U.S. DEPARTMENT OF ENERGY

Electricity Delivery & Energy Reliability

American Recovery and Reinvestment Act of 2009

Demand Reductions from the Application of Advanced Metering Infrastructure, Pricing Programs, and Customer-Based Systems – Initial Results

Smart Grid Investment Grant Program

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Executive Summary

The U.S. Department of Energy (DOE), Office of Electricity Delivery and Energy Reliability (OE), is implementing the Smart Grid Investment Grant (SGIG) program under the American Recovery and Reinvestment Act of 2009. The SGIG program involves 99 projects that are deploying smart grid technologies, tools, and techniques for electric transmission, distribution, advanced metering, and customer systems.[1]

This report provides initial results from the SGIG projects that are implementing advanced metering, customer systems, and time-based rates to achieve one or more of the following demand-side objectives: (1) reducing electricity consumption during peak periods and (2) reducing overall electricity consumption, or achieving energy conservation. Appendix A provides a list of the 62 projects, the types of devices, systems, and programs that are being implemented, and their deployment progress as of June 30, 2012.

Achieving these demand-side objectives result in the following benefits:

- Deferred capital expenditures and improved capital asset utilization
- Reduced electricity generation and environmental impacts
- Expanded options for customers to manage electricity consumption and costs

This report focuses on the three projects that produced quantitative evaluation reports of their demand-side efforts from the summer of 2011:

- Oklahoma Gas and Electric (OG&E)
- Marblehead Municipal Lighting Department (MMLD)
- Sioux Valley Energy (SVE)

Collectively, these projects offered time-based rates to about 7,000 customers, and each had the primary objective of reducing electricity consumption during peak periods. Two of the projects – OG&E and MMLD – are involved in the SGIG consumer behavior studies, which are a subset of nine SGIG projects that are working with DOE-OE and applying experimental design methods to help obtain results that are statistically valid to support investment decision making. Appendix B contains further information on the methods used in the SGIG consumer behavior studies.

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[1] For further information see “Smart Grid Investment Grant Progress Report, July 2012.” It can be found at http://www.smartgrid.gov/sites/default/files/doc/files/sgig-progress-report-final-submitted-07-16-12.pdf.

Initial Results

Table ES-1 provides a summary of the initial results from the three projects. With two years of data, the OG&E study provides more information on its results than the other two projects. The analysis showed peak demand reductions of as much as 30% from a sample of about 6,000 mostly residential customers (including control groups) that used programmable communicating thermostats (PCTs), in-home displays (IHDs), and web portals to respond to time-based rates that included combinations of time-of-use, critical peak, and variable peak pricing. Customers reported positive experiences, had few complaints and many reduced their electricity bills. Based on their two years of experience, OG&E decided to roll-out its programs to 40,000 additional customers in 2012. OG&E will continue offering free programmable communicating thermostats, but will not include in-home displays because of the relatively low level of augmented demand reductions relative to their costs.

Project Elements	OG&E	MMLD	SVE
Number of customers	6,000 residential customers	500 residential customers	600 mostly residential customers
Time-based rate(s)	Time-of-use and variable peak pricing with critical peak pricing components	Critical peak pricing	Critical peak pricing
Customer systems	In-home displays, programmable communicating thermostats, web portals	Web portals	Web portals
Peak demand reduction during critical peak events	Up to 30%	37%	Up to 25%
Customer acceptance	Positive experience, many reduced electricity bills	Positive experience, but did not use the web portals often	Interested in continued participation, many reduced electricity bills

Table ES-1. Summary of the Initial Results (Summer 2011)

The MMLD analysis showed peak demand reductions from a sample of about 500 entirely residential customers (including a control group) of about 37% in response to three critical peak pricing events. More than 85% of the participants reported having positive experiences.

SVE analyzed its critical peak pricing pilot for 600 mostly residential customers (including control groups) and access to web portals. These customers reduced their peak demand by 5%-

25% during seven events. A majority of the participants were interested in continuing and many reduced their electricity bills.

Observations

The initial results show that time-based rates can be used to reduce peak demand while achieving customer acceptance and, in many cases, bill reductions. This result, and the range of estimated impacts, is consistent with findings in other studies, which are referenced by the Federal Energy Regulatory Commission.[2]

As has also been found in other studies, customer systems such as PCTs, IHDs, and web portals generally have beneficial effects for customers in responding to time-based rates. However, several of the projects encountered challenges with installation of equipment inside customer premises, and with integrating the devices with advanced metering infrastructure, communications, and back-office systems. There is also a general sense that several of the newer customer systems, such as web portals and in-home displays, are still evolving and that more experience is needed with them before their appropriate roles in demand-side programs can be fully assessed.

In addition, valuable experiences are being gained by the projects in areas for which there are not very many previous studies. For example, new information is being collected on customer motivations for participating in demand-side programs including having the opportunity to save money, doing something for the environment, having greater control over consumption and costs, and having the opportunity to enjoy the new devices. However, saving money is most often the primary motivator for customer participation.

And, market research is showing that the names (brands) of the new rates and product offerings are important for attracting customer interest. Extensive market testing is often needed to identify the names and brands that work best. Market research can be a valuable tool in developing effective programs that have a high degree of customer interest and acceptance. This is important because the extent of enrollments affects the amount of demand reduction that can be achieved.

Next Steps

Going forward, while all 62 of the demand-side projects have valuable lessons-learned to share, DOE-OE analysis will focus on the ones providing quantitative results. This includes the nine

[2] Federal Energy Regulatory Commission, "A National Assessment of Demand Response Potential" June 2009. http://www.ferc.gov/legal/staff-reports/06-09-demand-response.pdf

projects conducting consumer behavior studies.[3] However, qualitative information from all of the demand-side projects will also be analyzed to identify lessons-learned and best practices. Follow-up analysis will be conducted on the SGIG demand-side projects in the future.

[3] There are a total of 11 consumer behavior studies because 2 of the 9 projects are conducting 2 studies each.

1. Introduction

The U.S. Department of Energy (DOE), Office of Electricity Delivery and Energy Reliability (OE), is implementing the Smart Grid Investment Grant (SGIG) program under the American Recovery and Reinvestment Act of 2009. The SGIG program involves 99 projects that are deploying smart grid technologies, tools, and techniques for electric transmission, distribution, advanced metering, and customer systems. For further information about the status of SGIG deployments and initial accomplishments please see the "Smart Grid Investment Grant Program Progress Report, July 2012."[4]

DOE-OE is examining the impacts and benefits of these projects and is presenting the results through a series of analysis reports. These reports cover a variety of topics, including:

- Peak demand and electricity consumption reductions from advanced metering infrastructure, customer systems, and time-based rate programs,
- Operational improvements from advanced metering infrastructure,
- Reliability improvements from automating distribution systems,
- Efficiency improvements from advanced volt/volt-ampere reactive (VAR) controls in distribution systems, and
- Efficiency and reliability improvements from applications of synchrophasor technologies in electric transmission systems.

1.1 Purpose and Scope

This impact analysis report provides initial results from the SGIG projects that are implementing advanced metering infrastructure (AMI), customer systems (i.e., customer-based information and control technologies), and/or time-based rates to achieve one or more of the following demand-side objectives: (1) reducing electricity consumption during peak periods and (2) reducing overall electricity consumption, or achieving energy conservation. These technologies and programs, which necessarily involve participation by customers, help to defer construction of additional power plants and power lines to meet peak demands (measured in kilowatts and megawatts) and reduce overall electricity consumption (measured in kilowatt-hours and megawatt-hours).

[4] This report can be found at http://www.smartgrid.gov/sites/default/files/doc/files/sgig-progress-report-final-submitted-07-16-12.pdf.

There are 62 SGIG projects that are pursuing these objectives and they are referred to as "demand-side projects" in this report. Additional information on these projects is provided in Appendix A.

AMI consists of smart meters, the communications networks to connect the meters with utilities, and the back-office systems necessary to process meter data. Smart meters capture electricity consumption information at intervals of 60 minutes or less. This information helps utilities and customers to better manage electricity consumption.

The 62 demand-side projects involve activities that have a wide range of sizes and scopes. For example, many are conducting small-scale pilots that involve relatively small numbers of participants and are aimed primarily at evaluating the efficacy of the devices and customer experiences, and resolving systems integration issues. These projects are generally not facing near-term decisions about investments in demand-side programs but rather are gathering information for potential investments in the future. On the other hand, there are several projects that involve larger numbers of participants and are generally more focused on nearer-term investment decisions regarding the potential roll-out of demand-side programs. DOE will focus its analysis on those studies in which nearer-term results are anticipated.

DOE-OE is working with nine of the projects to conduct statistically rigorous studies to reduce uncertainty about the magnitude of customer responses to demand-side programs (including the application of time-based rates). These studies, collectively referred to as the SGIG consumer behavior studies (CBS), apply a special set of DOE-OE requirements. One of the aims of the CBS projects is to estimate peak demand and electricity consumption impacts with as much precision as possible. Toward this end, the projects are working with DOE-OE and Lawrence Berkeley National Laboratory to implement experimental design methods and procedures for randomly assigning study participants to treatment and control groups. Appendix B provides further information on the methods used in the SGIG consumer behavior studies.

Each of the CBS projects has a two-year study period which includes plans to publish interim and final evaluation reports. In addition to these project reports, DOE-OE will conduct separate analysis to assess the results of these studies from a national perspective and identify lessons learned that can be widely applied to address customer response, acceptance, and retention and other important program design issues.

Each of the 62 demand-side projects has its own deployment schedule for the installation and operation of equipment and program implementation. All of the projects began purchasing and installing equipment in 2010 and many of them undertook system testing before making the equipment operational. In addition, for those projects implementing time-based rates, additional time was needed to obtain regulatory approvals before the rates could be offered to customers. As of June 30, 2012, which marks the end of the time period that this report covers, only a few of the projects have initial results to report.

This report summarizes the results observed to date from the three projects that produced reports of the results of their demand-side activities: Oklahoma Gas and Electric (OG&E), Marblehead Municipal Lighting Department (MMLD), and Sioux Valley Energy (SVE). Collectively, these projects offered time-based rates to about 7,000 customers. Two of the three – OG&E and MMLD – are CBS projects. DOE expects to provide the results from several additional studies in next year's report on this topic.

1.2 Organization of this Report

Section 2 of this report presents information about the devices, systems, and time-based rate and incentive-based programs that the 62 SGIG demand-side projects are deploying, and provides a discussion of expected benefits. Section 3 summarizes what the projects are doing and their deployment progress as of June 30, 2012. Section 4 provides a summary of the initial results from the three projects that provided quantitative analysis reports along with the preliminary findings of DOE-OE. Section 5 concludes with a brief discussion of next steps.

