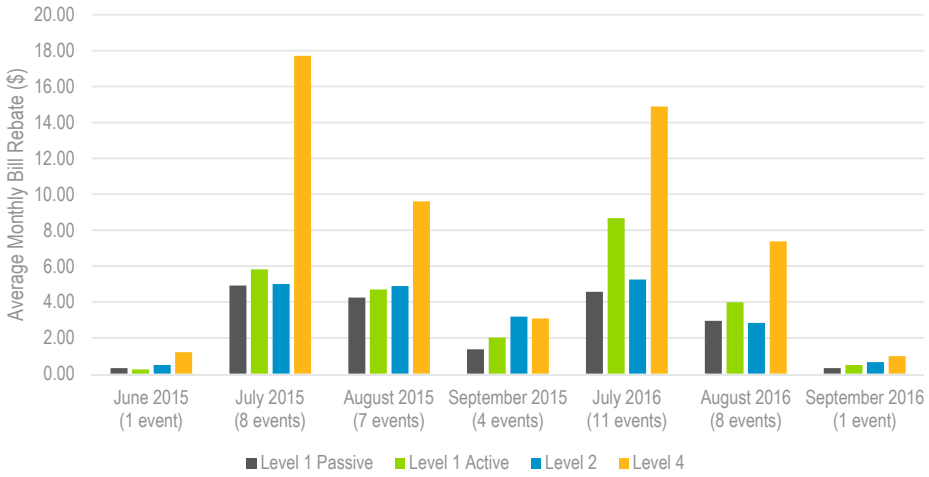
Figure E-9. Average Bill Rebates for PTR Customers



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

[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.

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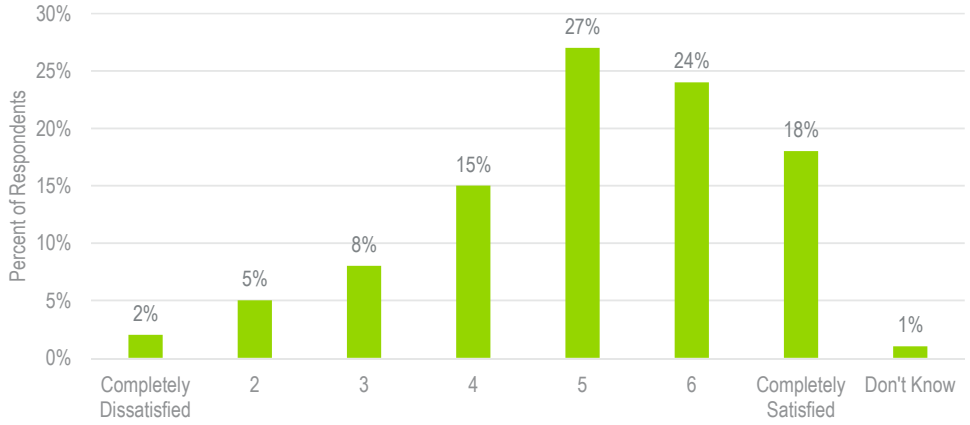
other utilities, including NSTAR, DTE, and MN Power. Converted to a 7-point scale, NSTAR customers gave their pilot an average satisfaction rating of 5.6, 86% of DTE customers rated their pilot at least 4.2 out of 7, and MN Power customers rated their Pilot an average of 3.9 – 4.3 out of 7. As an opt-out 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.

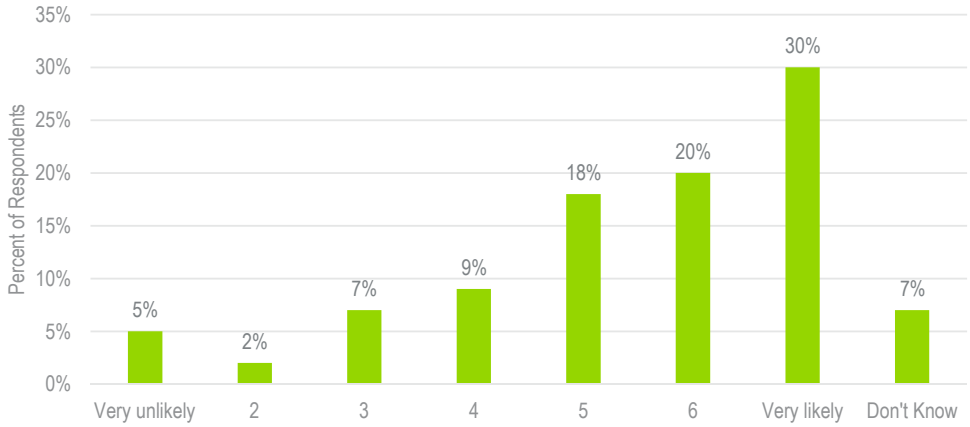
Figure E-10. Participant Overall Satisfaction with Smart Energy Solutions



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)

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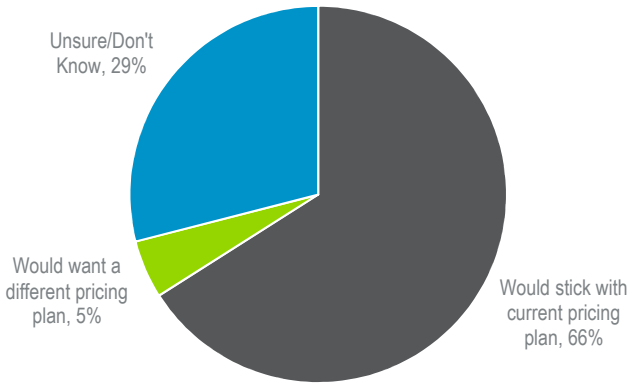
Additionally, most customers (66%) indicated that they would choose to stay on their current rate if the Pilot were extended, as shown in Figure E-12. Only 5% said they would definitely want to switch rates, with the rest being unsure.

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

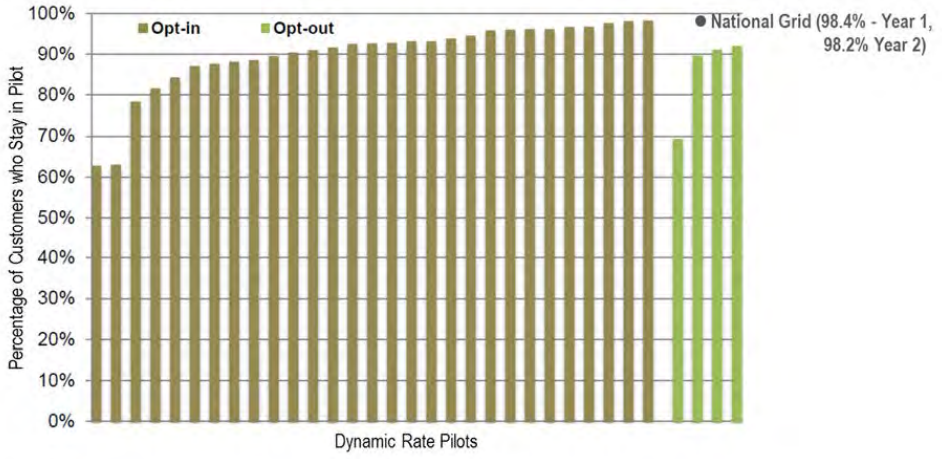
[21] The difference between the 15,000 customers offered an AMI meter and the 11,000 enrolled in the Pilot is accounted for by customers who get electricity from a competitive supplier, moved out before the Pilot rates went live, or chose to drop out of the Pilot before it started.

[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

[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.

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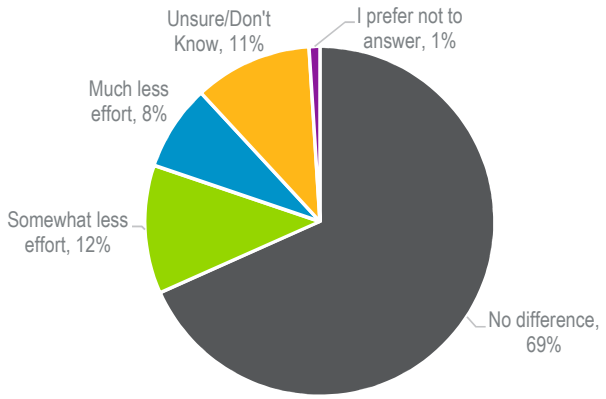
were aware or unaware of the bill protection feature.[25] This analysis did not reveal statistically significant differences in impacts and neither group had consistently higher or lower impacts than the other, supporting the conclusion that bill protection awareness did not influence customers' actions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

[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.

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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.

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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

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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.

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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

[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]

[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.

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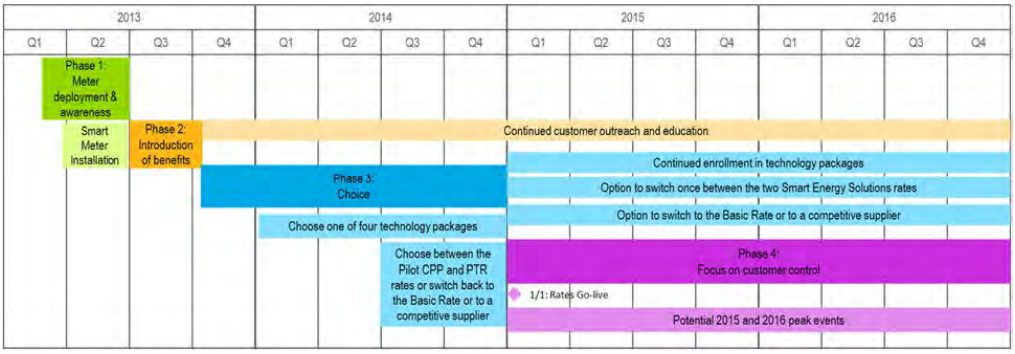
Figure 1-1. Four-Phase Rollout of Smart Energy Solutions



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

[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.

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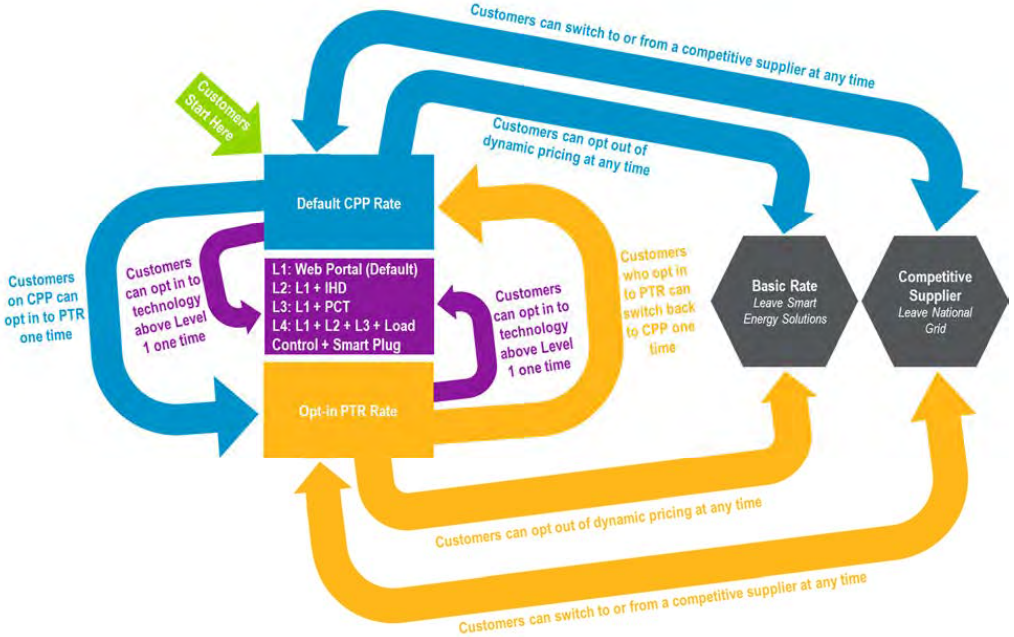
for customers, as illustrated in Figure 1-2.

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

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

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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.

[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.

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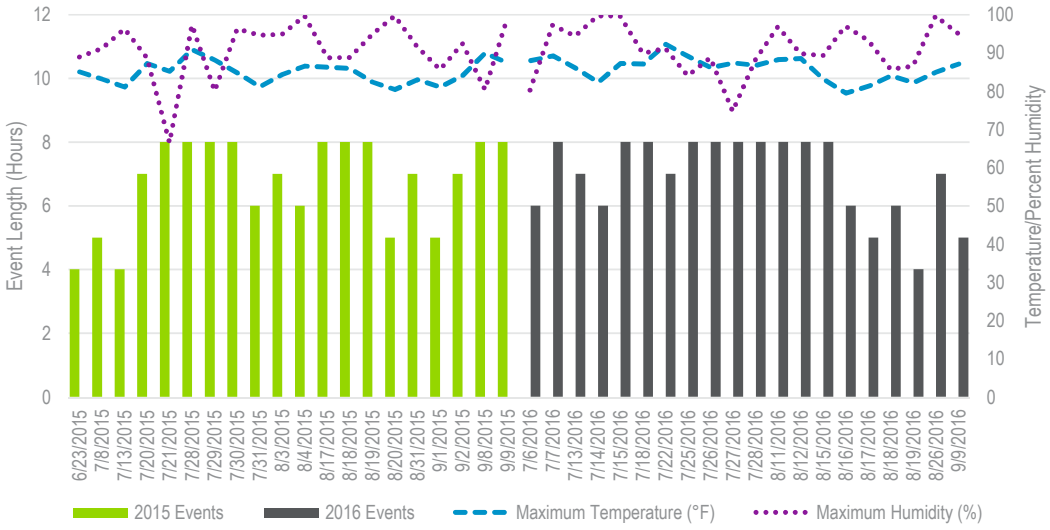
Figure 1-3. Summary of Peak Event Length, Temperature, and Humidity



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.

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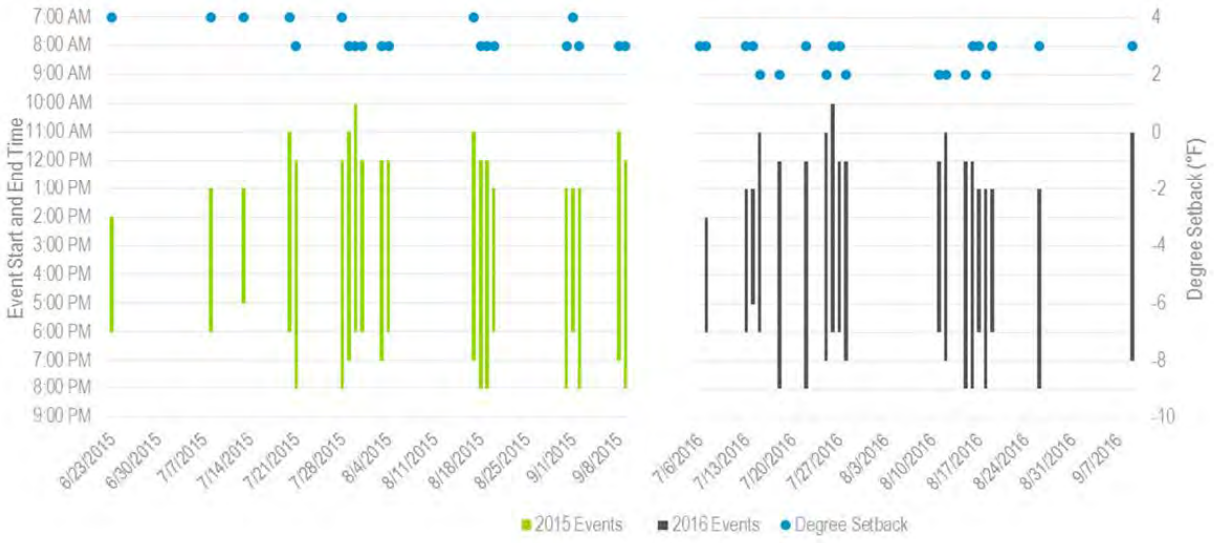
Figure 1-4. Summary of Peak Event Start and End Times and Degree Setback



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).

[35] As of January 3, 2017.

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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.

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

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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

[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.

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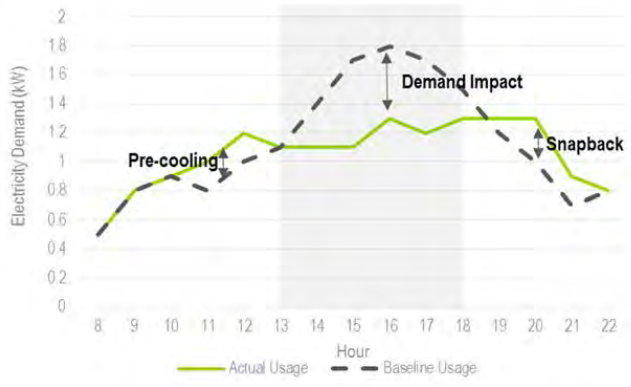
presented here and detailed explanations are included in APPENDIX A.

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

[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.