Appendix A provides a list of the 62 projects, the types of devices, systems, and programs that are being implemented, and their deployment progress. Appendix B provides further details on DOE-OE's consumer behavior studies and the guidelines that were provided to the projects to achieve desired levels of statistical rigor.

2. Overview of Demand-Side Devices, Systems, Programs, and Expected Benefits

There are many types of devices, systems, and programs that can be used achieve the three demand-side objectives discussed in the Introduction. These objectives require participation by customers and ultimately rely on the effectiveness of customer-based programs. As shown in Appendix A, the 62 SGIG demand-side projects are using many different combinations of the various options. These combinations include projects that are deploying:

- AMI and incentive-based programs (e.g., direct load control programs),
- AMI and customer systems, (e.g., information and control technologies)
- AMI and time-based rates, and
- AMI, customer systems, and time-based rates.

2.1 Communications Networks Associated with AMI

AMI is the common element in most of the demand-side projects. Figure 1 provides a schematic of how smart meters are used with communications networks, customer systems, and time-based rate programs.

AMI consists of the smart meters installed at the customer's premise which typically collect electricity consumption data in 15-, 30-, or 60-minute intervals; the communications networks to transmit the interval load data from the meter to the utility back offices; and the meter data management systems (MDMS) to store and process the interval load data for billings, web portals, or other purposes, including outage management.

The ability to communicate electricity prices and consumption levels frequently is an essential feature of the SGIG demand-side projects. AMI enables interval load data to be transmitted to utility back office systems where it can be processed and sent to billing systems. While bills are typically sent out monthly, information on electricity consumption can now be made available to customers (e.g., via web portals) the day after it has been collected by the utility. This requires communications networks that are capable of delivering accurate and reliable streams of data in a timely manner.

For many of the 62 demand-side projects, managing the large quantities of information about customer electricity consumption has proven to be a significant challenge. Issues have been encountered in data transmission, data processing, error checking, and integration with legacy systems.

When time-based rate programs are involved, the communication of price signals is a significant aspect of the design of the programs and can involve different forms of communications between utilities and customers. For example, certain time-based rates, such as critical peak pricing (CPP), only go into effect when peak demand conditions reach a point where utilities want to activate a higher rate to lower peak demand. CPP and other time-based rates are discussed in more detail in Section 2.2. In these cases, CPP customers are informed of a “critical peak day or event” before the event (usually a day, but sometimes only hours, in advance) through a number of communication channels including in-home displays, cell phones, text messages, emails, web portal postings, and Twitter feeds.

The availability of information on electricity consumption patterns from interval meter data can help customers receive and respond to time-based rates. For example, customers with CPP and

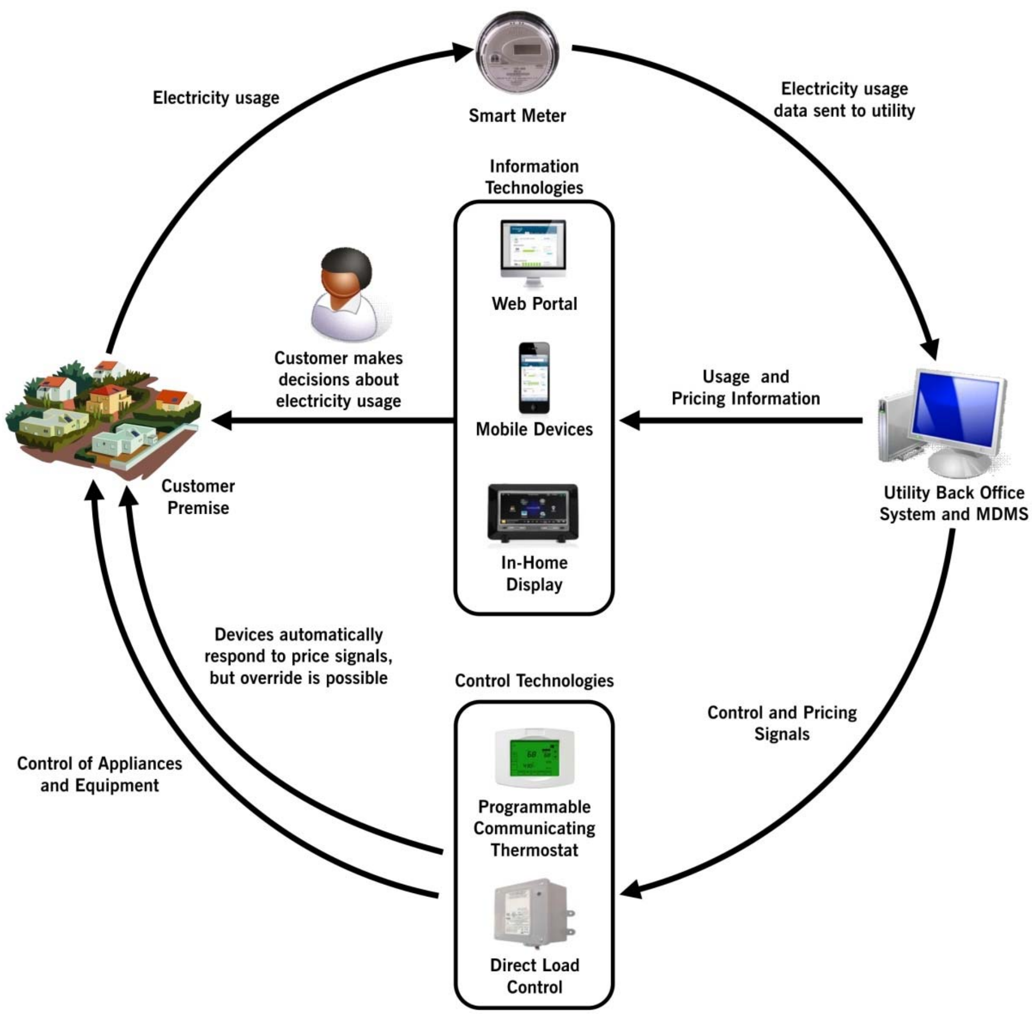

Figure 1. Overview of Demand-Side Devices and Systems for Managing Electricity Consumption and Costs

access to web portals can assess their consumption patterns by time of day before critical peak events and determine in advance the steps they can take to reduce their consumption during peak periods. After critical peak events, these customers can access the web portal to see how they did and identify additional ways to change their consumption and manage their bills.

2.2 Time-Based Rate and Incentive-Based Programs

Electricity consumption levels vary by time-of-day and season of the year. Peak periods are typically defined as those times of day or year when electricity consumption and the associated costs to supply that electricity are at their highest levels. The SGIG demand-side projects achieve peak demand reductions and shift load from on- to off-peak periods, by two methods: **time-based rate** and **incentive-based** programs.

Development of AMI

Over the past ten years, the costs of AMI, which includes smart meters, the communications networks to connect the meters with utilities, and the back-office systems necessary to maintain and support them, have decreased. The implementation of these devices and systems allows electricity consumption information to be captured, stored, and reported in intervals of 60 minutes or less to both utilities and their customers. The ability to rapidly communicate this information enables utilities and public policymakers to more fully engage electricity customers in better managing their consumption and costs, and utilities to develop and pursue demand-side resources and objectives.

In regulatory proceedings across the country, many utilities are presenting rationales to explain the business cases for investments in AMI. Three core questions have been consistently raised in these proceedings: (1) cost recovery of the investments, (2) benefits from utility operational savings, and (3) benefits (to both utilities and customers) from the introduction of time-based rates and incentive-based programs. Stakeholders want to understand what the full costs of implementing the utility's AMI plan will be, the risks to ratepayers and shareholders, cost recovery mechanisms through rates, and cost allocations among customer classes.

Regulators also want to better understand how AMI investments will reduce utility expenditures on operations and maintenance efforts over time (e.g., elimination of meter reading positions, reduced truck rolls, etc.). For some utilities, operational savings provide sufficient benefits to justify AMI investments. However, for other utilities, operational savings alone may not be sufficient to provide acceptable paybacks and other benefit streams are needed, such as those derived from reductions in peak demand from time-based rates and incentive-based programs, to make a financially attractive business case for AMI.

Time-Based Rate Programs

Time-based rate programs come in many forms and offer various levels of electricity prices that may differ according to hour(s) of the day, day(s) of the week, and month(s) of the year. As such, these rates typically charge more for electricity during times when power supply costs are relatively high, and less during times when power supply costs are relatively low.

Traditionally, utilities have used rate designs that do not convey the time variability of electricity costs. Traditional rates include for example: (1) Flat rates in which all usage during a given period of time (e.g., 30-day billing cycle) is charged the same rate; and (2) Tiered rates which typically charge different rates based on blocks of usage (e.g., first 500 kWh vs. next 500 kWh) during a given period of time (e.g., 30-day billing cycle).

There are several different types of time-based rates, including:

- **Time-of-use (TOU) rates**. TOU pricing typically applies to usage over broad blocks of hours (e.g., on-peak = 6 hours for summer weekday afternoons; off-peak = all other hours in the summer months) where the price for each period is predetermined and constant. TOU rates are primarily implemented to provide incentives for changing the timing of the consumption of electricity (i.e., shifting from peak hours to off-peak hours) by making it cheaper to purchase power in off-peak periods and more expensive to do so in on-peak periods.
- **Real-time pricing (RTP)**. RTP rates typically apply to usage on an hourly basis (but could apply to usage on as little as a 5-minute basis), where the price of electricity differs each hour of each day. RTP rates are primarily implemented to provide financial incentives for customers to shift consumption from on-peak to off-peak periods. None of the SGIG demand-side projects are offering RTP programs.
- **Variable peak pricing (VPP)**. VPP is a hybrid of time-of-use and real-time pricing where the different periods for pricing are defined in advance (e.g., on-peak = 6 hours for summer weekday afternoon; off-peak = all other hours in the summer months), but the various price levels established for the on-peak period varies according to the costs of de3livering electricity. VPP rates have a dual purpose: to change the timing of a customer’s consumption of electricity (i.e., shifting from peak hours to off-peak hours) and to reduce a customer’s consumption of electricity over a certain number of hours on a limited number of days when certain system conditions occur (e.g., extremely high costs or system emergencies) by making it much more costly to purchase during on-peak periods on these limited days.
- **Critical peak pricing (CPP)**. When utilities observe or anticipate high wholesale market prices or power system emergency conditions, they may call critical events during a

specified time period (e.g., 3 pm – 6 pm on a hot summer weekday); the price for electricity during these time periods is raised. Two types of rate design exist: one where the time and duration of the price increase are predetermined when events are called and another where the time and duration of the price increase may vary based on the demand of the electric grid. CPP rates are primarily implemented to reduce a customer's consumption of electricity over a certain number of hours on a limited number of days when certain system conditions occur.