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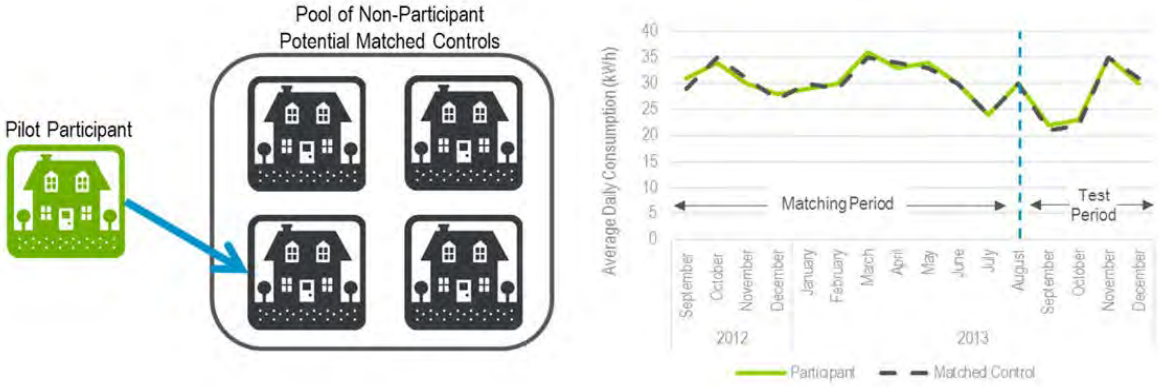
Energy Impacts

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]

[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.

[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.

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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.

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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.

[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.

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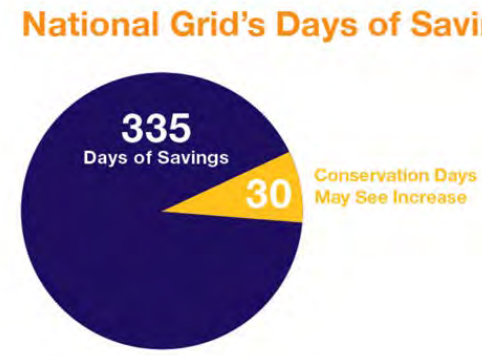
Figure 2-1. Smart Energy Solutions Conservation Days

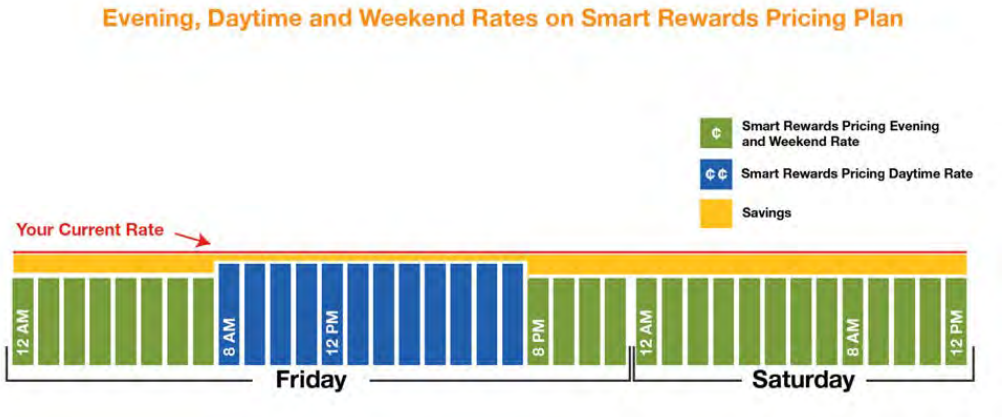


Source: National Grid

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

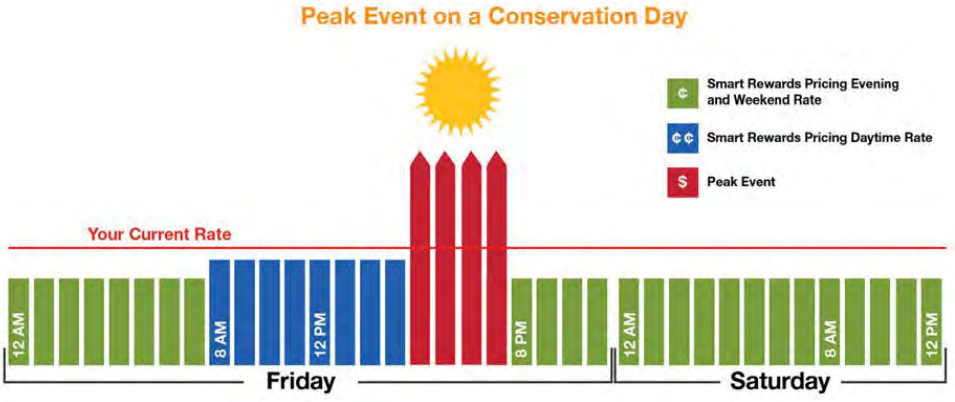


Source: National Grid
Note: "Your Current Rate" refers to the Basic Rate customers were on before the start of Smart Energy Solutions.

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

[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.

[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

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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

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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.

[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.

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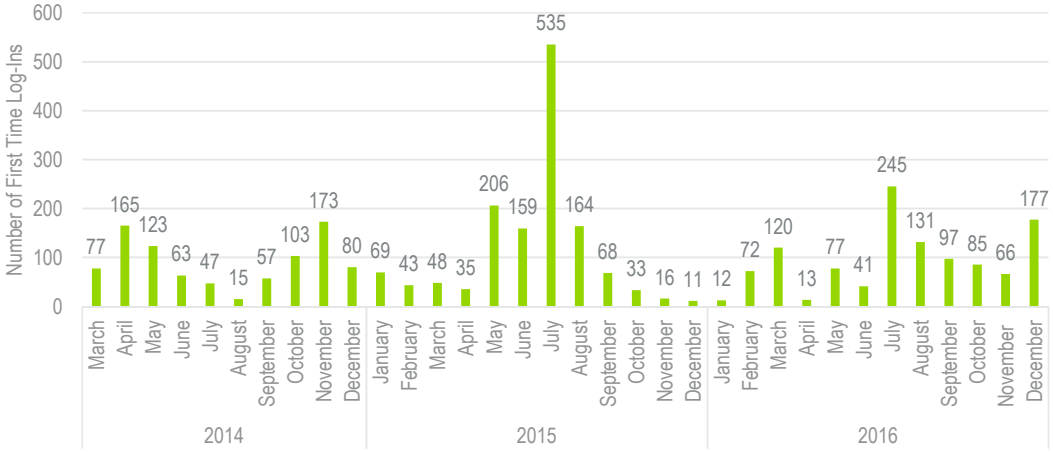
There were a total of 2,504 active customers in the Pilot at the end of 2016; an increase of 478 (or 22%) compared to the end of 2015. This is the net increase, meaning it includes increases resulting from new customers joining the Pilot and achieving an active status, increases from passive customers 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.

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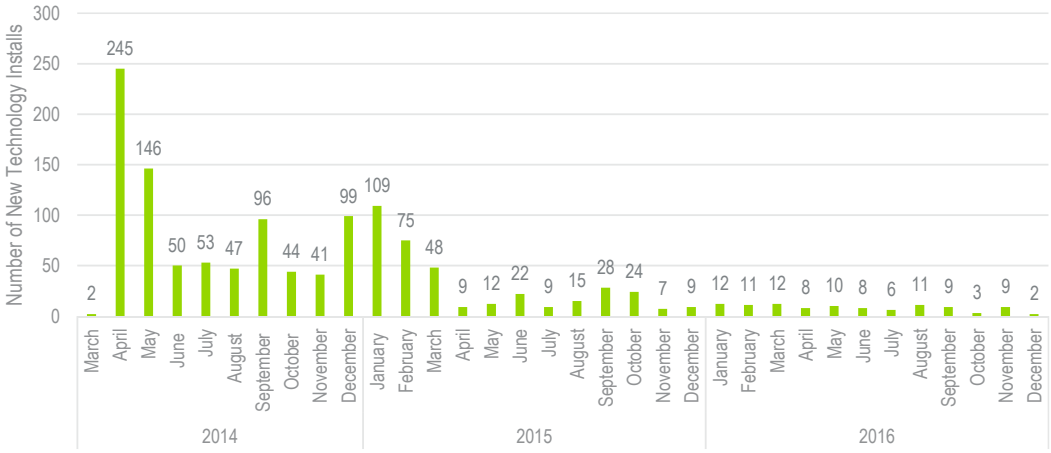
Figure 2-9. Number of Technology Installs by Month



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:

[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.

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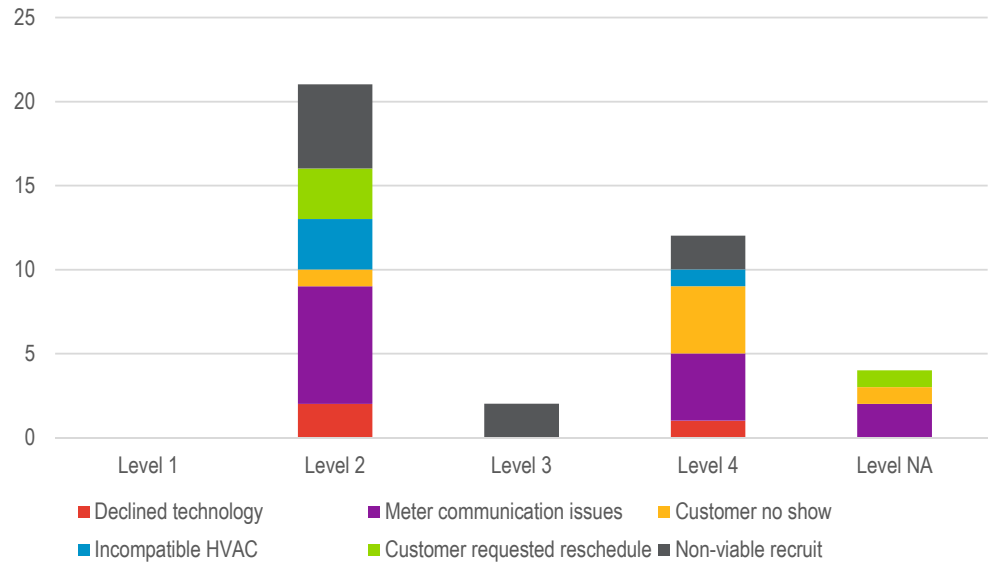
1. "Declined technology" indicated that the customer changed their mind or did not want any technology on the spot. In one case, the landlord had ordered the technology but did not live at the home and the tenant declined the technology;
2. "Meter communication issues" were due to technology not receiving 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

[53] Level NA = customer's requested technology level not recorded.

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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.

[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.

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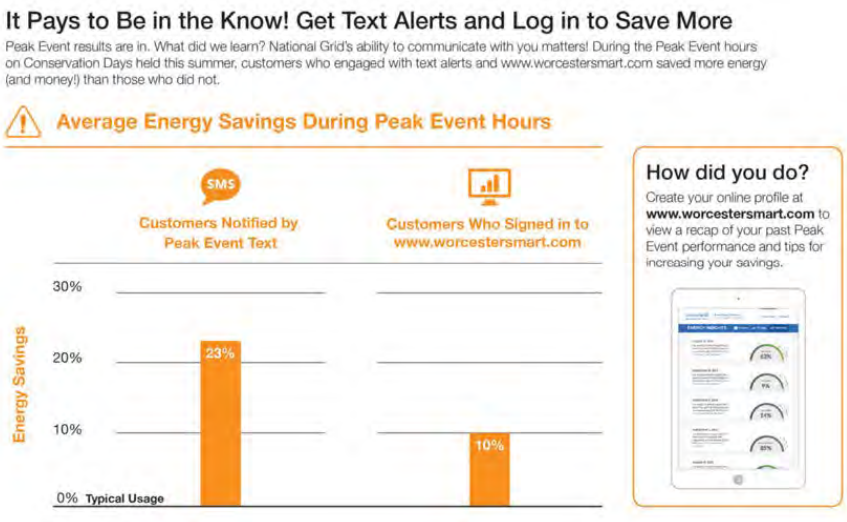
Figure 2-11. Excerpt from Smart Energy Solutions Bill Insert Sent in May 2015

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



Source: National Grid

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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.

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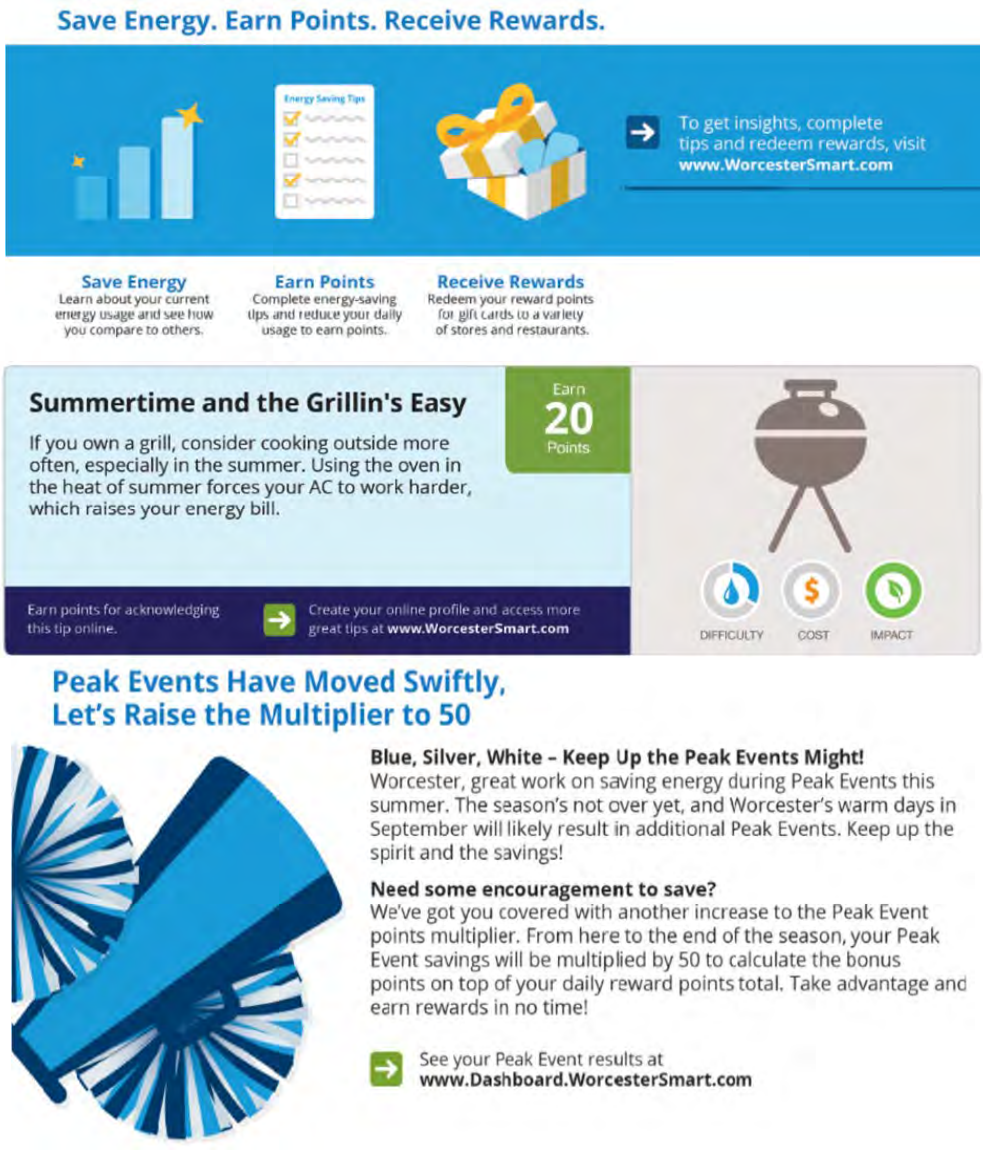
Figure 2-13. Excerpts on Rewards Platform from Smart Energy Solutions Mailers in June and August 2016



Source: National Grid

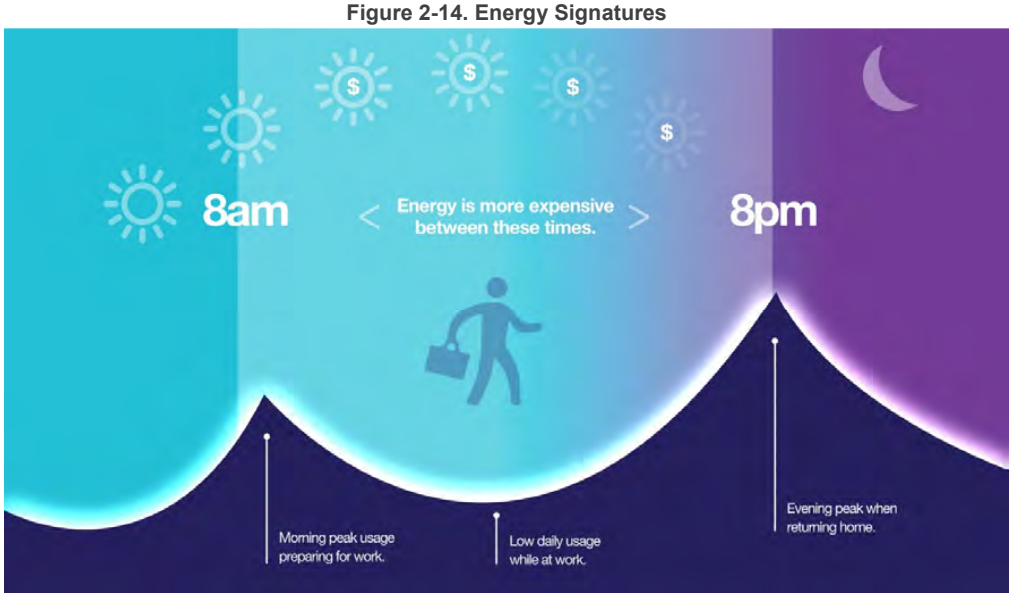
Energy Signatures were another new feature added to the Pilot in 2016. National Grid used customer data to create five common "energy signatures" or load profiles. Customers could self-identify with one of the signatures to receive personalized tips on how to conserve energy both during and outside of 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%).

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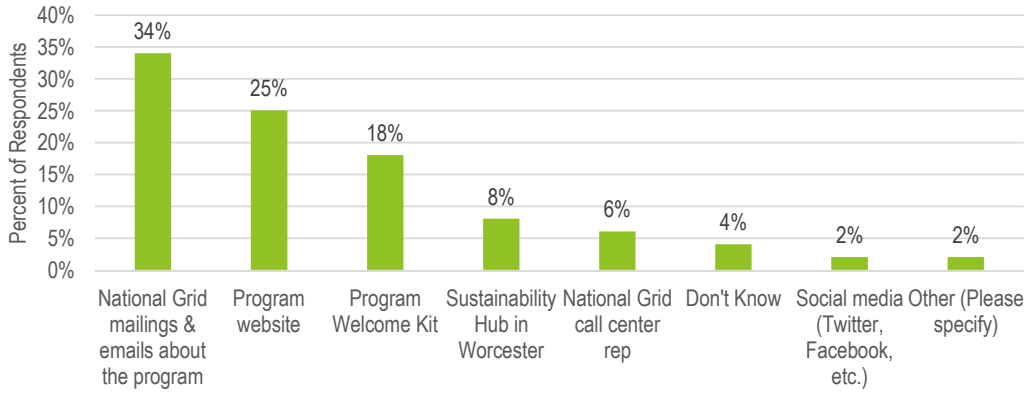
Figure 2-15. Most Useful Sources of Information about the Pilot



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]

[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.

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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

[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)

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- 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

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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

[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.

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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.

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

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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

[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.

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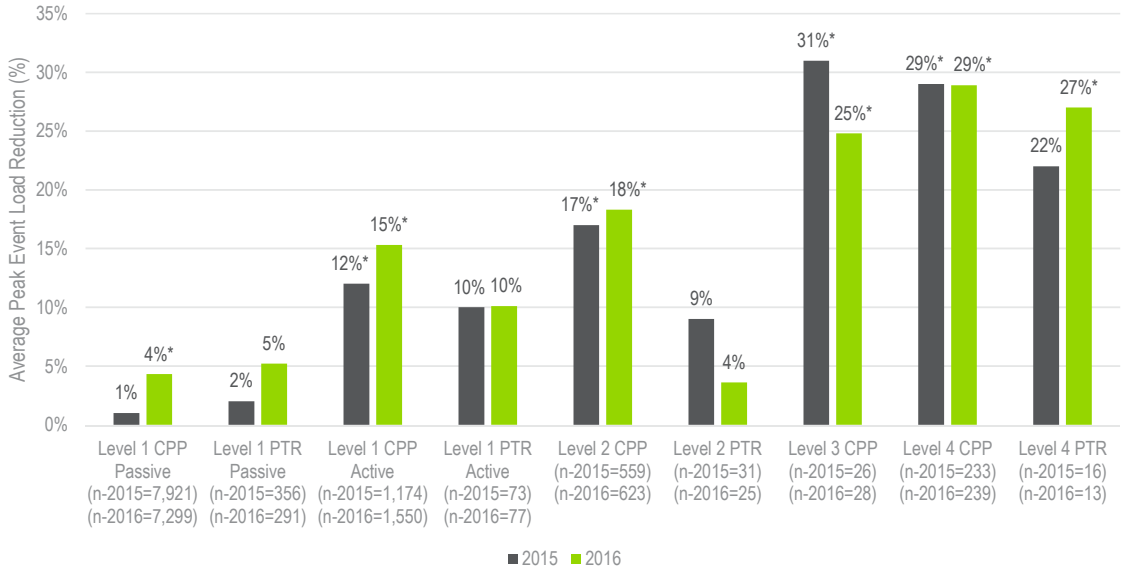
saved more than passive CPP customers, which could reflect that these customers have a higher level of engagement since they had to opt in to the PTR rate. Impacts for passive customers on both price plans increased considerably in 2016 compared to 2015. Impacts for most of the other groups stayed fairly 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.

[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.

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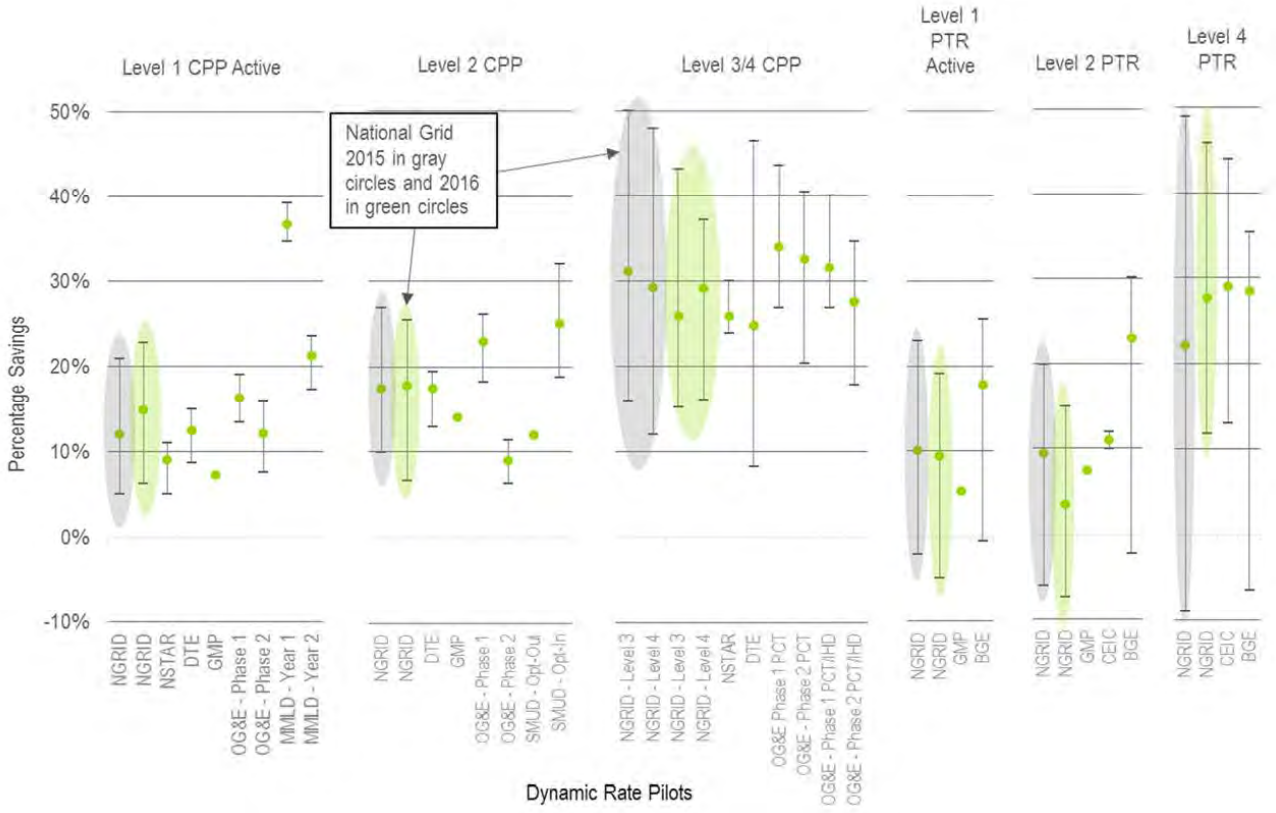
Figure 3-2. Residential Peak Event Impacts Percentage Comparison to Other Utilities



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

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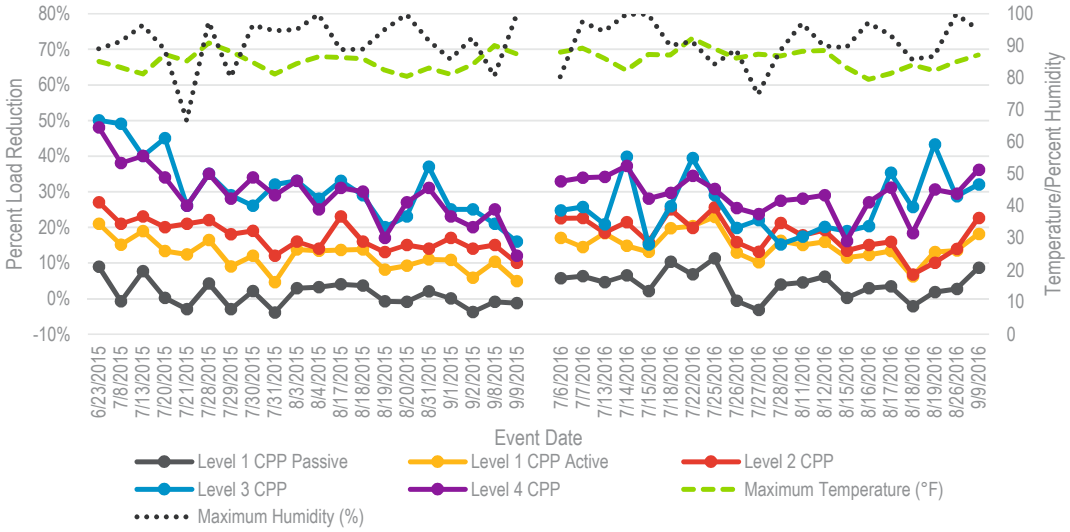
Figure 3-3 shows the average percentage impact for each event for the five residential CPP customer groups, and Figure 3-4 shows the average percentage impact for each event for the four residential PTR groups. For almost all of the technology/price groups, the impact was highest for the first Peak Event 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

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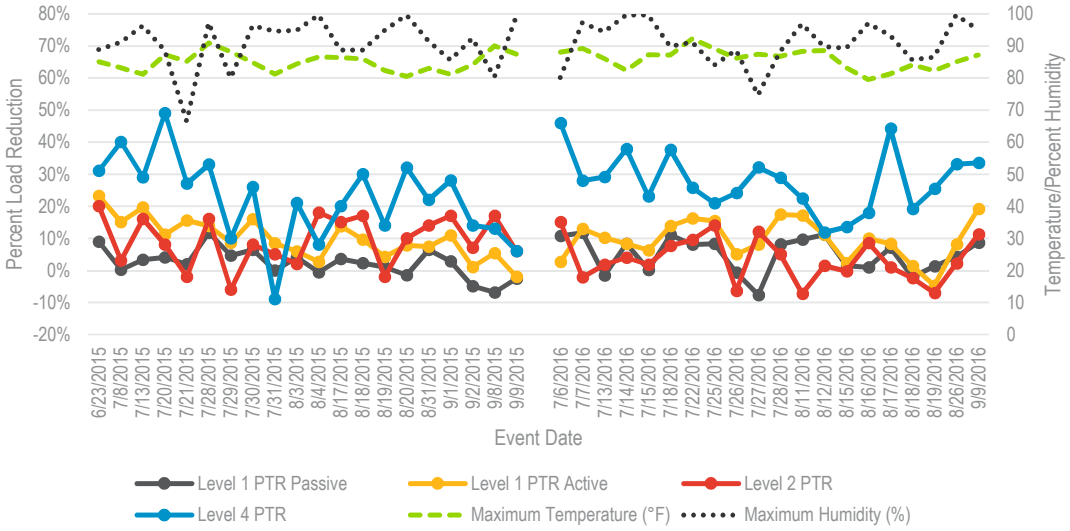
Figure 3-4. Percentage Savings for PTR Customers



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-

[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.

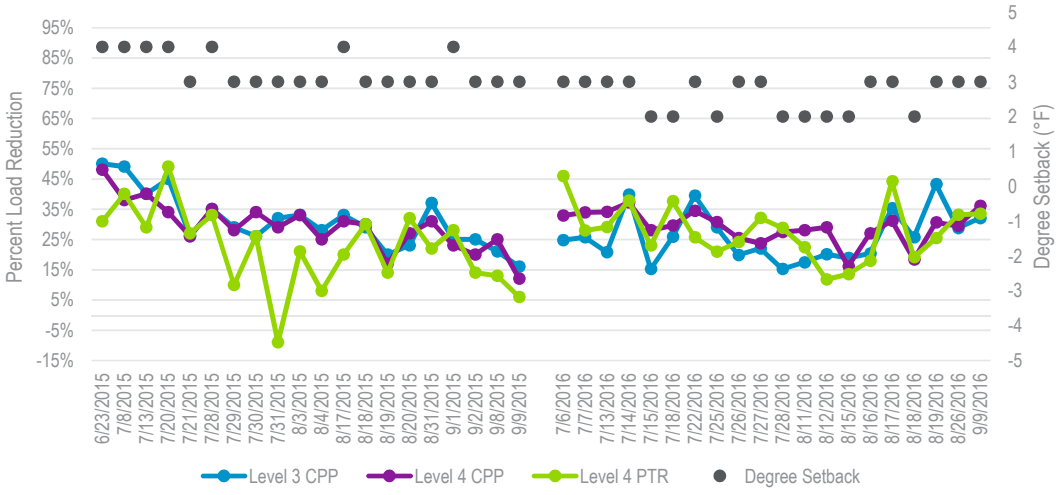
[70] Correlation coefficient of 0.30.

[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.

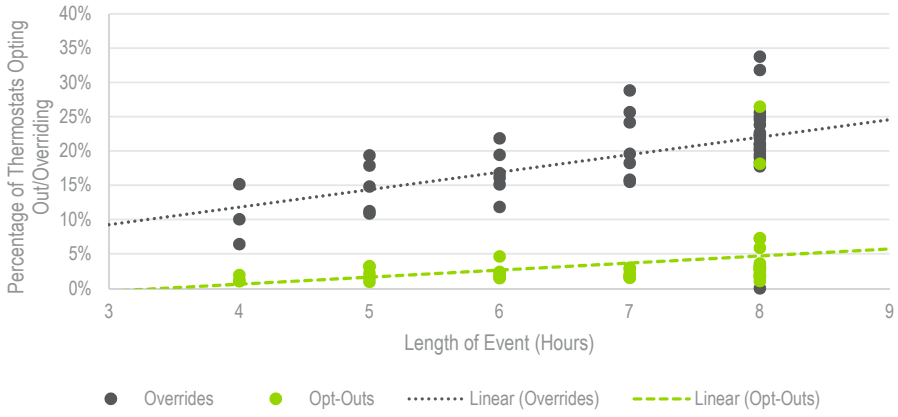
outs and overrides were also positively correlated with the end time of the Peak Event, meaning customers were more likely to opt-out/override the later into the evening a Peak Event went.[73]

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

[73] The correlation coefficient between the end time of the Peak Event and opt-outs and overrides was 0.33 and 0.50, respectively.

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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.

[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.

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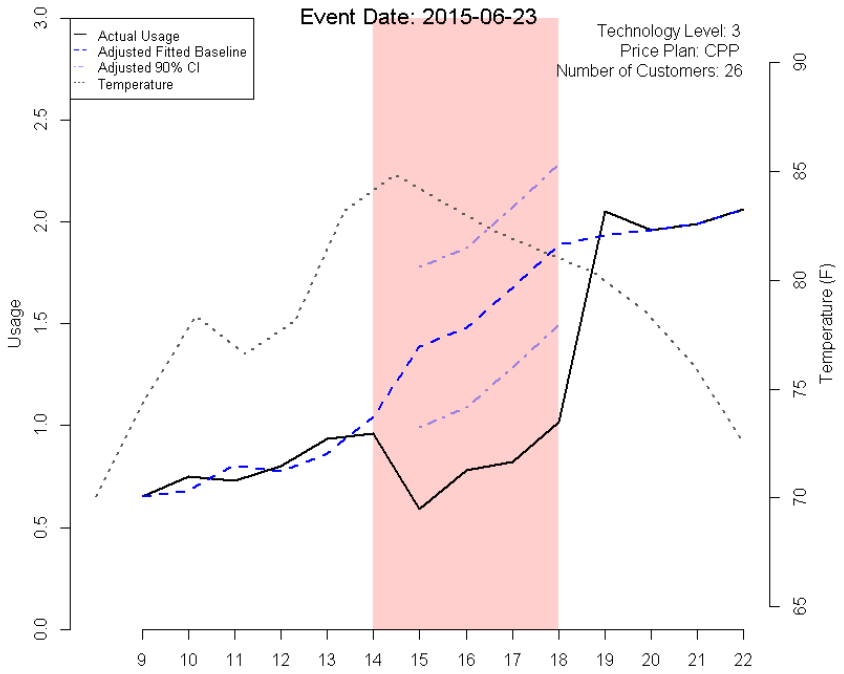
Figure 3-7. Level 3 CPP Actual and Baseline Usage on 2015-06-23



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.