- **Critical peak rebates (CPR).**[5] When utilities observe or anticipate high wholesale market prices or power system emergency conditions, they may call critical events during pre-specified time periods (e.g., 3 pm – 6 pm summer weekday afternoons), the price for electricity during these time periods remains the same but the customer is refunded at a single, predetermined value for any reduction in consumption relative to what the utility deemed the customer was expected to consume. CPR is primarily implemented to reduce a customer's consumption of electricity over a certain number of hours on a limited number of days when certain system conditions occur.

Incentive-Based Programs

Utilities offer incentive-based programs instead of, or in addition to, time-based rate programs to achieve demand-side objectives. The primary aim of incentive-based programs is to reduce peak demand.

Incentive-based programs include direct load control (DLC) programs, which usually involve installation of radio-controlled switches that can turn power to designated appliances and equipment on and off in response to system needs. Utilities provide customers financial incentives for participating in incentive-based programs, and for DLC programs they can install switches on one or more of participating customers' electricity consuming devices, such as central air conditioners, water heaters, or swimming pool pumps. Customers agree to have their power turned off to the devices during predetermined peak periods, and the number of interruptions is usually capped within a calendar year.

Also included are interruptible and curtailable rate programs, which usually involve financial incentives to participants (usually larger commercial and industrial customers) for reducing demand to predetermined levels during scheduled events (e.g. emergencies) when demand reductions are needed.

[5] Technically, CPR is not a time-based rate program, as it provides a financial incentive for reducing demand during critical peak event periods. In this respect, CPR could instead be classified as an Incentive-based Program. To maintain consistency with FERC and others in the electric utility industry, however, CPR is classified here as a time-based rate program.

DLC and interruptible and curtailable rate programs were offered and implemented successfully before the expanded use of AMI and smart meters. AMI and smart meters can enhance the capabilities of these "legacy" programs by providing a common communications platform for DLC, a way to check remotely on the health of the load control device, and a mechanism for evaluating the changes in electricity consumption that occurred from the operation of the DLC equipment or the interruptible rates after they were used.

2.3 Customer Systems

Customer systems include both information and control technologies. The aim is to provide customers with information and tools to enable more active management of electricity consumption and associated costs, which include improved capabilities for responding to time-based rates. ***Information technologies*** provide customers with the opportunity to manage their electricity consumption by providing them with data about their electricity consumption and costs through mobile devices, IHDs, and web portals. ***Control technologies*** provide customers with the opportunity to manage their electricity consumption through load control devices such as PCTs or other electricity management tools that either customers or utilities control.

Information technologies such as web portals and in-home displays attempt to provide information in visually appealing ways to improve understanding and insight about actions that can save energy and reduce bills. These information displays can be designed to guide customers about ways to reduce peak demand or achieve electricity conservation. Web portals, for example, often provide electricity "dashboards" that give customers access to their historical and near real-time usage information. IHDs and mobile devices offer other mechanisms for providing customers with information on their near real-time electricity usage and, as mentioned, notification of critical peak events.

Control technologies include devices such as PCTs, which both customers and utilities can control, and DLC switches which utilities primarily control. These devices are often used to automatically control customers' heating and cooling systems. Automation is an important feature in control technologies and once set manual actions are unnecessary. In addition, home area networks and energy management systems can be installed to automatically control appliances in response to price signals, load conditions, or pre-set preferences.

On the horizon are household appliances (e.g., refrigerators and dish washers) that can come pre-installed with "smart chips" and can send or receive signals to enable the timing of certain functions (e.g., defrost cycles) to be remotely controlled. Activities are underway by power companies and equipment manufacturers to advance software, standards, and protocols for smart appliances.

In general, residential customer systems are relatively new in the marketplace, and much is unknown about cost-effectiveness and customer acceptance. Experimentation and testing of devices and approaches is proceeding rapidly, and this is likely to be a dynamic marketplace for many years.

2.4 Expected Benefits

Peak demand reductions, load shifting, and electricity conservation are demand-side resources that can be used by system planners and operators to increase system reliability and reduce costs. When cost-effective, demand-side resources can provide benefits such as lower capital costs from deferral of supply-side capacity additions, lower fuel costs from reductions in electricity demand, and reduced environmental emissions from reduced levels of fossil-fuel generation. Demand reductions can also result in lower bills for customers.

Table 1 provides a summary of the expected benefits from the implementation of cost-effective demand-side resources, including deploying AMI and customer systems, and implementing time-based rate or incentive-based programs.

Expected Benefit	Source of the Expected Benefit
Deferred capital expenditures and improved capital asset utilization	• Reduced or delayed requirements for power plants and power lines • Reduced capacity payments or other peak demand charges • Lower peak demands from customer participation in time-based rate or incentive-based programs measured by kilowatt or megawatt reductions
Reduced electricity generation and environmental impacts	• Reduced combustion of fossil fuels and lower emissions of air pollution • Reduced land and water use requirements for power plants and rights-of-way for power lines • Reduced electricity consumption from customer participation in information-based programs measured by kilowatt-hour or megawatt-hour reductions
Expanded customer options for managing electricity consumption and costs	• Financial incentives (through new rates and programs) for customers to change their electricity consumption patterns, including possibly lower bills • Devices and systems for better customer acceptance through information and automated controls

Table 1. Summary of Expected Benefits from Demand-Side Projects

3. SGIG Demand-Side Projects and Deployment Progress

The 62 SGIG demand-side projects are making progress deploying AMI, customer systems, and time-based rate and incentive-based programs. This section provides an overview of project activities, scopes, and objectives and a summary of progress as of June 30, 2012.

Appendix A lists the 62 projects and provides more complete information on the number of devices installed and operational, customers enrolled in time-based rate programs, and the types of devices and systems. As shown, the SGIG demand-side projects are involved in many strategies to affect peak demand, load shifting, and electricity conservation. While most involve AMI, there is much diversity in the number implementing time-based rates, incentive-based programs, and customer systems of various kinds.

3.1 AMI and Smart Meters

As discussed, AMI and smart meters are fundamental components of the SGIG demand-side projects. Figure 2 shows the progress of smart meter installations for all 65 of the SGIG projects;[6] 11.3 million smart meters were installed and operational as of June 30, 2012. At completion, the AMI projects are expected to install a total of at least 15.5 million smart meters, which more than doubles the number of smart meters that were installed in the United States before the program. In addition, SGIG smart meter deployments represent a significant contribution toward the 65 million smart meters that industry estimates will be installed by 2015.[7] The 65 projects includes three non-demand-side SGIG projects that are installing smart meters exclusively for their operational benefits such as remote service connections and disconnections and outage detections.

Figure 3 shows SGIG AMI project expenditures as of June 30, 2012. This includes both federal expenditures and the cost share of the project recipients. The largest cost component is for smart meters, which represents about 66 percent of total AMI expenditures. Supporting communications equipment and meter data management systems comprise the other 33 percent.

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[6] Three of the 65 SGIG AMI projects are not implementing time-based rate programs or installing customer systems and are therefore not included in the 62 SGIG demand-side projects.

[7] Edison Foundation, Institute for Electricity Efficiency, “Utility-Scale Smart Meter Deployments, Plans, & Proposals,” May 2012.

Smart Meters	
Number of SGIG AMI projects	65
Number of smart meters expected at completion	at least 15.5 million
Number of smart meters installed and operational (as of June 30, 2012)	11.3 million

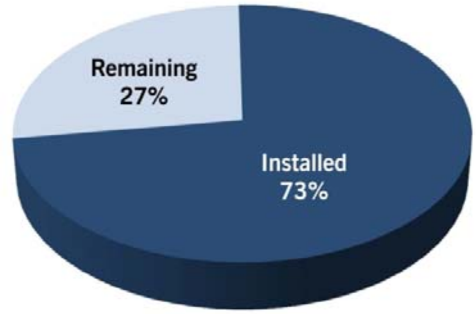

Figure 2. Cumulative SGIG Smart Meter Deployments as of June 30, 2012

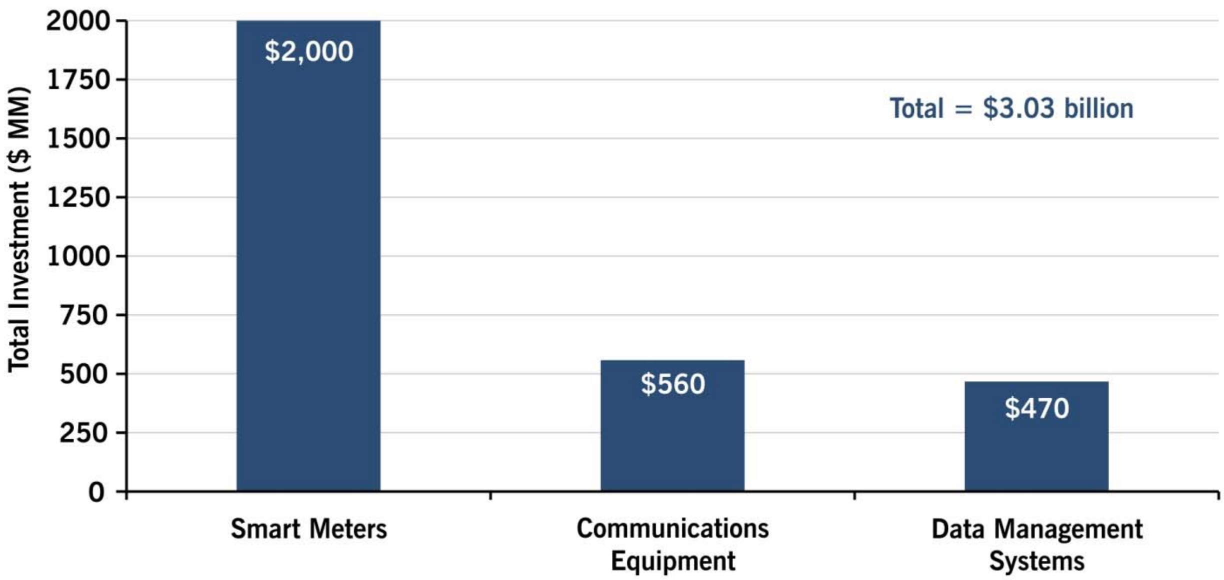

Figure 3. AMI Project Expenditures as of June 30, 2012

3.2 Customer Systems

Figure 4 provides a breakdown of the 46 demand-side projects that are deploying DLC devices, PCTs, and IHDs. As shown, 12 of the projects are deploying multiple types of customer systems. At completion, these projects are expected to deploy about 725,000 total devices.