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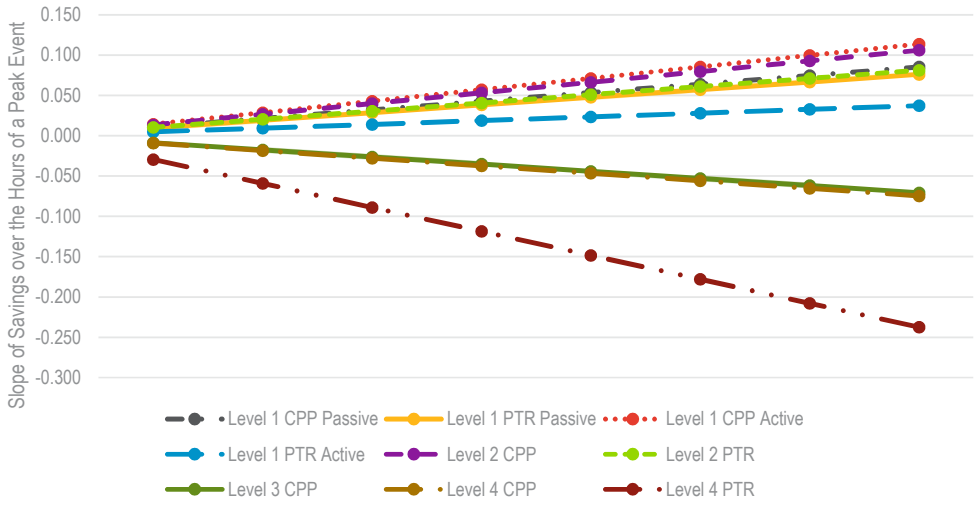
Figure 3-8. Savings Persistence Over the Course of a Peak Event



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

[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.

[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.

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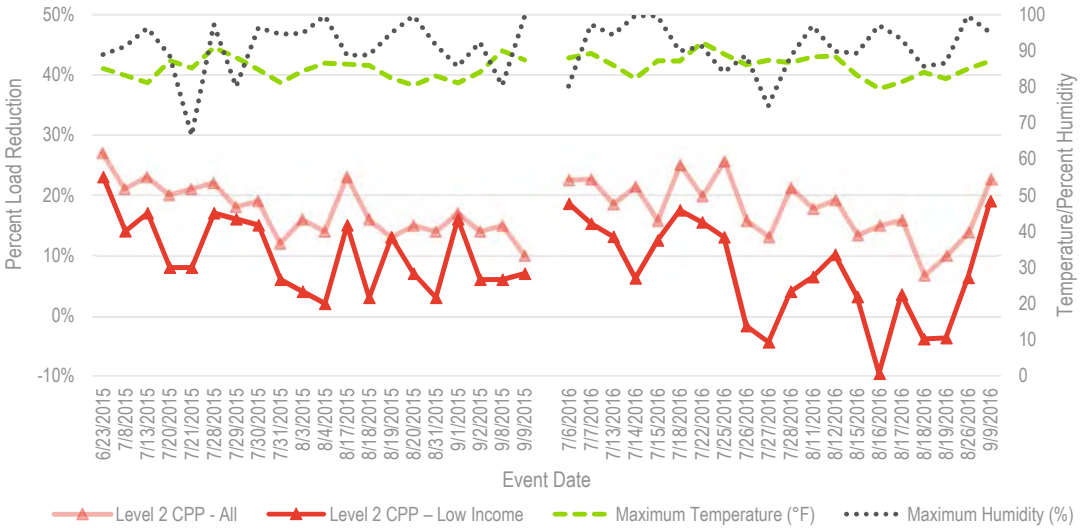
Figure 3-9. Event Savings for Low-Income Customers in Level 2 CPP



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

[79] See for example IEE Whitepaper (2010). *The Impact of Dynamic Pricing on Low Income Customers*.

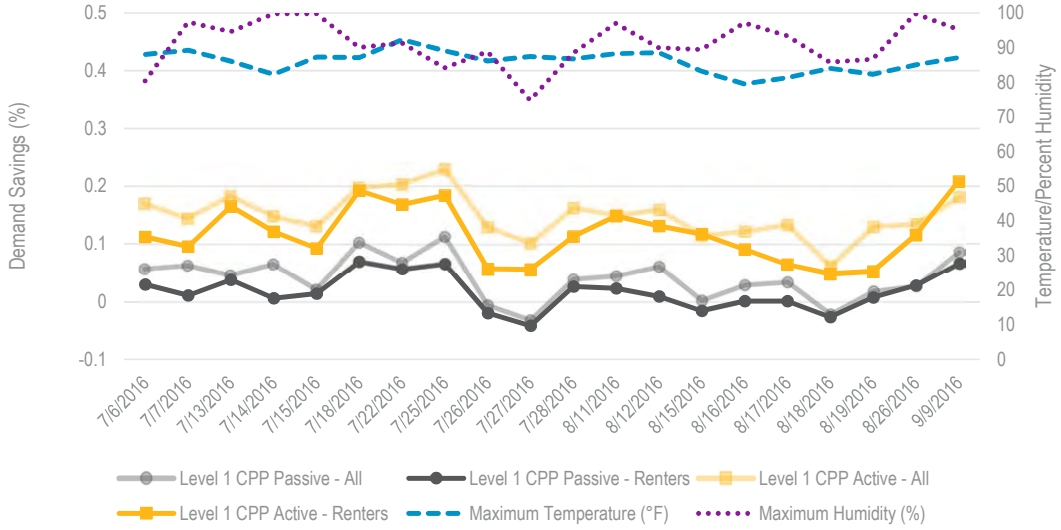
[80] The low-income focus groups suggested that some low-income customers experience these conditions but the sample sizes were not large enough to conclude that these conditions are more prevalent for low-income customers than for residential customers in general.

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



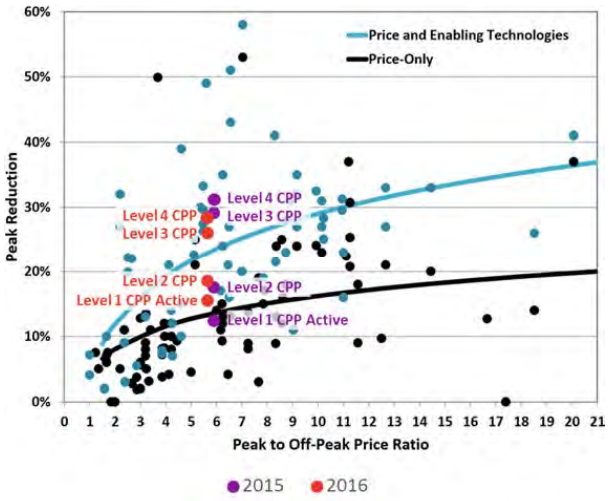
Source: Navigant analysis

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

[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.

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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.

[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.

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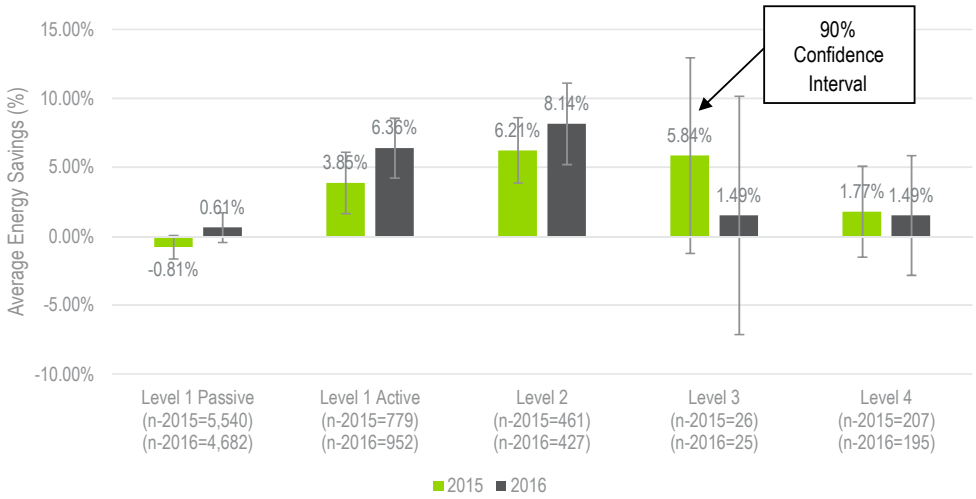
Figure 3-12. Average Energy Impacts for CPP Customers by Technology Level



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.

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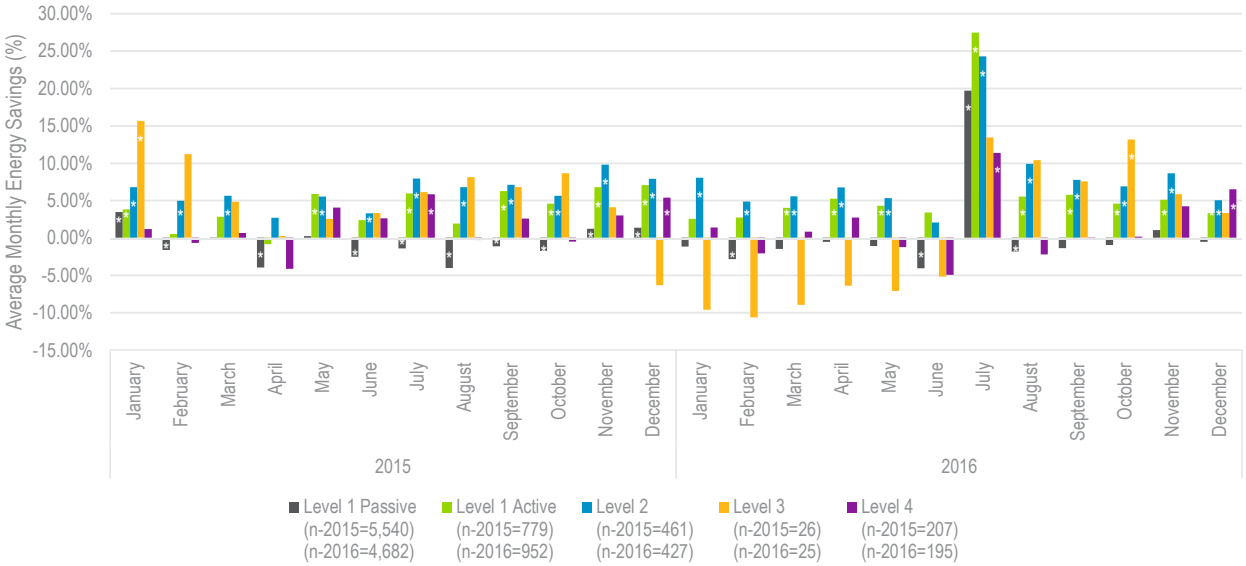
Figure 3-13. Average Monthly Energy Impacts for CPP Customers by Technology Level



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.

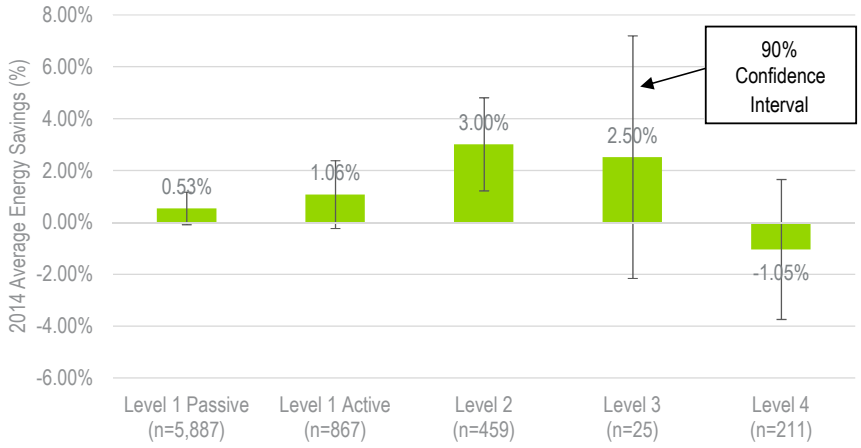
3.2.2 2014 Impacts

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

[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

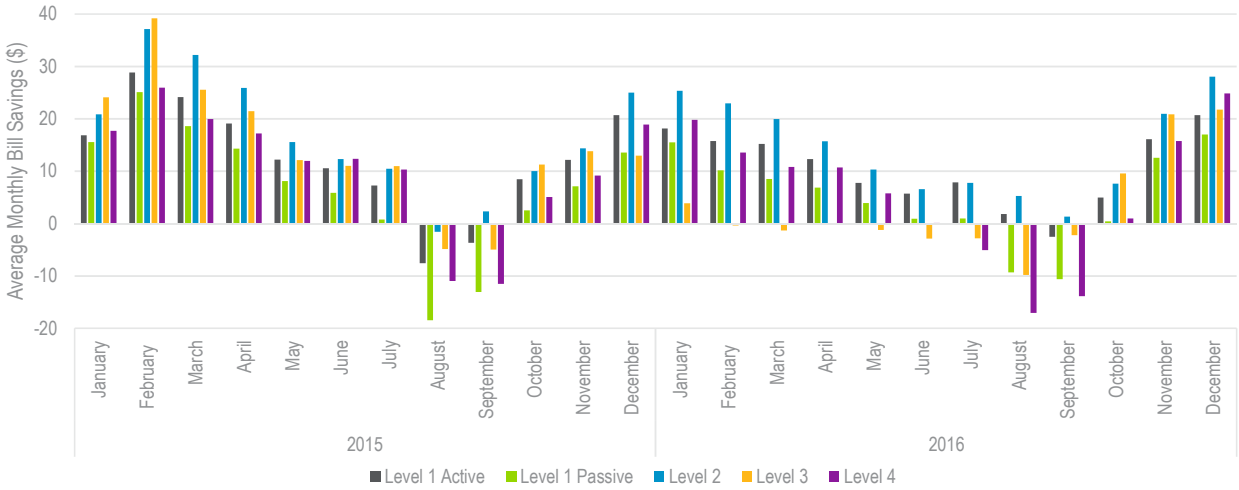
	2015		2016	
	With 135 Peak Event Hours	With 175 Peak Event Hours	With 139 Peak Event Hours	With 175 Peak Event Hours
CPP	$146	$142	$90	$87
PTR	$20	$26	$19	$25

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

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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

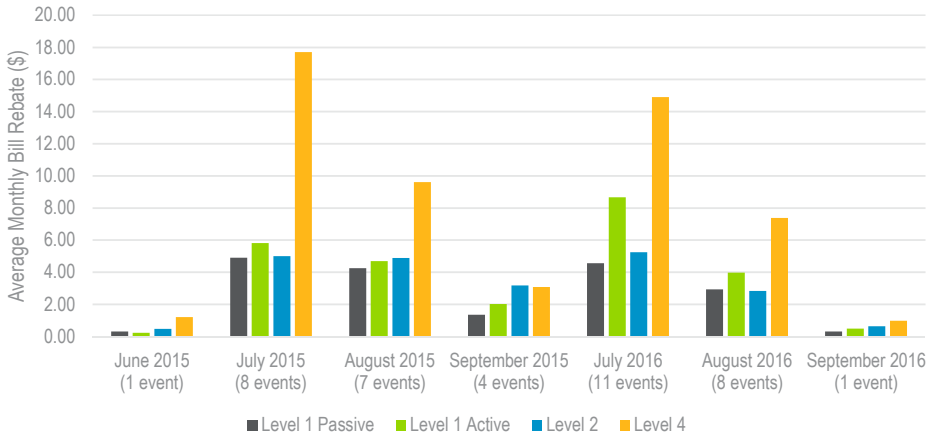
	2015	2016
Level 1 Passive	$79	$56
Level 1 Active	$148	$123
Level 2	$204	$171
Level 3	$172	$35
Level 4	$125	$66

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

[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.

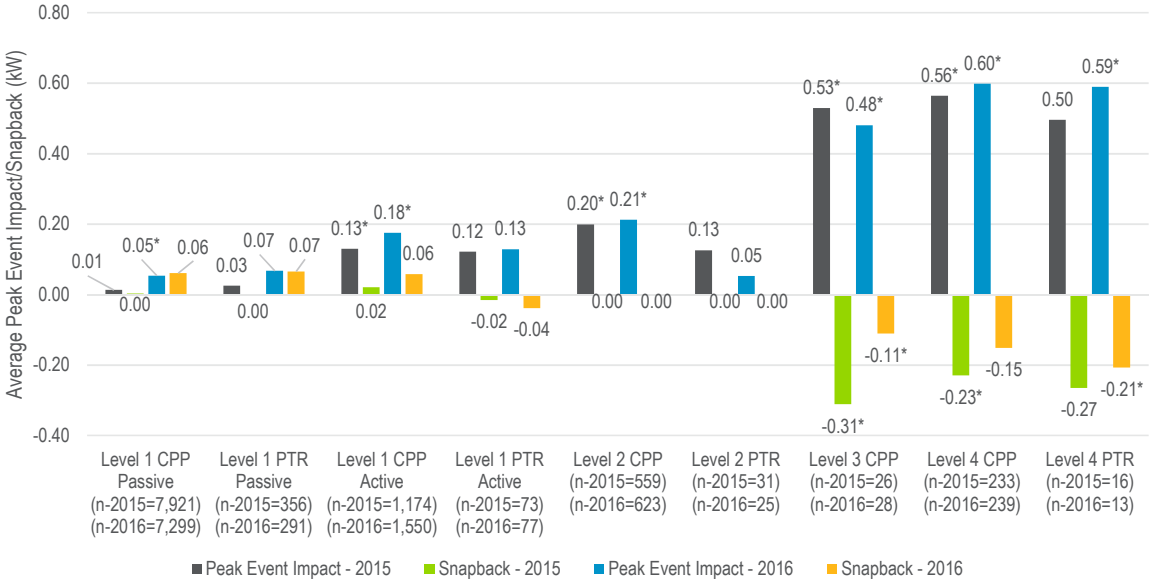
CPP customers were expected to exhibit all three types of load shifting as they were on a TOU rate and thus had an incentive to be price-conscious and shift usage to lower-cost times of the day and week, i.e. off-peak hours and weekends. Load shifting contributed to bill savings for CPP customers. PTR 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.

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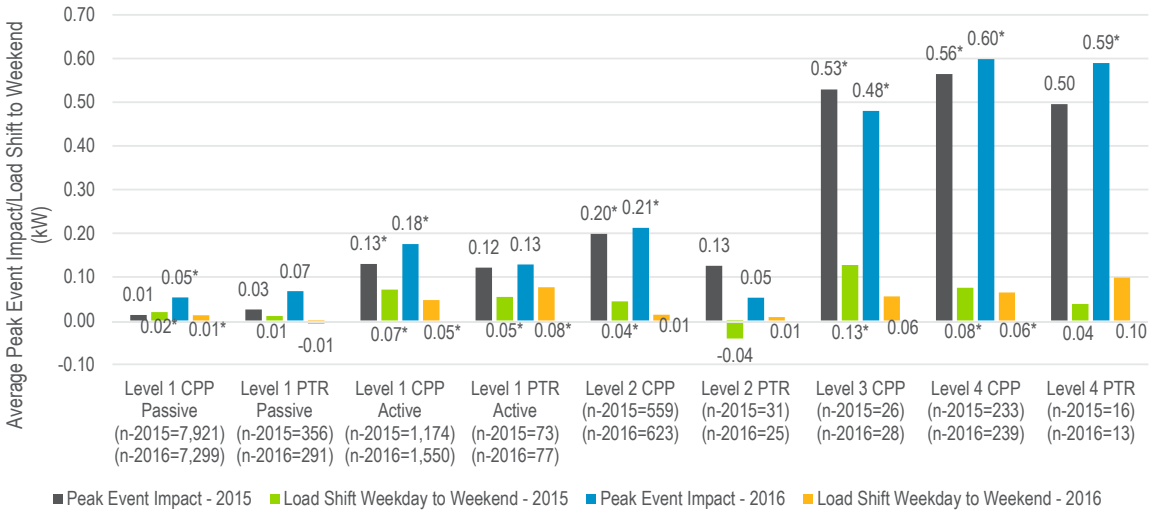
Figure 3-18. Weekday to Weekend Load Shifting Compared to Peak Event Impacts



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.

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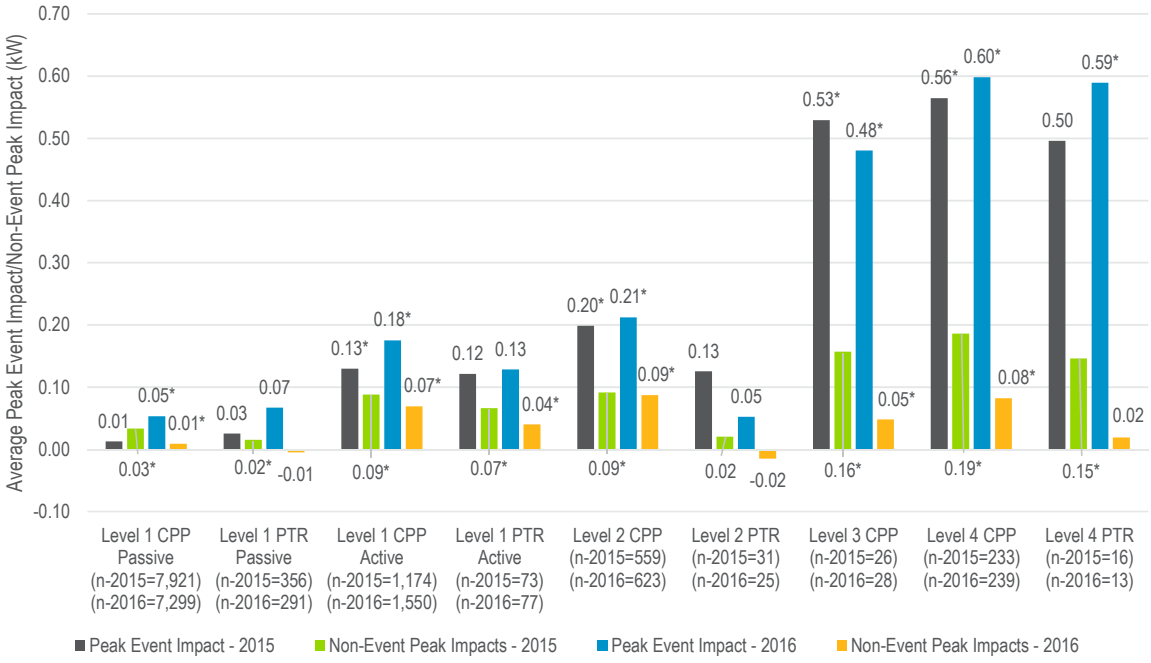
Figure 3-19. Non-Event Peak Impacts Compared to Peak Event Impacts



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.

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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

[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.

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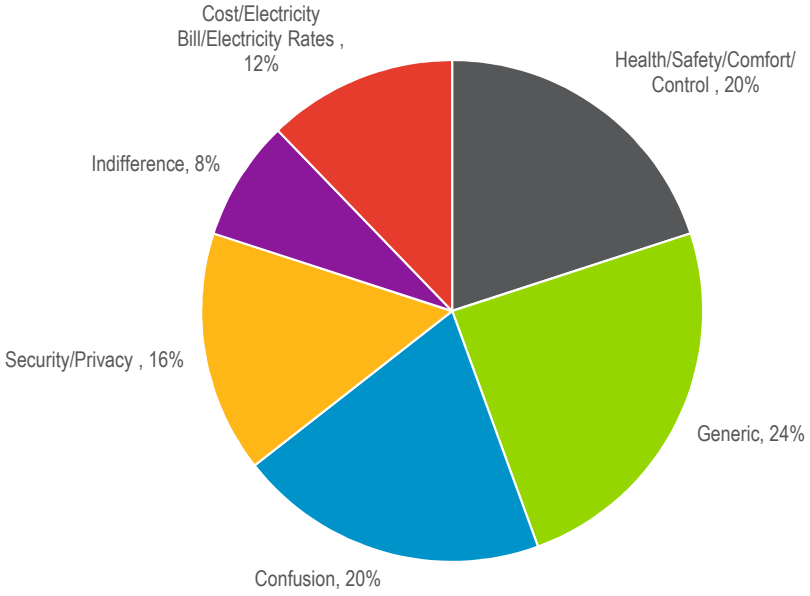
"I don't want this."

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).

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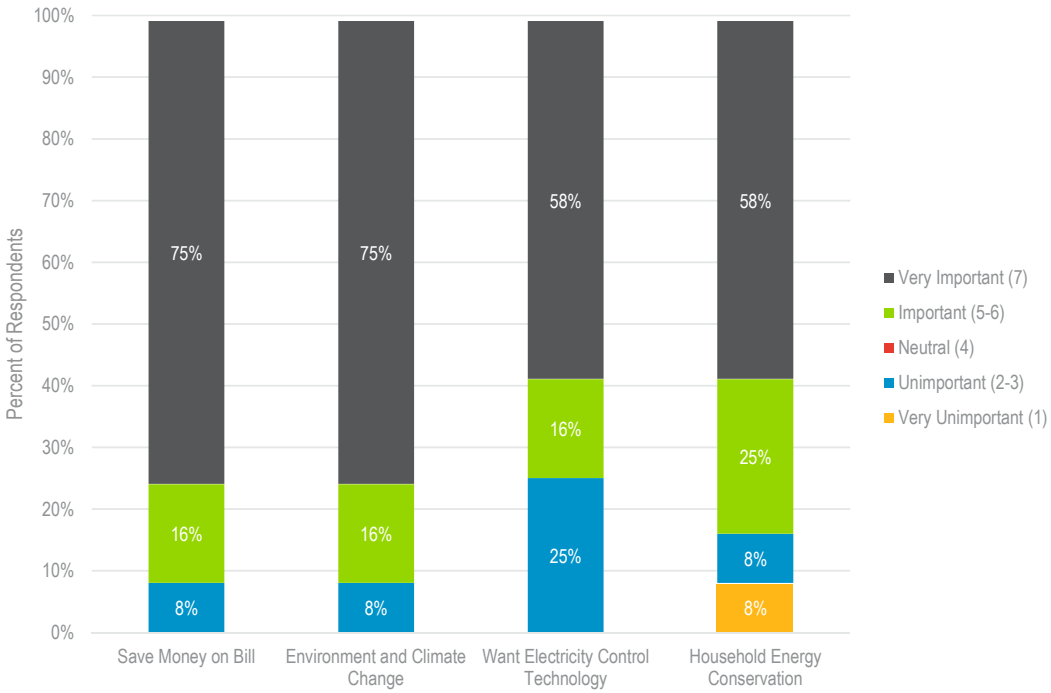
Figure 4-2. Customer Motivations for Pilot Participation, as Expressed in the Pre-Pilot Survey



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).

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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.

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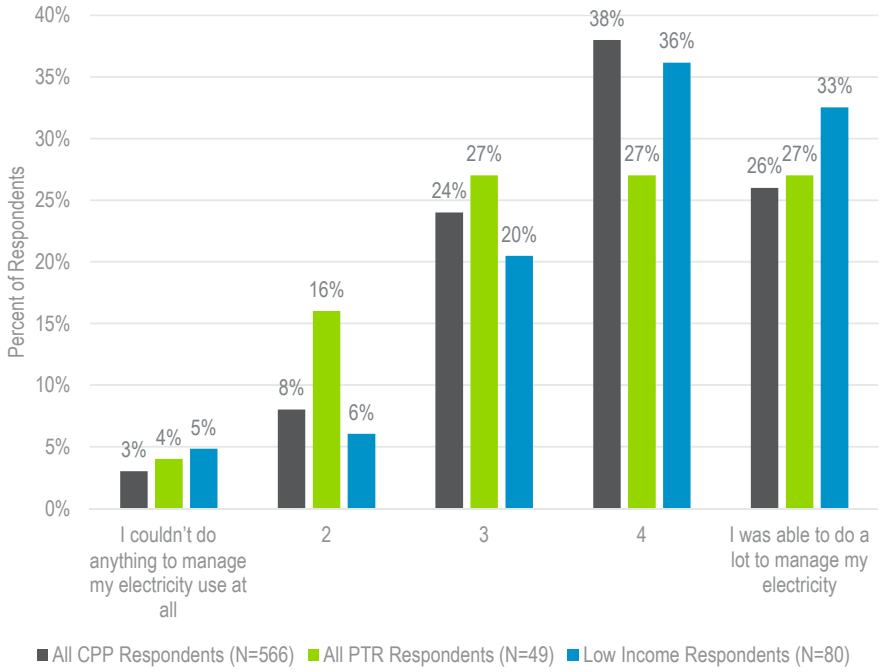
Figure 4-4. Reported Ability of Low-Income Customers to Manage Electricity Use at End of Pilot



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.

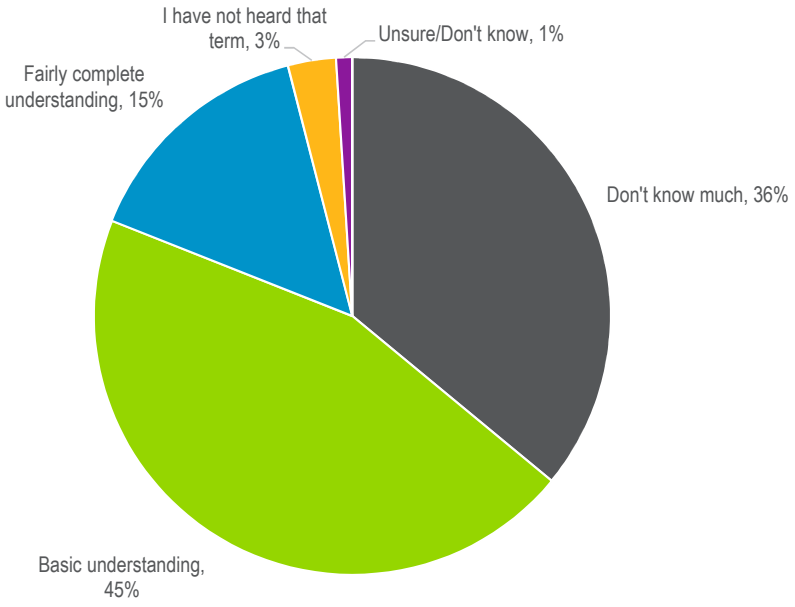
4.2.1 Rate Awareness and Understanding Increased over Time

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)

[89] The Regulatory Assistance Project. *Time-Varying and Dynamic Rate Design.* July 2012.

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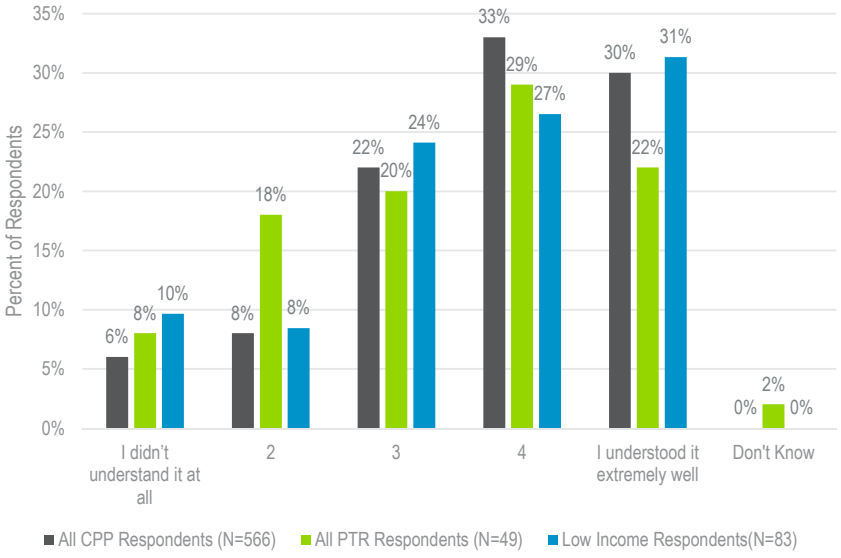
By the time the end of pilot survey was administered (October 2016), almost all customers (97%) were aware of the Pilot and the rate they were on. Additionally, the majority of customers on both price plans, including those with low incomes, indicated that they had a good understanding of their pricing 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.

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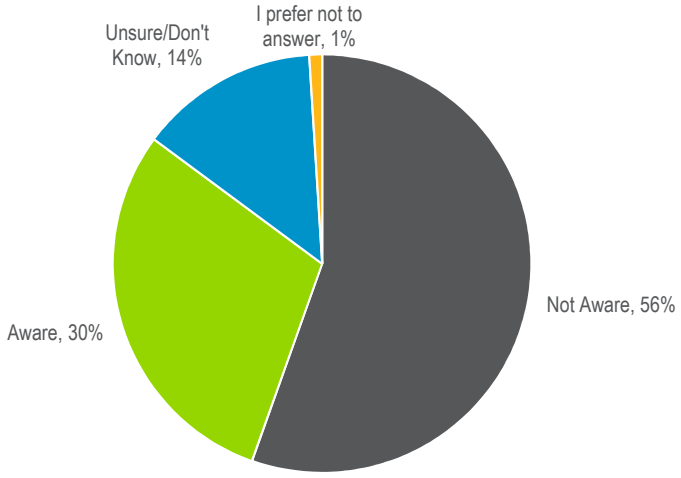
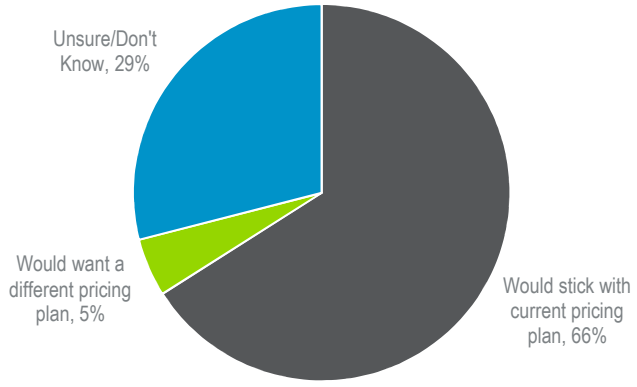
Figure 4-7. Customer Awareness of Ability to Switch Pricing Plans



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)

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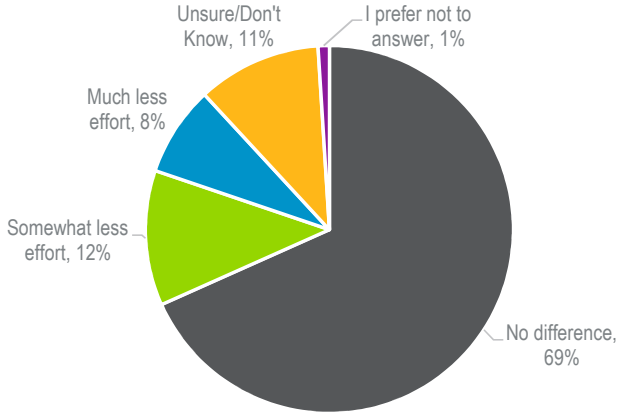
4.2.2 Customers Exhibited Mixed Awareness and Understanding of Program Features

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)

[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.