Figure 5 shows the number of DLC devices, PCTs, and IHDs installed and operational as of June 30, 2012. This includes about 220,000 DLC devices, 190,000 PCTs, and 7,000 IHDs.

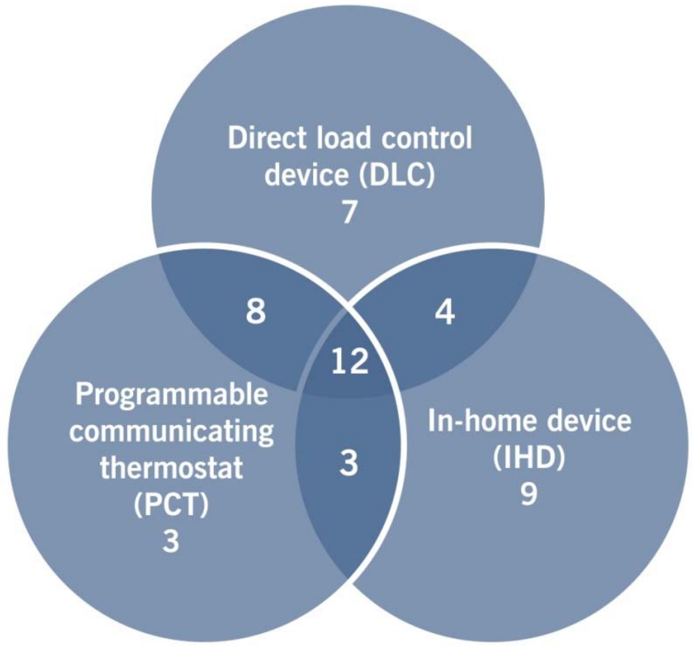

Figure 4. Breakdown of Projects Deploying DLC, PCT, and IHD

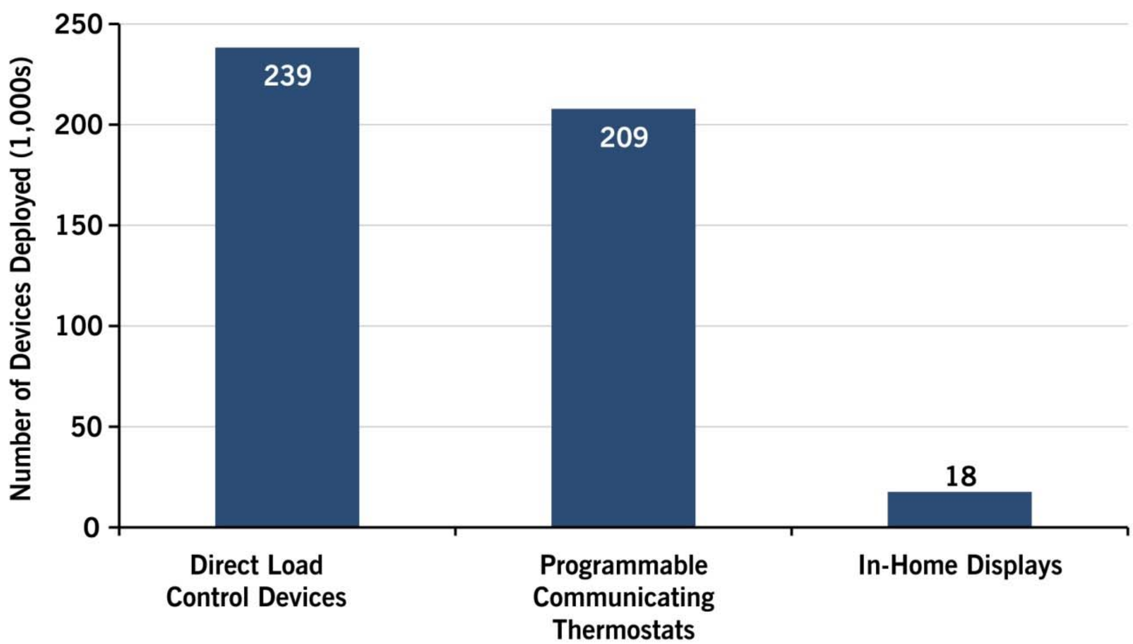

Figure 5. Deployment of DLC, PCT, IHD as of June 30, 2012

Web portals are another important customer system being offered by the SGIG demand-side projects. Figure 6 provides information on the number of projects offering web portals, and Figure 7 provides information on the number of customers with access and enrollment as of June 30, 2012. As shown, web portals are widely offered by the projects and many customers are beginning to access them. In most cases, customers sign-up to view the web portals and the figure shows that about half of the customers who have access have enrolled to do this.

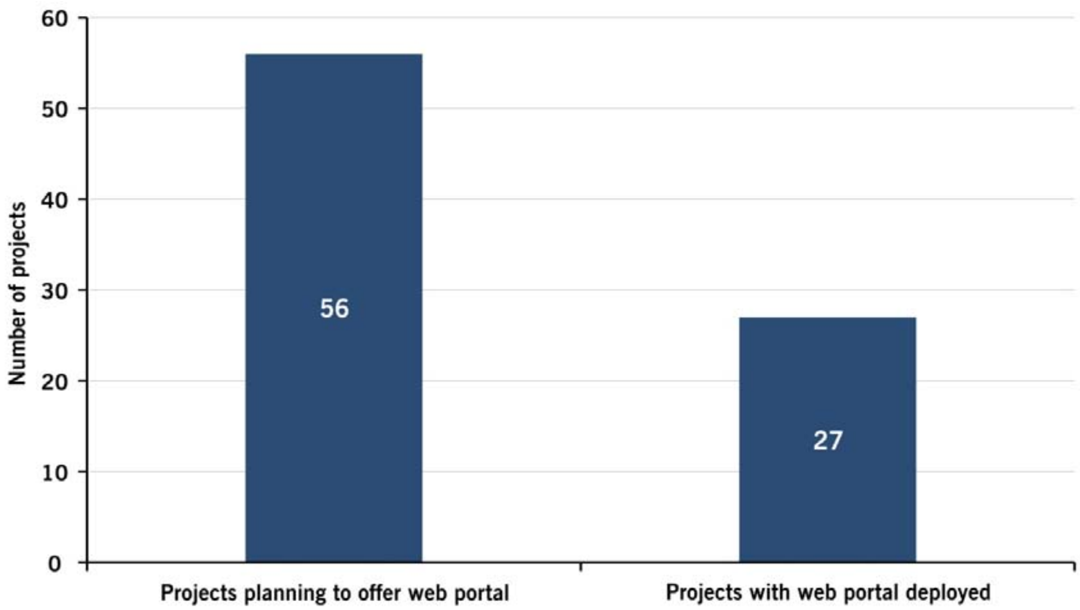

Figure 6. Deployment of Web Portals as of June 30, 2012

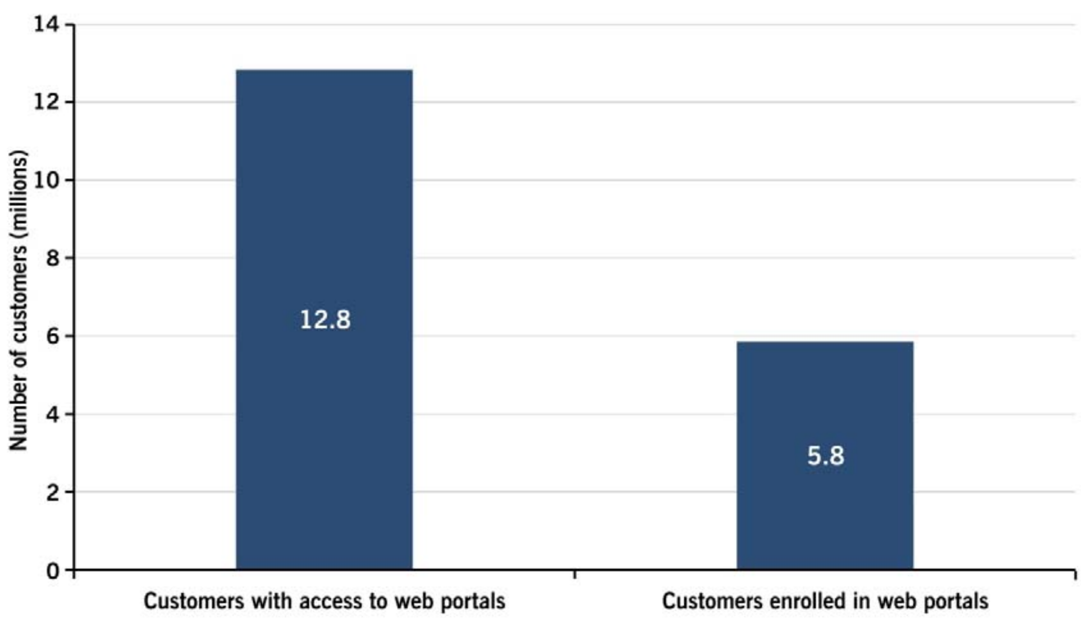

Figure 7. Access to and Enrollment in Web Portals as of June 30, 2012

3.3 Time-Based Rate Programs

Figure 8 provides a breakdown of the 32 projects that are implementing time-based rate programs. As shown, TOU is the most prevalent and include 21 projects; CPP is next with 15 programs. Some projects are implementing more than one type of time-based rate.