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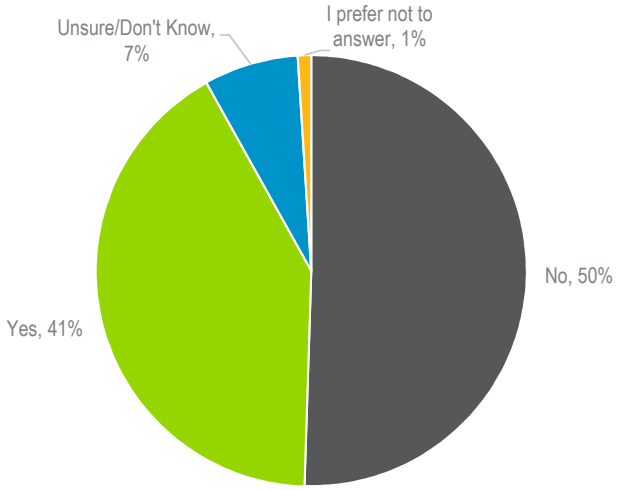
Technology

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.

[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."

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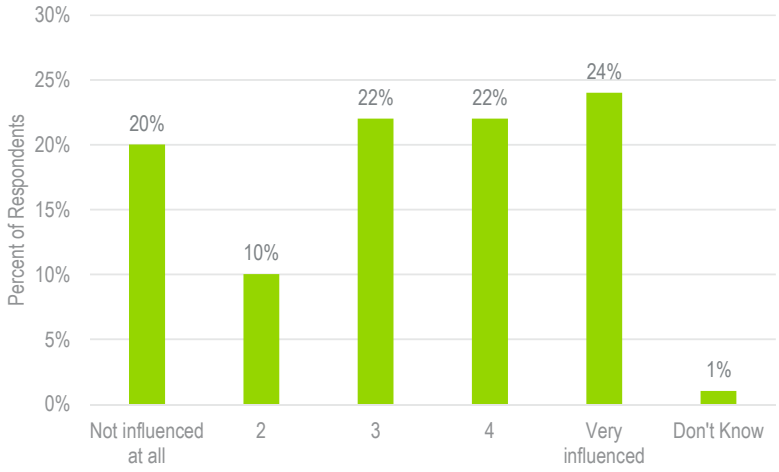
Figure 4-11. Reported Influence of Rewards Platform on Energy Efficient Actions



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

[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.

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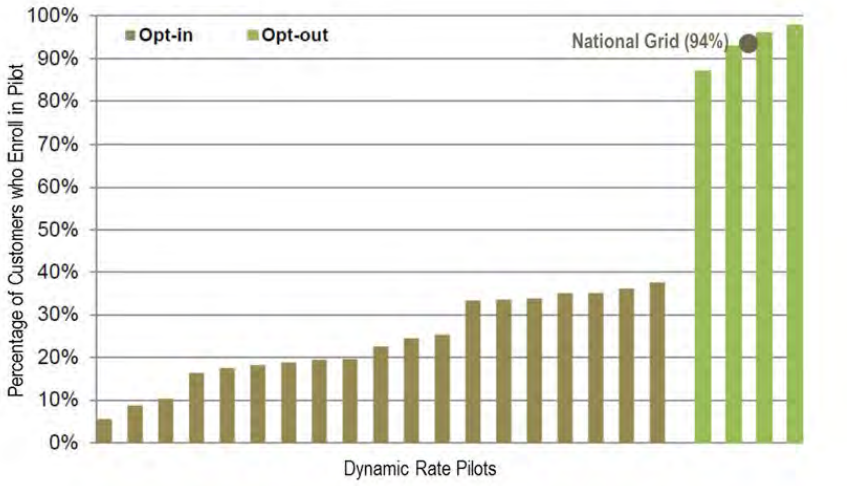
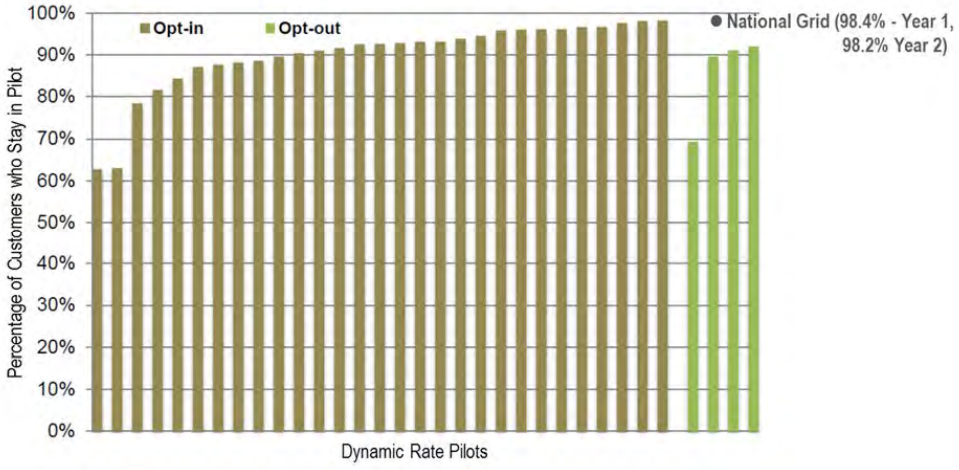
customers were higher than one-year retention rates for other opt-out rate pilot programs, even after two years of the Pilot. In fact, the Pilot had hardly any drop outs from the first year to the second year, making the first and second year retention rates virtually identical.

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.

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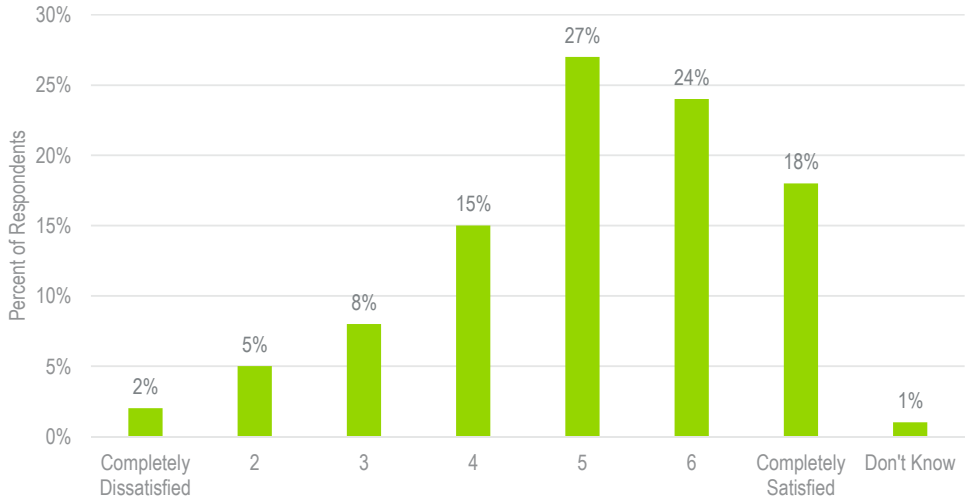
4.2.4 Strong Customer Satisfaction with Program

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.

[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.

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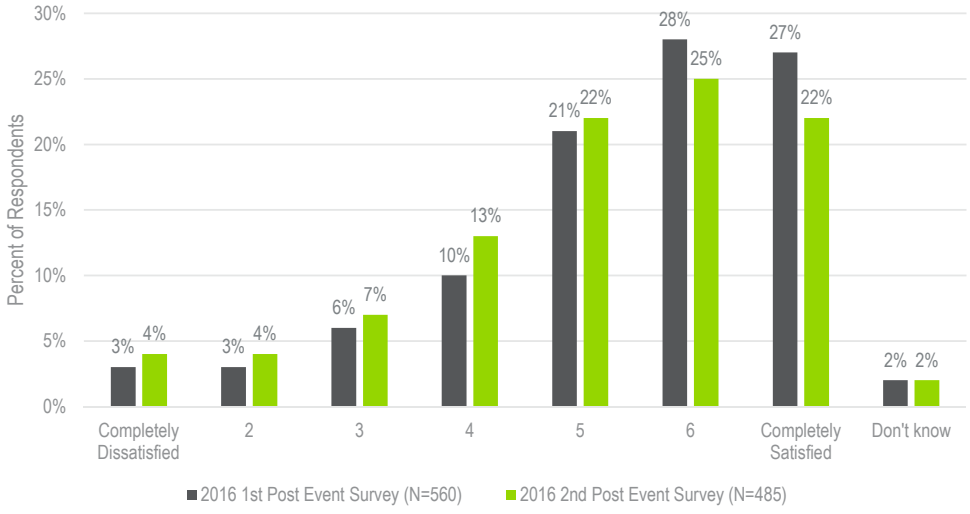
DTE conducted an opt-in pricing pilot that had a TOU/CPP price plan and included technology offerings very similar to Smart Energy Solutions'. By the end of DTE's pilot, 86% of customers rated their pilot at least a 6 on a 10-point scale.[97] Translated to the 7-point Smart Energy Solutions scale, 86% 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)

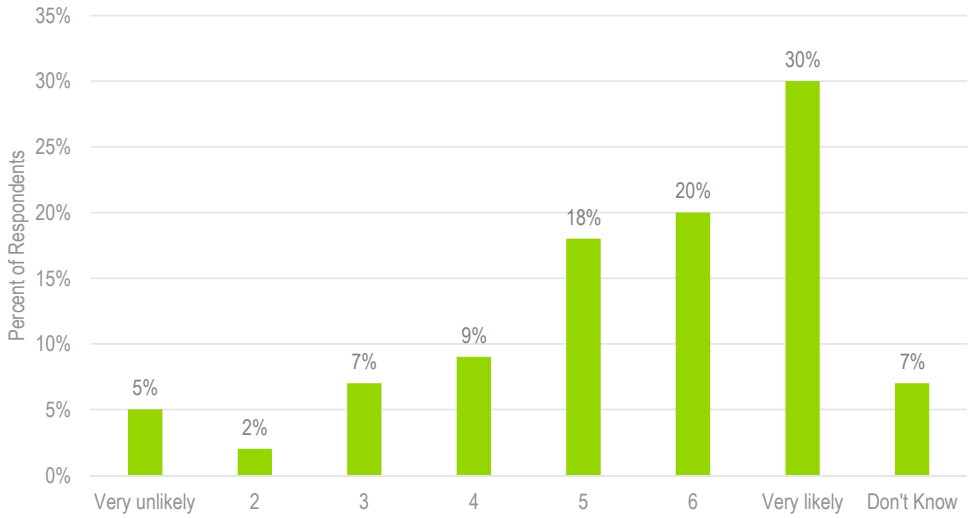
[97] See Cappers, P., H. Liesel, R. Scheer. 2015.

[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.

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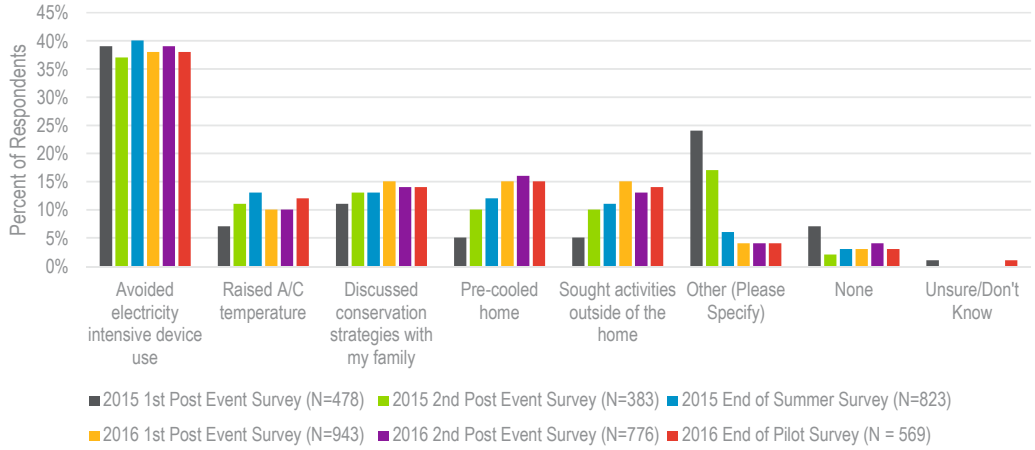
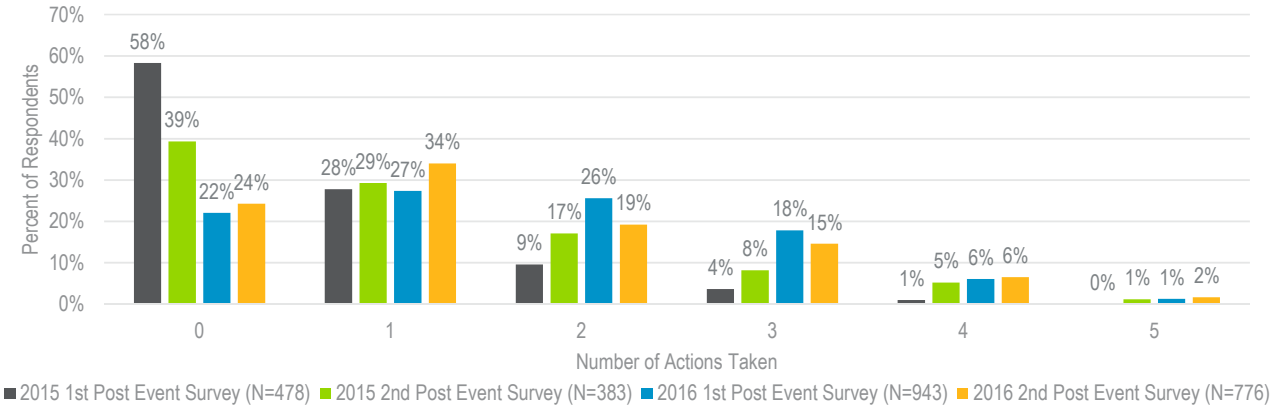
Figure 4-17. Actions Customers Took to Reduce Electricity Usage on Conservation Days



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)

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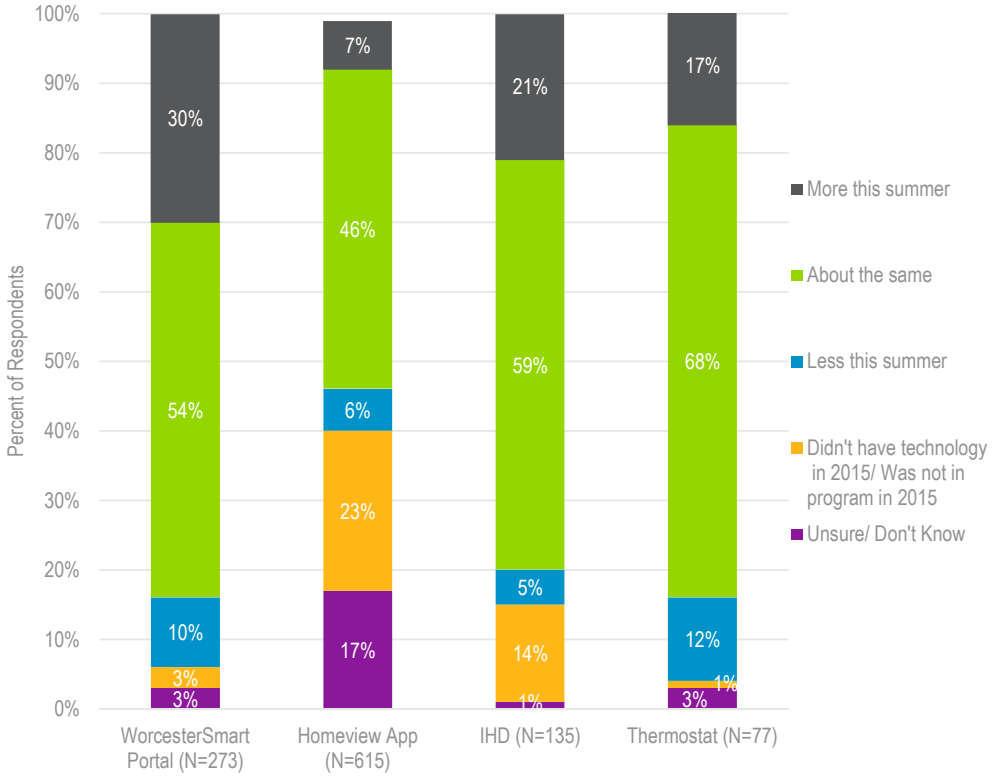
As shown in Figure 4-19, most customers did not change the frequency with which they viewed the WorcesterSmart web portal (54%), the Homeview App (46%), their IHD (59%), or their smart thermostat (68%) through the two summers of the Pilot. The IHD and the web portal were the two technologies that had 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

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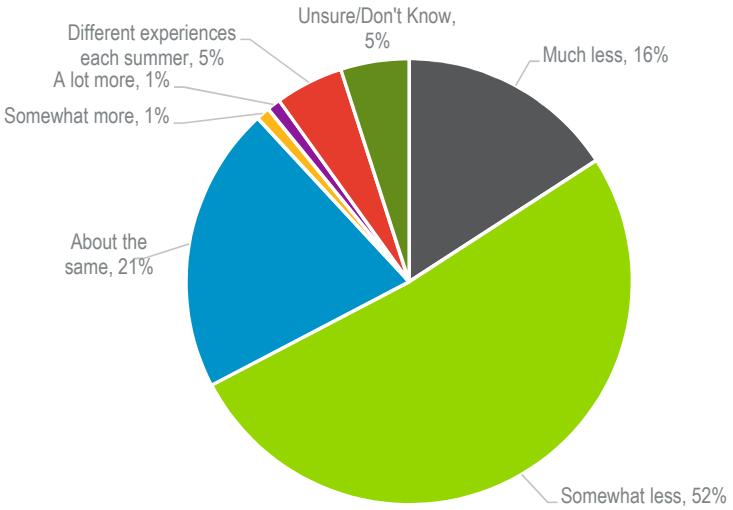
the Pilot compared to a normal summer. The majority of customers (68%) believed they reduced their electricity usage at least "somewhat" (see Figure 4-20).