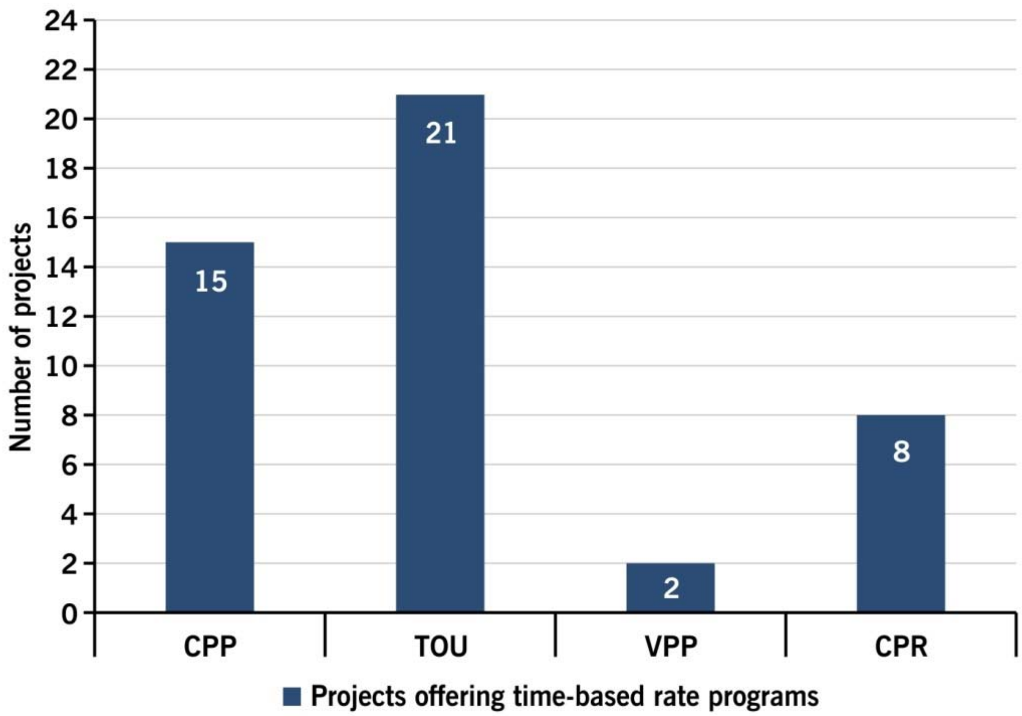

Figure 8. Types of Time-Based Rate Programs as of June 30, 2012

Figure 9 shows access and enrollment for time-based rate programs as of June 30, 2012. Many of the projects offering time-based rate programs are still enrolling customers so enrollment levels are expected to increase over time. For example, about 2.6 million customers have access to time-of-use rates but 280,000 have enrolled so far.

3.4 Consumer Behavior Studies

Table 2 on page 17 provides a summary of the scope and objectives of the projects that are conducting consumer behavior studies, including the types of time-based rates, customer systems, and study design features. The nine projects are conducting a total of 11 consumer behavior studies. Appendix B provides information on the guidelines developed by DOE-OE for the projects conducting consumer behavior studies to achieve desired levels of statistical rigor.

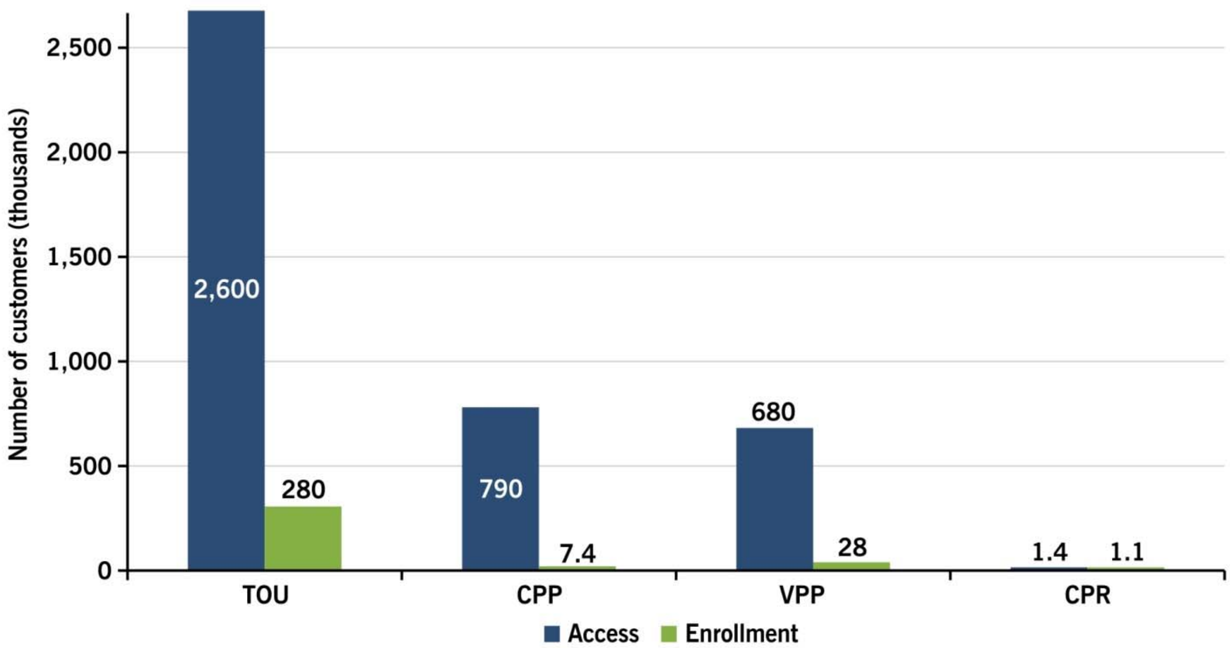

Figure 9. Access and Enrollment in Time-Based Rates as of June 30, 2012

The nine CBS projects are required to use statistically rigorous, randomized and controlled experimental designs for estimating impacts on electricity consumption from implementing time-based rates and customer systems. DOE-OE's aim is for studies undertaken in this manner to further the electric industry's understanding of the magnitude of these impacts, the incremental effects of causal factors, and the key drivers that motivate changes in behavior. If carried out properly, because the studies involve statistically rigorous techniques, they can provide more definitive answers to policymakers and stakeholders to key questions. For example, these questions include:

- How much will customers change their electricity consumption (i.e., peak demand, load shifting, and electricity conservation) in response to time-based rate programs?
- How much will customers change their electricity consumption in response to automation/control technologies, information technologies, and/or other non-rate elements either in isolation or in tandem with time-based rates?
- What motivates customers to accept and participate in time-based rate programs?
- What motivates customers to remain on time-based rate programs?

	Nevada Energy (Northern)	Nevada Energy (Southern)	Oklahoma Gas & Electric	Marblehead Municipal Light District	Central Vermont Public Service	Vermont Electric Power	Minnesota Power	FirstEnergy Service	Sacramento Municipal Utilty District	Detroit Edison Company	Lakeland Electric	Total
Rate Treatments												
TOU	■	■							■		■	**4**
CPP	■	■	■	■	■		■		■	■		**8**
CPR					■			■				**2**
VPP			■			■						**2**
Non-rate Treatments												
Education	■	■										**2**
Customer Service						■						**1**
IHD	■	■	■		■	■	■	■	■	■		**9**
PCT	■	■	■					■		■		**5**
DLC								■				**1**
Features												
Bill Protector	■	■	■	■							■	**5**
Experimental Design												
Opt In	■	■	■	■	■	■	■		■	■	■	**10**
Opt Out								■	■		■	**3**
Number of Participants	**9,509**	**6,853**	**3,196**	**500**	**3,735**	**6,440**	**4,025**	**5,000**	**97,480**	**3,075**	**3,000**	**142,813**

Legend

TOU Time of Use
CPP Critical Peak Pricing
CPR Critical Peak Rebates
VPP Variable Peak Pricing
IHD In-Home Display
PCT Programmable Communicating Thermostats
DLC Direct Load Control

Table 2. SGIG Consumer Behavior Studies

4. Analysis of Initial Results

This section presents the quantitative evaluation results of three SGIG demand-side project studies through the summer of 2011:[8]

- Oklahoma Gas and Electric (OG&E) is an investor-owned utility serving more than 770,000 customers in Oklahoma and Arkansas.
- Marblehead Municipal Lighting Department (MMLD) is a municipal utility serving about 11,000 customers in Marblehead, Massachusetts.
- Sioux Valley Energy (SVE) is an electric cooperative serving about 18,000 customers in rural Minnesota and South Dakota.

As discussed, OG&E and MMLD are in the SGIG CBS group, which means they developed CBS plans that were approved by DOE-OE[9]. These plans describe the study's experimental design for limiting self-selection bias and maximizing the internal and external statistical validity of the reported results. The plans require the studies in the CBS group to report information which makes it possible to determine the statistical significance of the analytical results.[10] Studies not in the CBS group, such as the one by SVE, were not required to develop DOE-approved study plans and may not have applied the experimental rigor needed to determine the level of statistical significance of the analytical results. Nevertheless, the SVE study (and others like it) provides useful information for assessing peak demand and electricity consumption impacts of the SGIG demand-side projects.

[8] The OG&E report can be found at http://www.smartgrid.gov/sites/default/files/doc/files/GEP%20OGE%20Summer%202011%20Report-2.pdf. The MMLD report can be found at http://www.smartgrid.gov/files/2012-mmld-energysense-year-one-evaluation-report.pdf. The SVE report can be found at http://www.smartgrid.gov/sites/default/files/doc/files/sve-empower-report-final-3-2-2012.pdf.

[9] Prior to approval, each CBS plan was reviewed by a team of experts in statistics, experimental design, rate design, and demand response to provide comments for strengthening the level of statistical rigor.

[10] DOE-OE published a series of ten guidance documents for CBS recipients on how to conduct their studies and apply appropriate experimental designs and statistical techniques. These documents can be found at http://www.smartgrid.gov/recovery_act/consumer_behavior_studies.

4.1 SGIG Consumer Behavior Studies

This subsection contains information on the results of the OG&E and MMLD studies.

OG&E

OG&E's study involves analysis of how customers respond to varying combinations of enabling technologies and time-based rates. OG&E serves about 750,000 customers in Oklahoma and western Arkansas, and a number of wholesale customers throughout the region. The summer of 2011 was one of the hottest on record in Oklahoma and the system peak of 6,509 MW occurred on August 3.

The study assesses whether customers make use of enabling technologies to actively manage their consumption and costs, with the primary objective of reducing system peak demand and deferring the need to build additional generation capacity. The study design involves a sample of approximately 5,000 residential and 1,200 small commercial customers,[11] and a test period that includes two phases during the summer months (June to September) of 2010 and 2011.

The study involves a randomized control trial design in which "opt-in" customers are randomly assigned to control and treatment groups[12] among the various time-based rate and technology options. Study participants were provided with 100% bill protection in the first year as a way to help familiarize them with the financial implications of their participation in the time-based rate programs.

Table 3 summarizes the results of the randomized assignment of customers to treatment and control groups. Rate treatments included Variable Peak Pricing (VPP) that utilized a five-hour peak period during the summer. The five-hour peak period occurred between 2 p.m. and 7 p.m. daily during the summer months (June 1 – September 30.) The rates during the five-hour peak period vary daily depending on the cost of electricity. The VPP also includes a critical peak price (CPP) component that is applicable year-round when OG&E forecasts a "critical peak event" and needs a reduction in system peak demand. In addition, OG&E also offered a time-of-use (TOU)

[11] This report does not contain results of the portion of the study involving commercial customers because sample sizes were relatively small and the findings were less statistically significant. A report of results is available on www.smartgrid.gov. See "OG&E Smart Study TOGETHER Impact Results Final Report – summer 2011" 1299-02 February 29, 2012.

[12] In general, treatment groups involve those participants who receive time-based rates, PCTs, IHDs, and/or web portals (i.e., "treatments") about who study analysts seek to measure changes in their behavior. Control groups involve a comparable group of participants who do not receive treatments and who serve as a comparison for treatment group to measure changes in behavior.

rate with a CPP component. OG&E provides customers with at least two hours of notice of critical peak events, and each event can last up to eight hours.

The technology/information treatments included in-home displays (IHD), programmable communicating thermostats (PCT), and access to web portals. These were deployed to enable customers to better manage their electricity consumption and costs through improved understanding of their usage patterns.

Treatment/Control Groups	TOU-CPP	VPP-CPP	Total
Web portal only	528	559	1,087
IHD and web portal	440	442	882
PCT and web portal	412	427	839
IHD, PCT, and web portal	430	433	863
Control	-	-	999
Total	**1,810**	**1,861**	**4,670**

Table 3. Total Number of Customers in Treatment and Control Groups in 2010 and 2011

Table 4 summarizes the time-based rate offerings and the number of days in the summer of 2011 that participants were exposed to the rates. On-peak price levels were communicated to customers by 5 p.m. on the previous day. As shown in the table, there were four on-peak price levels: Low and off-peak, Standard, High, and Critical. As such, each day was identified by the on-peak price level on a day-ahead basis. Customers in the control group received the standard rate.

Price Level	Residential VPP-CPP	Residential TOU-CPP	Number of days in summer 2011 at each price level
Low and off-peak	4.5¢/kWh	4.2¢ per kWh	63
Standard	11.3¢/kWh	23.0¢/kWh	25
High	23.0¢/kWh		28
Critical	46.0¢/kWh		6
Critical peak event	46.0¢/kWh	46.0¢/kWh	7 (included in the above)

Table 4. 2011 Rate Offerings in OG&E's Consumer Behavior Study Project

Because OG&E could call a critical peak event any time up to 2 hours before the beginning of the event, a day could be originally identified as Low, Standard or High and subsequently have a critical peak event called, thereby replacing the originally identified price with the critical price of 46 cents/kWh during the critical hours called. There were 7 critical peak events called during the summer of 2011.

Study Results

Figure 10 shows 24-hour load profiles averaged for all of the customers in the study's VPP-CP treatment and control groups on one of the seven critical peak event days in 2011 (July 15). The vertical red lines indicate the hours of the critical peak event, while the dotted grey lines indicate the hours of the daily peak period. Each of the treatments showed demand reductions during the peak period, relative to the control group. The largest reductions were observed for the customers with PCTs (about 30%), while these also involved a "rebound effect" after the event as air conditioners switched back on to cool homes after the critical peak events were over. Although not shown in the figure, a maximum peak demand reduction of 1.8 kW per customer was observed during critical events, compared to an average reduction of about 1.3 kW per customer observed during peak (non-event) periods.

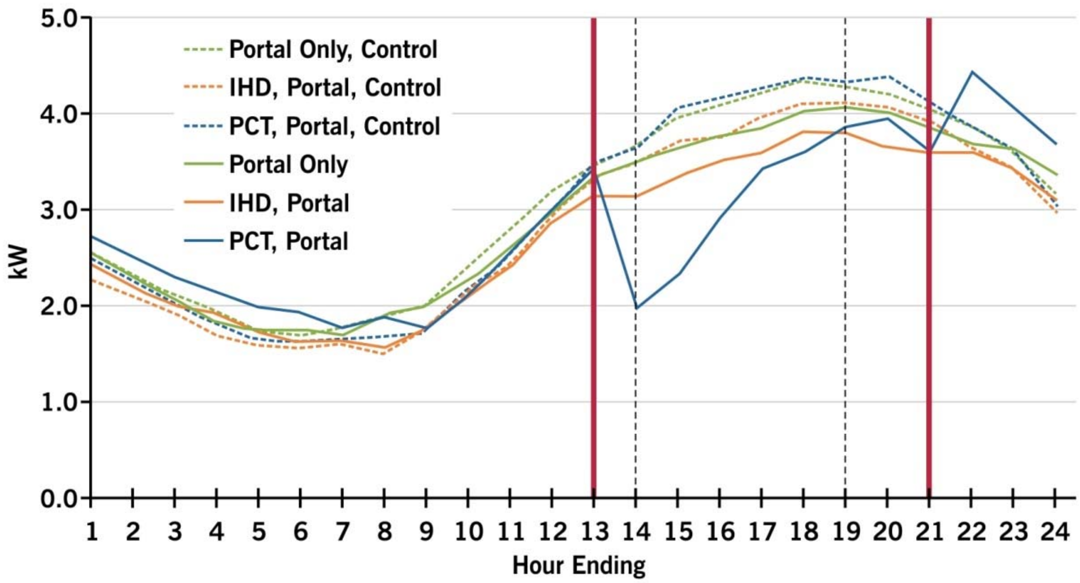

Figure 10. VPP-CPP July 15, 2011 Critical Event Day

OG&E reports that customer acceptance was generally favorable and customer complaint and drop-out levels were relatively low. This may be due, in part, to the fact that most of the participating customers experienced reductions in their summer electricity bills. The average bill reduction over the summer periods was over $150.

Due in part to the favorable results of this study, OG&E is rolling out its VPP-CP rate to a total of about 150,000 customers across its entire service territory by 2014. As of now, OG&E is planning to give away a free PCT to anyone who signs up for the rate.

Table 5 summarizes the key results of the study and shows that OG&E's objectives for peak demand reductions and customer acceptance were generally met.

Summary of Key Findings of the OG&E Consumer Behavior Study
• Study results show that a 1.3 kW average peak demand reduction per customer is possible.
• Goal of 20% participation by Dec. 2014 in VPP-CP rate offering supported by high satisfaction rates of study participants.
• Study results show value in providing PCTs for free or discounted to join rate in 2012.
• Achieving 20% participation goal (~150K residential customers) will allow OG&E to offset the need for a new natural gas-fired peaking plant (~210 MW) in 2014.

Table 5. Summary of Key Findings of the OG&E Consumer Behavior Study (Interim and Final Reports)

Observations

As mentioned above, customers with PCTs appeared to increase consumption in overnight off-peak hours relative to the control group, especially those in the VPP-CPP rate group. This suggests that these customers were taking advantage of less expense off-peak electricity prices to increase cooling loads overnight. This effect warrants further study to assess whether customers increase off-peak consumption when migrating to time-based rates, especially if they have controllable loads like air conditioning that may be more readily consumed during the off-peak period when prices are lower.

Customers with IHDs appeared to have the largest overall electricity conservation effect in the first year of the study, regardless of the rate design, but in the second year the effect was no greater than those with web portals alone. This observation also warrants further study but suggests that IHDs may, in the short run, enable customers to identify and change behaviors that reduce wasteful energy use, but that over the longer term, the IHDs may not be any better than web portals at achieving and maintaining electricity conservation effects.

OG&E reports that not all of the customer equipment installations went as planned. In a few cases, customers received equipment they were not expecting. Demand-side projects involving thousands of customers may involve needs for record keeping that can be more complicated than expected. Thus there is a need in "customer-facing" programs for continual process improvement to ensure that customers are adequately screened for eligibility to receive certain pieces of equipment, utility contractors install the correct equipment, and information about both the equipment that was supposed to be installed, as well as the equipment that was actually installed, are documented properly. Steps taken with customers to build confidence in program marketing and implementation will help on-going and future recruitment efforts.

MMLD

MMLD conducted the first year of its CBS to evaluate customer responses to CPP and access to web portals. MMLD is a relatively small municipal utility with about 11,000 mostly residential customers located on the coast north of Boston, Massachusetts. The summer of 2010 was hotter than average but MMLD did not set any records for peak demand of electricity. MMLD's summer peak demand in 2010 reached approximately 28 MW on July 6. The objectives of the study focused on analysis of customer acceptance and the peak demand impacts of the program.

The design of the study includes a sample of approximately 500 residential customers and a two-year test period during the summers (June – August) of 2011 and 2012. The study involves a randomized control trial with delayed application of treatments (i.e., "recruit and delay") where half of the participating customers begin treatment on the CPP rate in year one, while the remaining customers serve as a control group on the existing flat rate in year one, but begin treatment on the CPP rate in year two. Table 6 shows the number of customers that were randomly assigned to treatment and control groups in 2011.

Treatment/Control Groups	Total
CPP	266
Control	266
Total	**532**

Table 6. Number of Customers in Treatment and Control Groups in 2011

Study participants are provided with 100% bill protection in the first year they are exposed to the CPP rate to help them better understand the financial implications, encourage participation, and minimize attrition. Bill protection gives participants the option of getting billed under the old rate. In the second year, however, the bill protection is removed. This allows MMLD to study the incremental effects of bill protection on customer acceptance and response. All study participants are eligible to receive PCTs in the second year of the study.

Table 7 shows the rate treatments included in the study. The CPP rate covers a six-hour period for critical peak events, which are called by MMLD when systems conditions warrant. Customers are notified of critical peak events by 5 p.m. the day before and were notified through their choice of phone and/or email. Study participants can receive notification of up to 12 critical peak events each year of the study. All participants receive access to web portals which provide information on their electricity consumption and costs, and educational materials designed to inform them about the CPP rate and steps they can take to reduce consumption and lower bills. The standard rate for the control group was 14.25¢ per kWh.

Price Level	Residential CPP Price	Number of days in summer 2011 at each price level
Flat	9.0¢ per kWh	89
Critical peak event	105.0¢ per kWh	3

Table 7. 2011 Rate Offerings in MMLD's Consumer Behavior Study

Study Results

As shown in Table 7, the CPP rate was in effect for 18 hours (3 events x 6 hours/event) with the flat rate in effect the remaining hours of the summer.

Figure 11 shows the 24-hour load profile for the average customer in the treatment and control groups for one of the three critical peak event days in 2011 (July 22). The green lines show the difference in the hourly load profiles between the treatment and control groups; the solid line represents the average customer and the dotted lines represent the lower bound (LB) and upper bound (UB) of the confidence interval (i.e., 90% of the time the difference in load between treatment and control will sit within these boundaries). The vertical red lines indicate the hours of the critical peak event. This figure shows that customers on CPP reduced peak demand by about 40% on average over the peak period, with a maximum reduction of about 1.1 kW per customer. On this and other critical peak event days, customers on CPP reduced their overall daily consumption of electricity but did not exhibit measurable electricity conservation on non-event days.