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).

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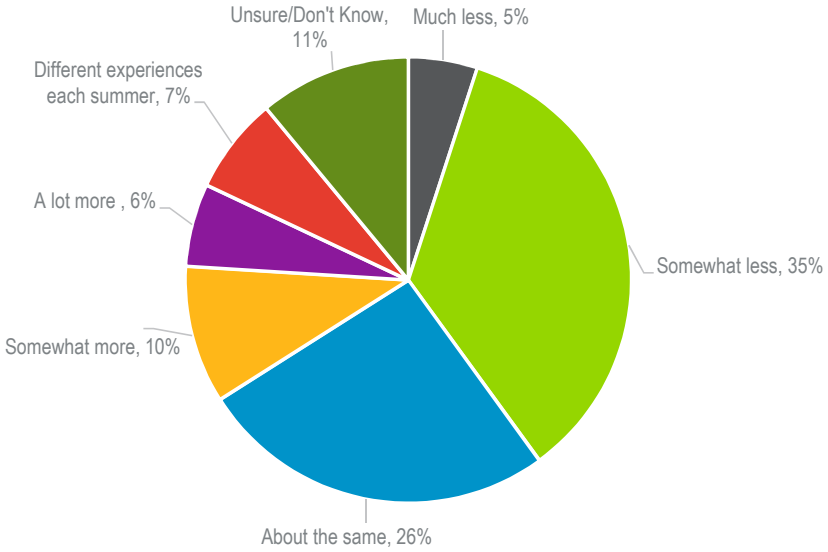
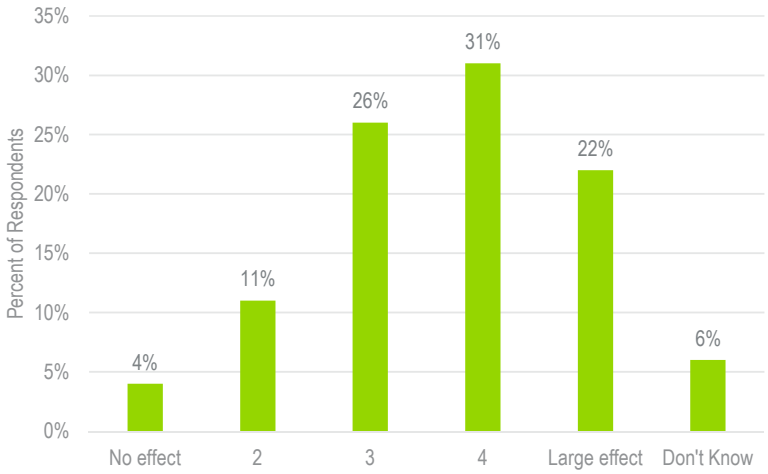
Figure 4-21. Customer-Perceived Change in Summer 2015 & 2016 Electric Bill Compared to a Normal Summer



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)

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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.

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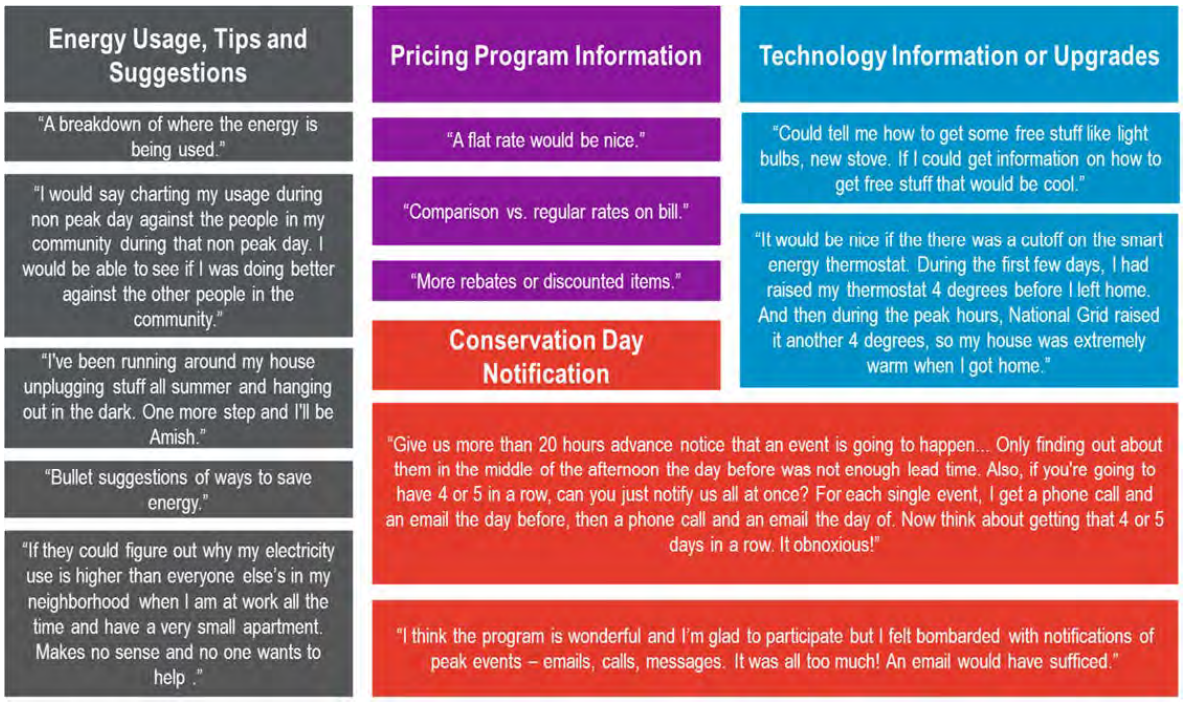
Figure 4-23. Additional Information Customers Would Like About Smart Energy Solutions



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.

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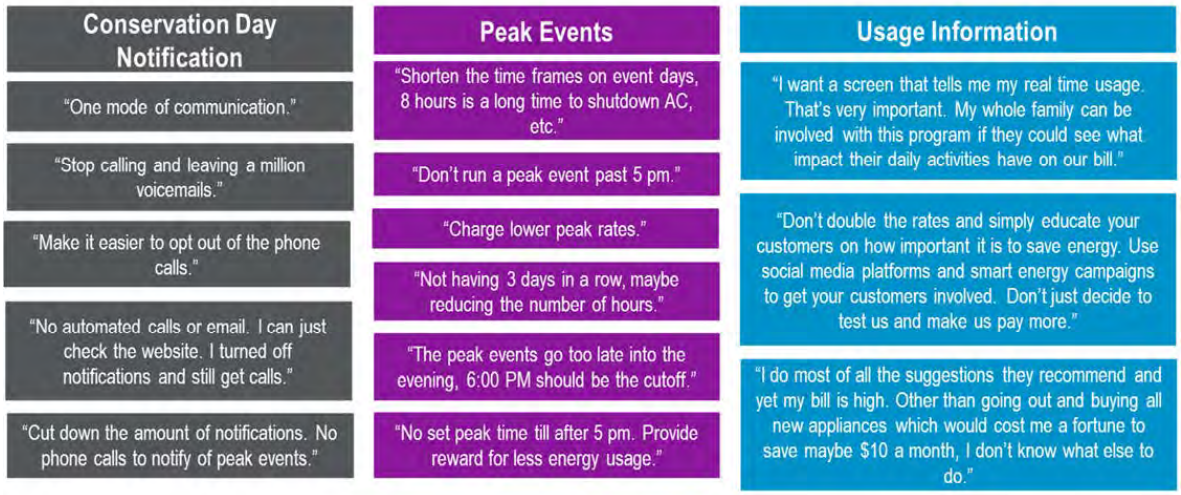
Figure 4-24. Customer Recommendations to Improve Smart Energy Solutions



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.

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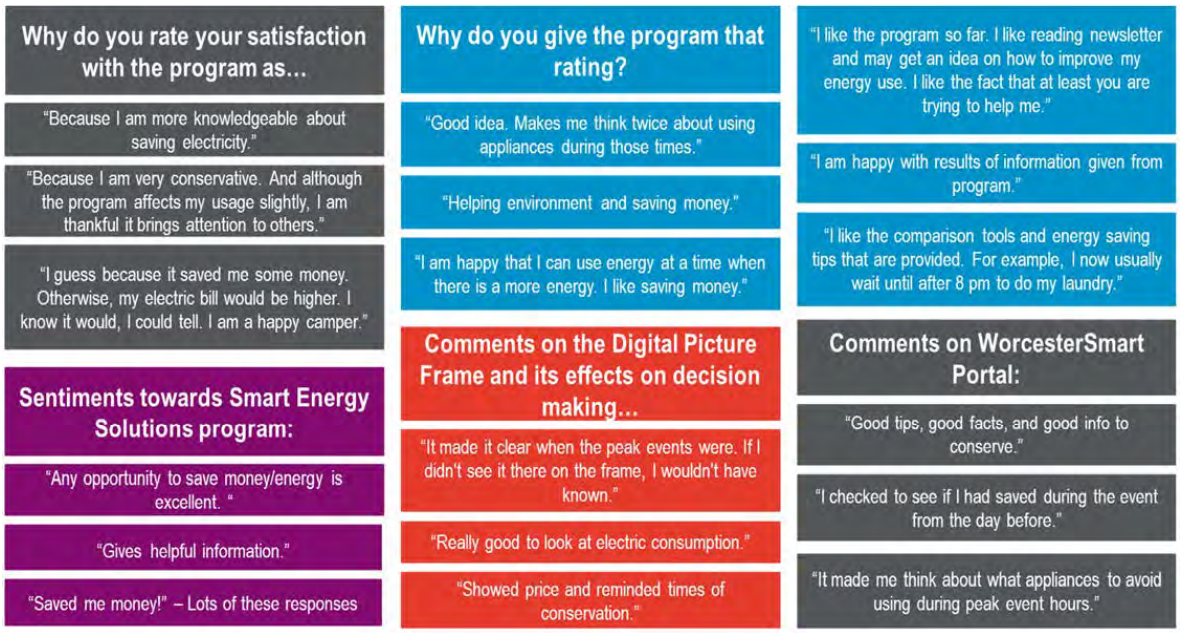
Figure 4-25. Customer's Positive Feedback on Smart Energy Solutions



Source: Navigant analysis of 2015 & 2016 post event surveys, 2015 end of summer survey, and 2016 end of pilot survey

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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.

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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.

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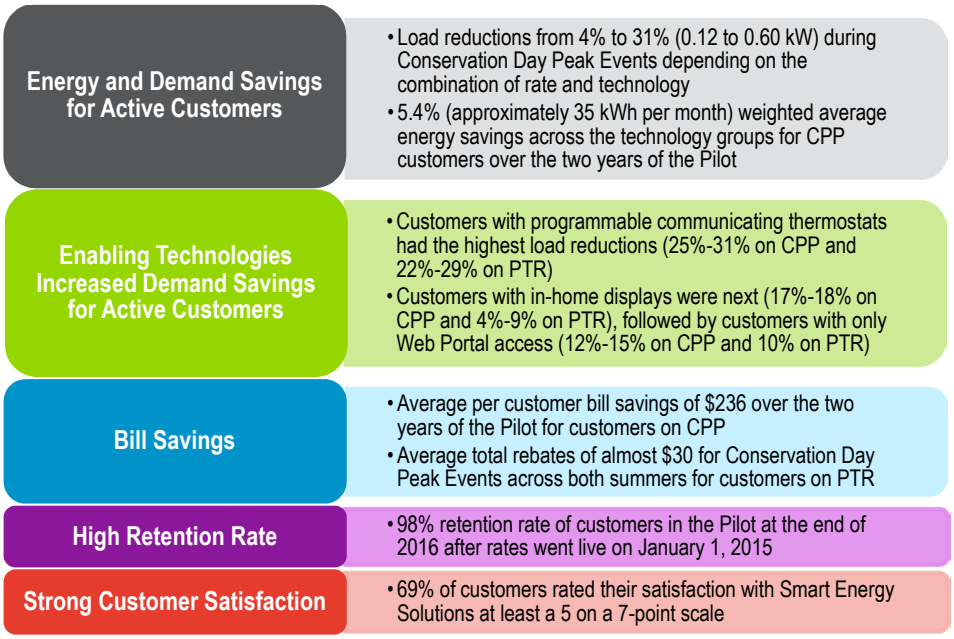
6. KEY FINDINGS AND LEARNINGS

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



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,

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

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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.

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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.

[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.

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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_{s,t} + \sum_{s=1}^{S=22} \sum_{r=1}^{R=20} \beta_{s,r}^s \cdot qh_{i,t} \cdot s_{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

[102] Recall that only hours between 8 a.m. and 10 p.m. were included in the regression.

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		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

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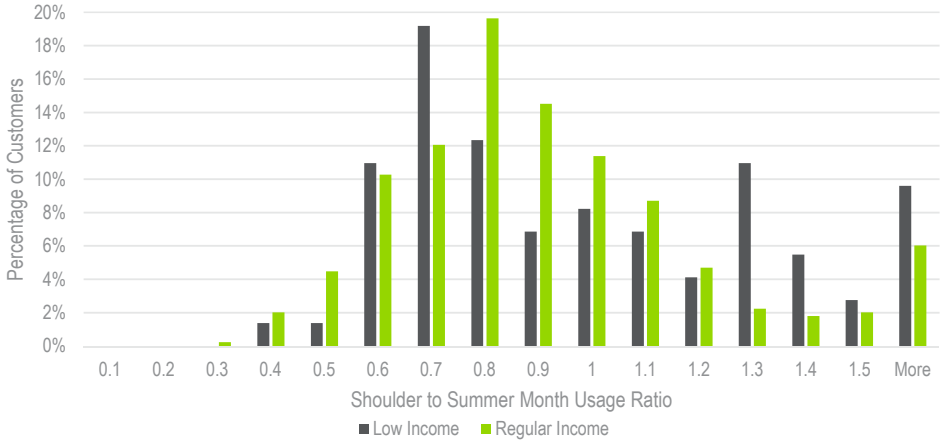
of shoulder to summer month usage.[103] A customer with CAC is likely to have considerably higher usage in the summer than in the shoulder months; therefore, a lower shoulder to summer month usage ratio indicates a higher likelihood of having CAC. Figure A-1 shows the distribution of the shoulder to 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

[103] Navigant chose to use July and August as the summer months and May and October as the shoulder months.

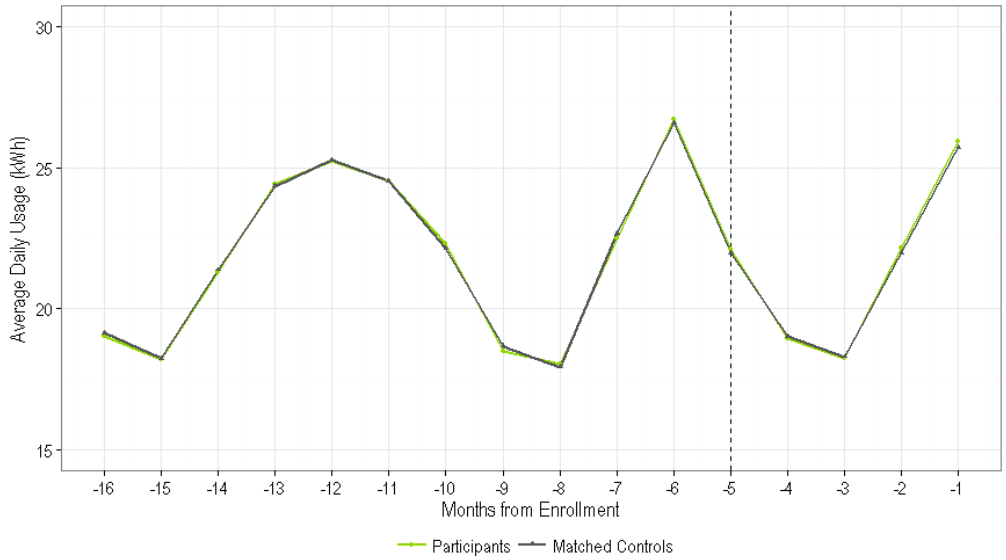
[104] Navigant used households in the following ZIP codes in the pool of non-participants from which to draw matched controls: 01601, 01602, 01603, 01604, 01605, 01606, 01607, 01608, 01609, 01610, 01611, 01501, 01527, 01545, 01505, 01583, 01520, 01612, 01524, 01542, 01537, 01540, 01590, 01519, 01560, 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.