MMLD reported that a significant majority of the participants said they had positive experiences on the CPP rate with 86% saying they had an overall positive experience, and 57% saying they had a very positive experience. This may be due, in part, to the fact that most of the participating customers experienced reductions in their summer electricity bills, as the rate was designed to charge a higher price during 12 critical peak events but only 3 were called. Table 8 provides a summary of the key findings from the first year of the MMLD study.

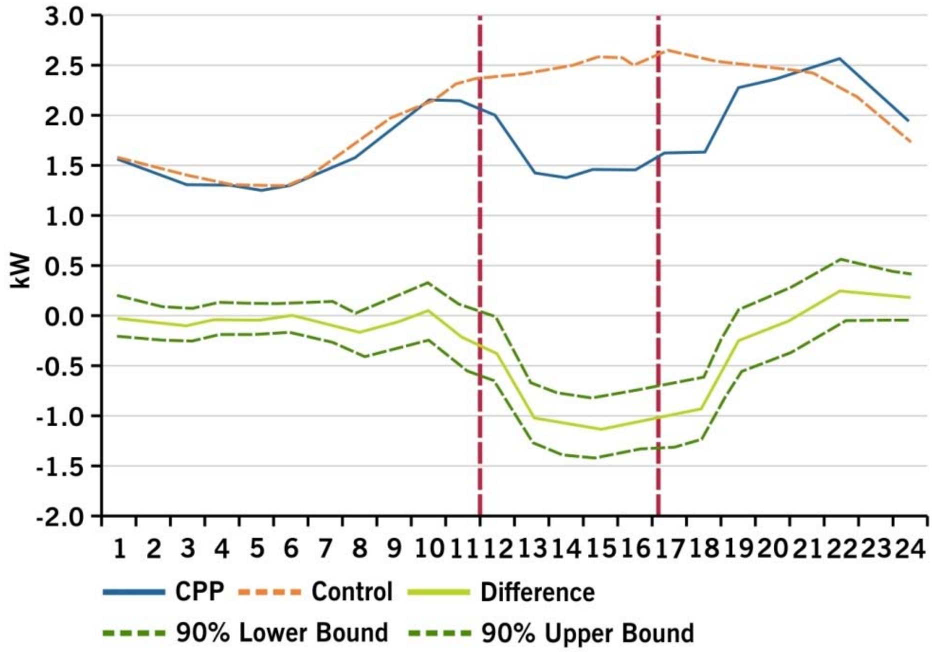

Figure 11. Customer Load Profiles for Treatment and Control Groups

Summary of Key Findings of the MMLD Consumer Behavior Study
• Study results show a 0.74 kW avg. peak load reduction per customer during events is possible. • Response during critical peak events is relatively consistent with very minimal decay as the event progresses. • Customer surveys show majority of customers on CPP had a very positive experience with the rate.

Table 8. Summary of Key Findings of the MMLD Consumer Behavior Study (Interim Report)

Observations

The CPP customers exhibited an average hourly reduction in demand during peak events of about 37% which was about 0.74 kW on a per customer basis. This is a substantial level of demand reduction even thought there were no PCTs in place. The second year of the study should provide information on the incremental effects of the PCTs in achieving potentially greater demand reductions.

All customers saved money on CPP. The rate was designed to be revenue neutral based on 12 critical peak events, but only 3 events were called. As such, virtually all participants saw bill reductions, regardless of their reductions in power consumption during CPP events.

It appears that use of the web portal was lower than expected. For example, about 39% of the treatment group participants reported using the web portal, and of those about 42% used it only once. In addition, about 17% of control group participants used it. This low level of use suggests that more study is needed to determine why and assess further outreach strategies to see what types of information would be most useful to present on the web portal and in what formats to increase access and use.

MMLD's offer of bill protection appeared to have a significant impact on recruitment as it eliminated perceived risks. Bill protection appears to be an effective tool in addressing customer concerns about the bill impacts of time-based rates. In addition, in the future, when sufficient interval load data has been accumulated for customers, the personalized "dashboards" presented on web portals can be designed to provide "what if" bills under different rate scenarios which may reduce the need for bill protection as an inducement in recruitment efforts.

4.2 Other SGIG Demand-Side Studies

This subsection presents information on the initial results of the SVE study.[13] Future reports will present results from other SGIG demand-side projects that have studies and/or lessons learned to report.

SVE

SVE conducted the first year of a pilot study to evaluate customer response to CPP and access to enabling technologies. SVE is an electric cooperative serving about 22,000 customers in rural Minnesota and South Dakota. About 88% of the customers are residential. The objectives of the study focused on analysis of customer acceptance and the reasons for different peak demand impacts of the program. SVE is billed by its power suppliers based on monthly peak demand

[13] The findings in this study are generally consistent with results found in other studies, but the report does not contain enough information to determine if self-selection bias is a concern, the degree of internal and external validity, and the statistical significance of the reported analytical results.

levels. Reductions in electricity use during peak periods translate directly into cost savings for SVE, which can then be passed on to customers.

The design of the pilot includes a sample of approximately 900 residential and rural residential/ farm customers and a two-year test period during the summers (June – August) of 2011 and 2012. The pilot involved randomly selecting customers and assigning them to one of four groups. Two groups received the CPP rate but differed by how they were recruited into the pilot: the first group was asked to volunteer (opt-in) to participate in the pilot, while the second group was told they would receive the rate unless they chose to go back to their old flat rate (opt-out). A third group of program participants consisted of customers who were not placed on the CPP rate but were notified of critical peak events and were encouraged to monitor their consumption through a web-portal or an in-home display (technology only). The fourth group acted as the control group. Table 9 shows the results of SVE's random assignment of customers to treatment and control groups.

Treatment/Control Groups	Residential	Farm and Rural Residential	Total
Opt-in	34	43	77
Opt-out	99	168	267
Technology only	97	161	258
Control	98	176	274
Total	**328**	**548**	**876**

Table 9. Total Number of Customers in Treatment and Control Groups in 2011

The CPP rate went into effect on days identified by SVE when system electricity demand would reach peak levels and result in higher wholesale power costs. Participating customers were notified of the critical peak event one day in advance using cell phone calls, email, text messages, or in-home displays. Under the terms of the rate, SVE could call up to 35 critical peak events over the summer. When called, the critical peak events covered a four-hour period between 4:00 p.m. and 8:00 p.m.

When the rate was in effect, CPP participants paid fifty cents per kilowatt-hour, compared to less than seven cents during all other times. SVE customers on standard rates paid more than nine cents per kilowatt-hour so the CPP participants could save money (about two cents per kilowatt-hour) during non-critical peak event hours. SVE found that the critical peak price of fifty cents per kilowatt-hour provided a financial incentive for participants to shift optional activities like washing clothes and dishes to times other than critical peak periods.

Study Results

The SVE results are based on a study they completed in March, 2012.[14] SVE called 13 critical peak events during the summer of 2011. Table 10 shows the estimates of peak demand reductions by customer class and treatment group. For example, residential customers in the pilot reduced their consumption during peak periods by about 5 to 25 percent, depending on whether they were in opt-in, opt-out, or technology-only groups. Farms and other rural residential customers in these same groups also reduced their consumption during peak periods, but by somewhat lower amounts. Participants who were not on CPP rate but who had access to information through the web portal or in-home displays also reduced their consumption during peak periods, but by much less than those on the CPP rate.

Customer Class/ Treatment Groups	Baseline kW	Estimated kW Impact	Estimated % Reduction
Rural Residential and Farm			
Opt-in	6.82	-1.28	-19%
Opt-out	5.71	-0.17	-3%
Technology only	5.20	-0.13	-2%
Residential			
Opt-in	3.51	-0.85	-24%
Opt-out	3.07	-0.41	-13%
Technology only	3.33	-0.21	-6%

Table 10. Estimated of Peak Demand Reductions by Customer Class and Treatment Group in 2011

Customer acceptance surveys showed that approximately 90 percent of customers said they were likely to continue on the CPP rate, about half of those said they were very likely to continue. One reason for this positive response is that most of the participating customers realized direct savings on their electrical bill. Only a handful of customers provided negative feedback, with the most complaints received after CPP events were called on consecutive days.

[14] Sioux Valley Energy. "EmPOWER Critical Peak Pricing Pilot Assessment." March 2, 2012.

Table 11 provides a summary of key findings.

Summary of Key Findings of the SVE's Study
• Study results show a 0.85 kW avg. peak demand reduction per customer during events is possible. • Customers who volunteered for the rate (opt-in) appear to provide greater peak demand reductions than those who are placed on the rate and do not elect to leave (opt-out). • Customer surveys show high levels of satisfaction and interest in continuing participation.

Table 11. Summary of Key Findings of the SVE's Study

Observations

It appears that an opt-out enrollment approach is more likely to elicit greater numbers of customers being exposed to time-based rates but that many of them either do not respond or provide far less demand reductions than those who volunteered (opt-in) to be exposed to such time-based rates. This is a finding consistent with a recent dual enrollment approach (opt-in vs. opt-out) study: Commonwealth Edison's Customer Applications Program.[15] In the end, a utility wishing to capture a certain amount of peak load reduction will need to assess issues of equity and fairness when determining the most appropriate way to achieve such goals with the different enrollment approaches it could consider.

4.3 Summary of Observations

In terms of general observations and lessons learned, the initial results show that time-based rates can be used to affect peak demand and electricity consumption while achieving customer acceptance and, in many cases, bill reductions. These results, and the range of estimated impacts, are generally consistent with findings in other studies.[16] The reductions found in the OG&E study, along with the generally favorable levels of customer acceptance, met the corporate objectives originally laid out for the project[17] and enabled the decision to roll-out the

[15] EPRI. "The Effect on Electricity Consumption of the Commonwealth Edison Customer Application Program: Phase 2 Supplemental Information," February 2012.

[16] Federal Energy Regulatory Commission, "A National Assessment of Demand Response Potential" June 2009. http://www.ferc.gov/legal/staff-reports/06-09-demand-response.pdf.

[17] OG&E's objectives were to achieve customer acceptance levels such that 20% of customers would volunteer to participate and that on-peak would be about 1.33 kW per customer.

rate and technology options to more customers to defer capacity expansion projects. Going forward, DOE-OE and OG&E will continue working together to share additional results and highlight lessons learned from implementation experiences during the roll-out.

In addition, as also found in other studies, the initial results suggest that customer systems such as PCTs, IHDs, and web portals help customers respond to time-based rates. However, several of the projects have reported challenges with accomplishing installations inside customer premises, and with integrating these devices with AMI, communications, and back-office systems. Also, as experienced by MMLD and other projects, there seems to be the general sense that several of the newer customer systems, particularly web portals and IHDs, are relatively new technologies and that more experience is needed with them by power companies, customers, and vendors before their appropriate roles in demand-side programs can be fully assessed.