[105] Low-income customers are given a 25% discount on their entire bill, including both the commodity and non-commodity charges.

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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 Peak Period	Off-Peak Period	Peak Event Period	Conservation Day Rebate
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

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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.

[106] Details can be found in: D.P.U. No. 1237, Tariff for Basic Service, September 3, 2014.

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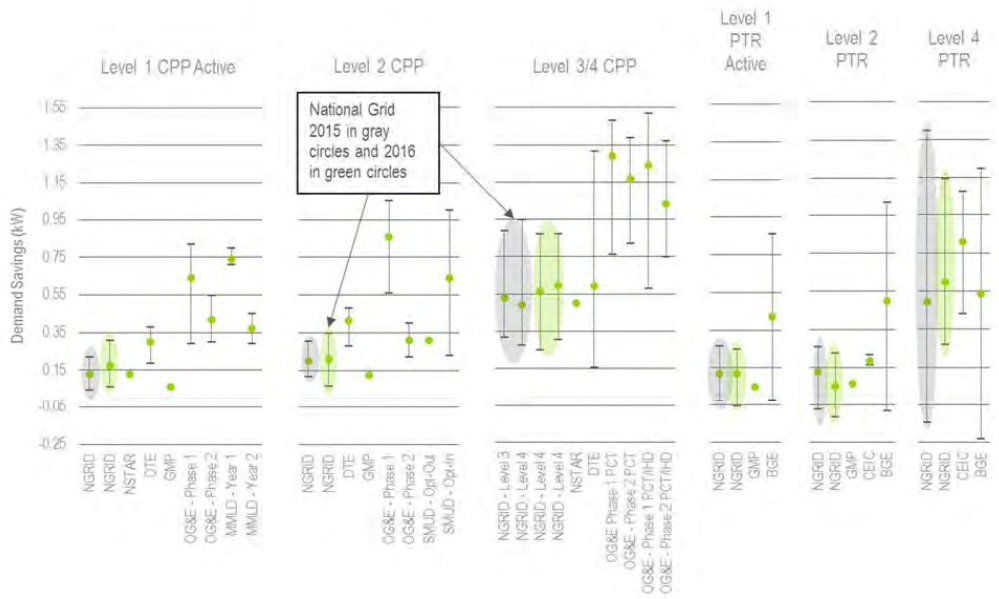
APPENDIX B. ADDITIONAL IMPACT ASSESSMENT RESULTS

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.

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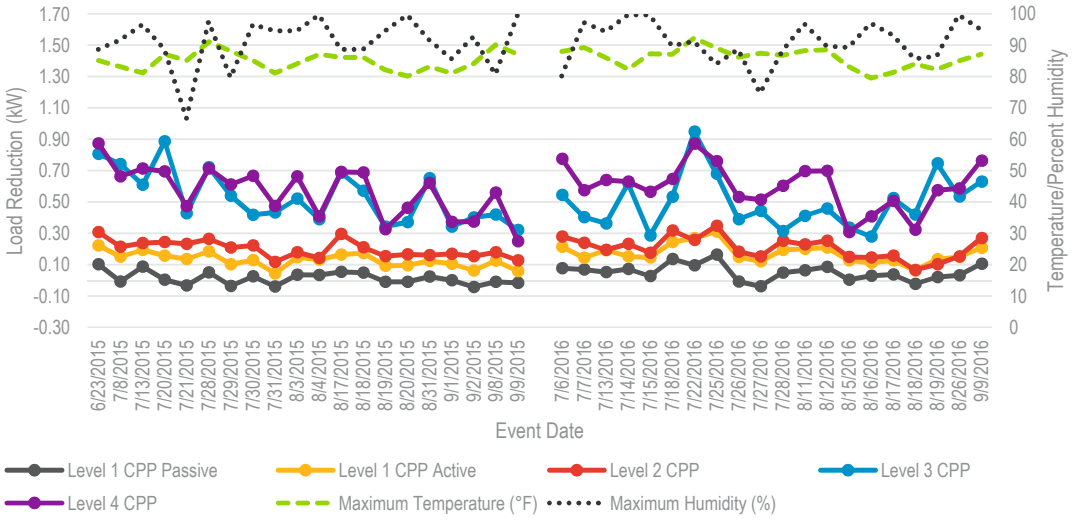
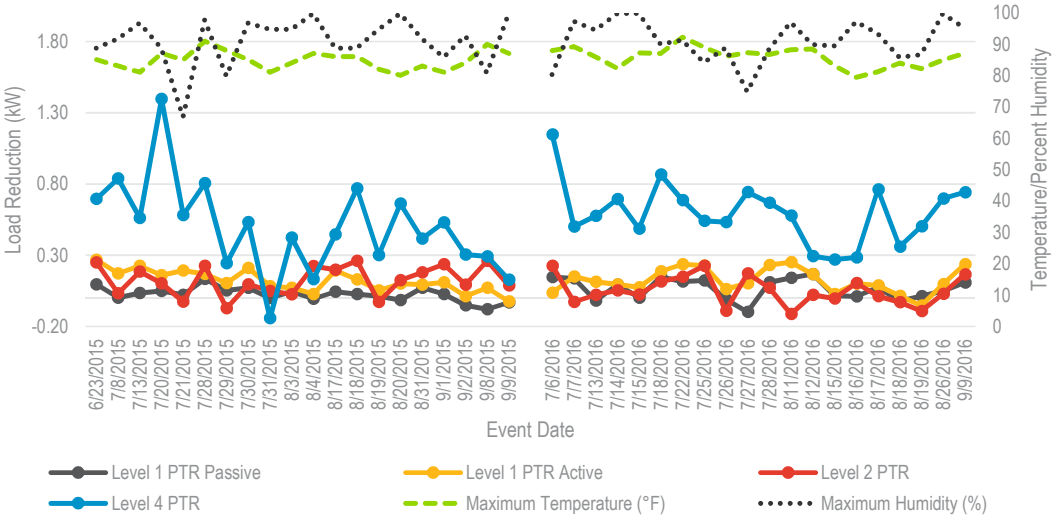
Figure B-2. Absolute Savings for CPP Customers



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

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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.

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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.

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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.

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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.

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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.

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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;

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- 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

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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

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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

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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.

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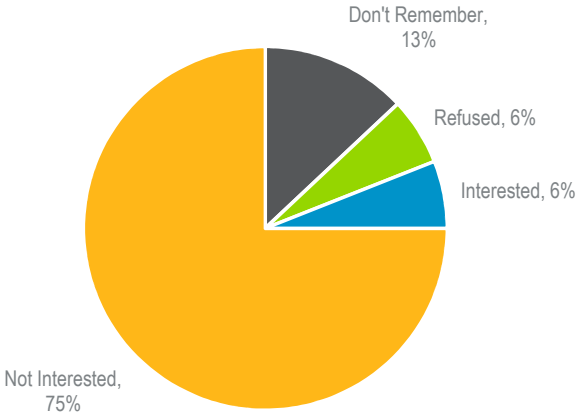
Figure C-1. Desire of Customers who Declined Meter to Participate in Pilot



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).

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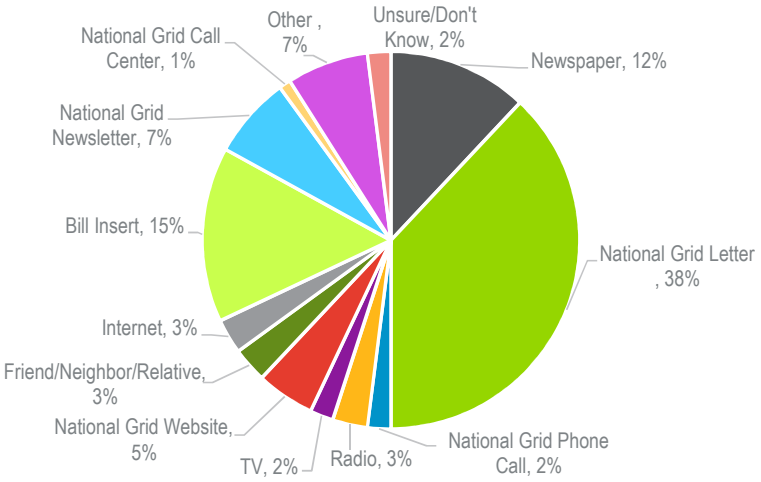
Figure C-2. How Customers Heard of the Pilot

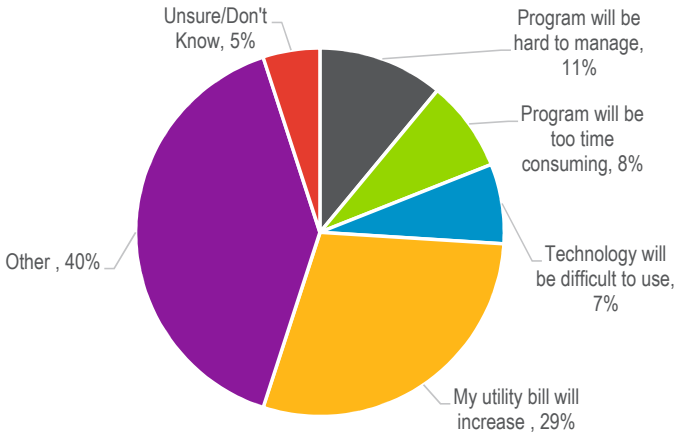


Source: Navigant analysis of pre-pilot survey (N=706)

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)

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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

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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.

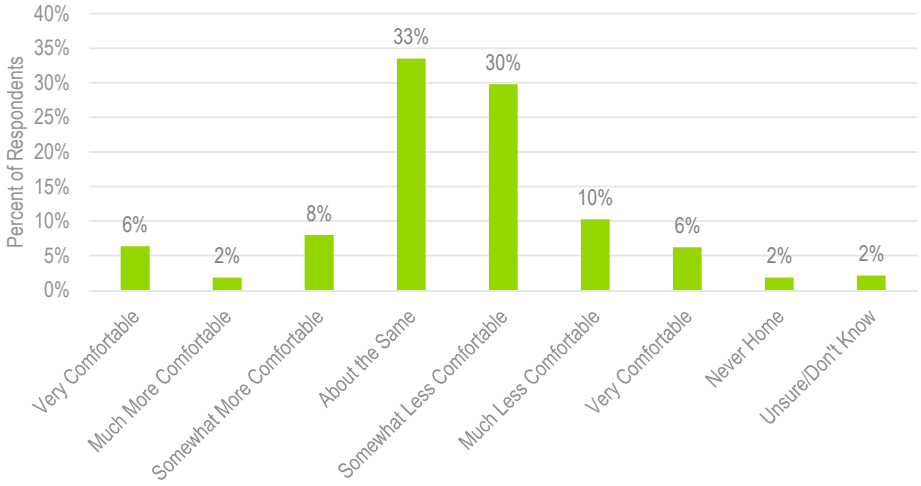
Table C-2. Number of Respondents per Post Event, 2015 End of Summer, and 2016 End of Pilot Survey by Technology Package

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)

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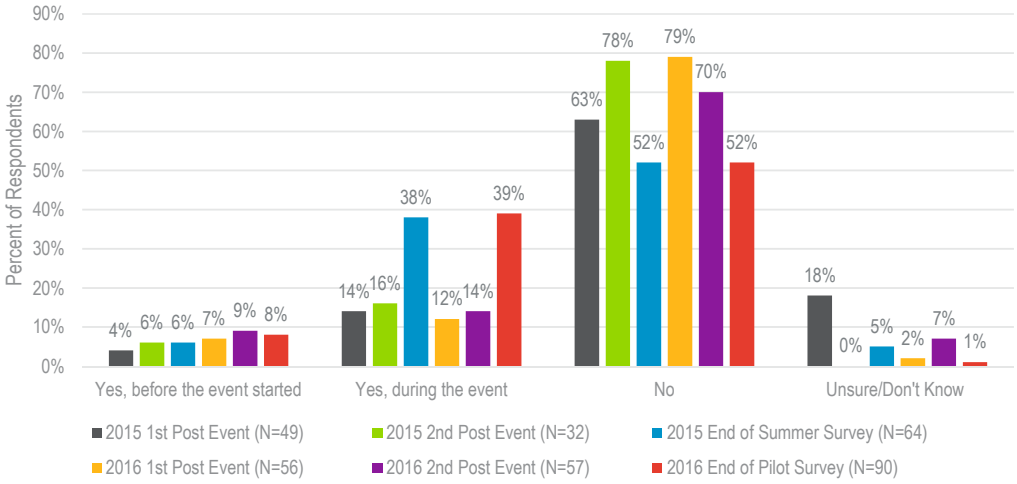
The end of pilot survey asked respondents with a thermostat a series of questions about how they used their thermostat during Peak Events throughout the two summers. In each year as the summer progressed, respondents reported using the override button on their thermostat more frequently (see Figure C-5). 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

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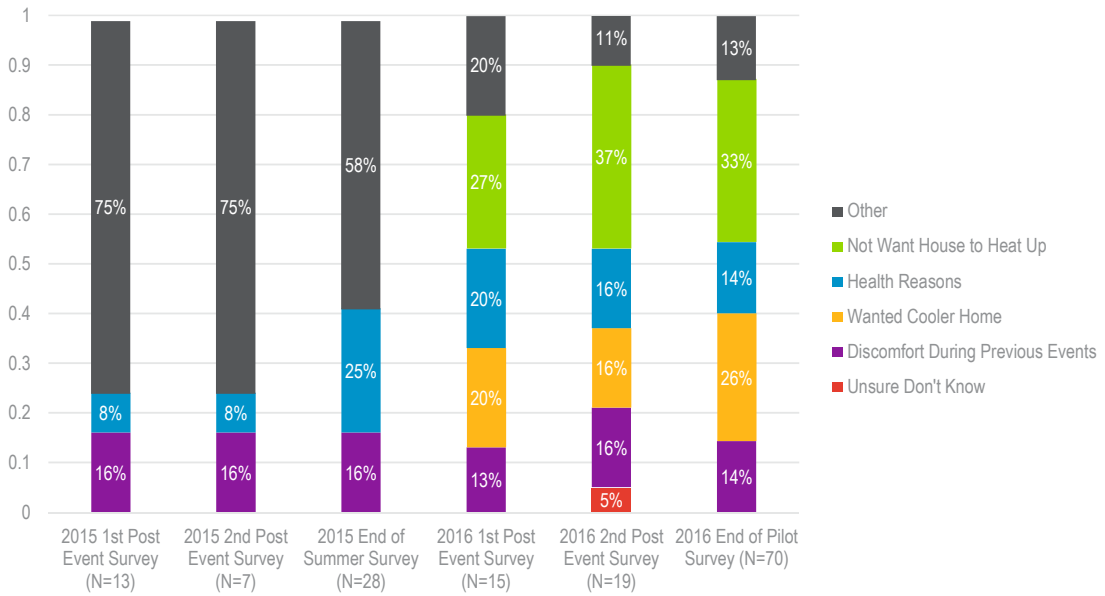
Figure C-6. Reasons for Smart Thermostat Overrides



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.

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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

[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

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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.

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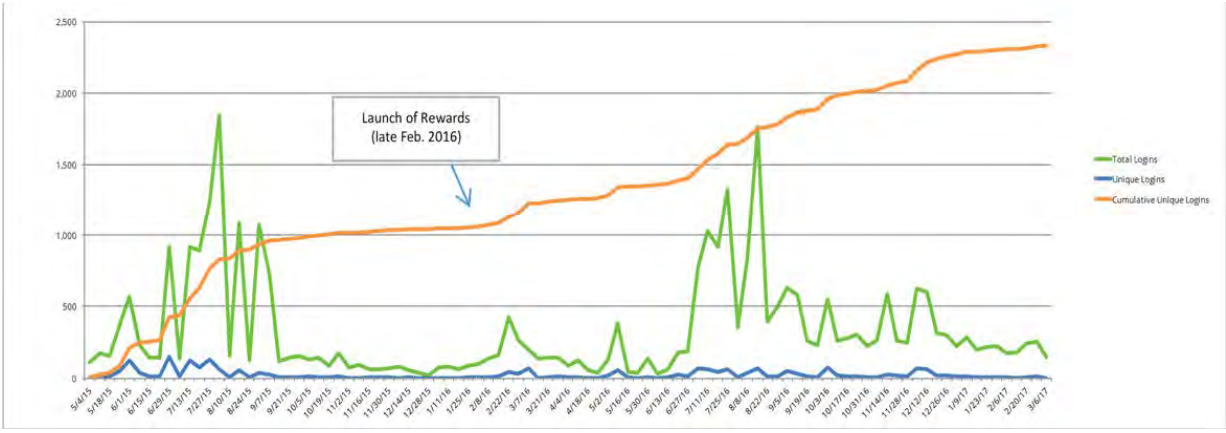
APPENDIX D. REWARDS PLATFORM EFFECTIVENESS

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%.

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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.

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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

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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

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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

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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.