And finally, valuable experiences are being gained by the projects in areas for which there are not a lot of results to draw upon from previous studies. These include topics related to customer motivation, engagement, recruitment, and marketing and education strategies. For example, the motivations reported to the projects for customer participation include having the opportunity to save money, doing something for the environment, having greater control over their consumption and costs, and finding enjoyment in the experience. However, it seems that saving money was the primary motivator for customers to join time-based rate programs or have interest in acquiring customer systems.

In addition, market research performed by the projects showed that the names of the new rates and product offerings are important for attracting customer interest and that extensive testing is often needed to identify names and brands that work best. Information like this about customer motivations and choices will be extremely valuable for customer engagement strategies and can be used to help guide the design of demand-side projects and programs in the future. DOE-OE will continue working with the SGIG demand side projects to report results, lessons learned, and best practices in this area.

5. Next Steps

Going forward, while all 62 of the demand-side projects will ultimately have important lessons-learned to share, DOE-OE analysis of the demand-side projects will focus on the ones making nearer-term decisions about system roll-outs, as these are generally of most interest to the industry as a whole, including the CBS projects. However, qualitative information from all of the demand-side projects will also be analyzed to identify lessons-learned and best practices.

In the summer of 2012, several more projects will be implementing and reporting on their demand-side activities, including MMLD, which will report on the second year of its CBS project. In addition, six other studies in the CBS group will be producing interim reports and several demand-side projects not in the CBS group are also expected to have results to report. DOE-OE plans to publish a series of research reports to convey what was learned from the SGIG consumer behavior study evaluation effort. These reports will include analysis of factors that influence customer acceptance (e.g., the role of information and education), customer retention (e.g., the role of alternative program designs) and customer response (e.g., the role of alternative rate designs).

6. References

Edison Foundation, Institute for Electricity Efficiency, "Utility-Scale Smart Meter Deployments, Plans, & Proposals," May 2012.

Energy Information Administration, "Electric Power Annual 2010," November 2011.

FERC. "A National Assessment of Demand Response Potential: Actual Forecast" Staff report by the FERC. June 2009. http://www.ferc.gov/legal/staff-reports/06-09-demand-response.pdf (Accessed May 1, 2012)

Goldman, C., N. Hopper, O. Sezgen, M. Moezzi, R. Bharvirkar, B. Neenan, R. Boisvert, P. Cappers, D. Pratt. "Customer Response to Day-ahead Wholesale Market Electricity Prices: Case Study of RTP Program Experience in New York." LBNL-54761. June 2004. http://drrc.lbl.gov/system/files/nmpc-lbnl-54761.pdf (Accessed May 23, 2012)

Oklahoma Gas and Electric. "OG&E Smart Study TOGETHER Impact Results Final Report – Summer 2011" 1299-02 February 29, 2012

Oklahoma Gas and Electric. "OG&E Consumer Behavior Study Evaluation Report," May 2012.

Marblehead Municipal Light Department. "Draft CPP Pilot Interim Evaluation Report," March, 12, 2012.

Scheer, Rich, and Peter Cappers. *DOE's Smart Grid Investment Grant Consumer Behavior Studies*. Washington D.C.: Department of Energy. Draft.

Sioux Valley Energy. "EmPOWER Critical Peak Pricing Pilot Assessment." March 2, 2012.

Appendix A. SGIG Demand-Side Projects

* – Project installed meters outside of the SGIG program.
^ – Project is not installing meters.
NA – Not applicable.
C – Project deployment data is confidential.
X – Indicates equipment that the project is deploying.

Projects	Devices Installed as of 6/30/2012				Customer Enrollment as of 6/30/2012		Types of Devices, Systems, and Programs			
	Smart Meter	DLC	Programmable Communicating Thermostat	In-home Display	Time-based Rate Program	Web Portal[18]	AMI + Incentive-based programs	AMI + Customer systems + Time Based Rate	AMI + Customer Systems	AMI + Time Based Rate
Baltimore Gas and Electric Company	22,623	113,224	139,565	NA	0	0	X	X		
Black Hills Corporation/Colorado Electric	44,920	NA	NA	NA	NA	0			X	
Burbank Water and Power	50,253	NA	NA	0	NA	0			X	
CenterPoint Energy Houston Electric, LLC	2,038,499	NA	NA	504	NA	11,245			X	
Central Lincoln People's Utility District	9,566	0	0	0	NA	0	X		X	
Central Maine Power Company	606,164	NA	NA	NA	0	0		X		
City of Auburn, Indiana	156	NA	NA	NA	0	0		X		
City of Fort Collins Utilities	322	0	NA	NA	NA	0	X		X	
City of Fulton, Missouri	5,505	NA	2	NA	0	0		X		
City of Glendale Water & Power	84,096	NA	NA	15	NA	0			X	
City of Leesburg, Florida	0	0	0	0	4	0	X	X		
City of Naperville, Illinois	18,651	NA	NA	NA	NA	0			X	
City of Ruston, Louisiana	10,596	NA	NA	NA	NA	0			X	
City of Tallahassee, Florida	NA	4	0	NA	NA	NA	X			

[18] Web portal enrollment numbers cover all eligible customers and not only those who have a SGIG smart meter.

Projects	Devices Installed as of 6/30/2012				Customer Enrollment as of 6/30/2012		Types of Devices, Systems, and Programs			
	Smart Meter	DLC	Programmable Communicating Thermostat	In-home Display	Time-based Rate Program	Web Portal[18]	AMI + Incentive-based programs	AMI + Customer systems + Time Based Rate	AMI + Customer Systems	AMI + Time Based Rate
City of Wadsworth, Ohio	12,567	0	0	0	0	0	X	X		
Cobb Electric Membership Corporation	191,276	NA	NA	NA	4	0		X		
Connecticut Municipal Electric Energy Cooperative	19,371	0	2	NA	0	0	X	X		
Denton County Electric Cooperative	19,938	9	8	5	NA	NA	X		X	
Detroit Edison Company	598,590	NA	45	35	1,126	1,645		X		
Duke Energy Business Services LLC	487,819	0	0	46	972	2,331,050	X	X		
Entergy New Orleans, Inc.	4,855	0	376	2,944	331	3,684	X	X		
EPB	115,243	0	NA	NA	0	0	X	X		
FirstEnergy Service Corporation[19]	5,071	29,905	104	0	NA	740			X	
Florida Power & Light Company	2,359,736	NA	238	226	120	2,359,736		X		
Golden Spread Electric Cooperative, Inc.	77,250	1,769	794	NA	NA	9,694	X		X	
Guam Power Authority	0	NA	NA	NA	NA	0			X	
Honeywell International, Inc.	NA	NA	NA	NA	8	NA				
Idaho Power Company	380,928	67	NA	0	574	117,510	X	X		
Indianapolis Power and Light Company	10,116	NA	NA	NA	0	0		X		
Iowa Association of Municipal Utilities	1,363	NA	1,526	NA	NA	1,526			X	
JEA	0	NA	NA	NA	NA	0			X	
Knoxville Utilities Board	3,352	NA	NA	NA	12	0		X		

[19] First Energy is deploying smart meters and DLC devices in separate locations so they are not doing AMI + incentive-based programs.

Projects	Devices Installed as of 6/30/2012				Customer Enrollment as of 6/30/2012		Types of Devices, Systems, and Programs			
	Smart Meter	DLC	Programmable Communicating Thermostat	In-home Display	Time-based Rate Program	Web Portal[18]	AMI + Incentive-based programs	AMI + Customer systems + Time Based Rate	AMI + Customer Systems	AMI + Time Based Rate
Lafayette Consolidated Government	13,818	0	0	0	0	0	X	X		
Lakeland Electric	82,434	NA	NA	0	1,756	0		X		
M2M Communications	NA	412	NA	NA	NA	73				
Marblehead Municipal Light Department	4,299	0	0	NA	485	213	X	X		
Minnesota Power	6,543	1,571	NA	NA	0	NA	X			X
Modesto Irrigation District	3,320	0	0	0	0	4,382	X	X		
New Hampshire Electric Cooperative	44,651	NA	NA	0	0	NA		X		
NV Energy	796,408	NA	130	82	0	305,338		X		
Oklahoma Gas and Electric Company	600,001	NA	7,032	2,791	58,416	6,410		X		
Pacific Northwest Generating Cooperative	75,530	NA	NA	NA	NA	NA				
PECO Energy Company	12,819	8	NA	170	0	0	X	X		
Potomac Electric Power Company – Atlantic City Electric Company	NA	17,279	6,431	NA	NA	0				
Potomac Electric Power Company – District of Columbia	257,224	0	0	NA	NA	0	X		X	
Potomac Electric Power Company – Maryland	144,801	52,252	37,670	NA	0	0	X	X		
Progress Energy Service Company	0	0	NA	NA	NA	NA	X			
Rappahannock Electric Cooperative	50,226	5,610	NA	NA	NA	0	X		X	
Reliant Energy Retail Services, LLC	NA	NA	NA	C	C	C				
Sacramento Municipal Utility District	604,155	0	0	0	8,981	22,276	X	X		
Salt River Project	389,164	NA	NA	NA	244,509	96,275		X		
Sioux Valley Energy	16,534	NA	NA	84	427	1,928		X		

Projects	Devices Installed as of 6/30/2012				Customer Enrollment as of 6/30/2012		Types of Devices, Systems, and Programs			
	Smart Meter	DLC	Programmable Communicating Thermostat	In-home Display	Time-based Rate Program	Web Portal[18]	AMI + Incentive-based programs	AMI + Customer systems + Time Based Rate	AMI + Customer Systems	AMI + Time Based Rate
South Kentucky Rural Electric Cooperative Corporation	63,415	1,391	NA	NA	1,570	0	X	X		
South Mississippi Electric Power Association	77,867	NA	NA	NA	0	0		X		
Southwest Transmission Cooperative, Inc.	51,673	42	NA	100	NA	NA	X		X	
Talquin Electric Cooperative, Inc.	50,699	NA	6	NA	NA	0			X	
Town of Danvers, Massachusetts	4,058	NA	NA	40	0	2,251		X		
Tri State Electric Membership Corporation	15,156	NA	NA	NA	NA	690			X	
Vermont Transco, LLC	29,420	NA	NA	0	3	0		X		
Vineyard Energy Project	NA	0	NA	0	NA	0				
Wellsboro Electric Company	1,855	NA	NA	NA	NA	0			X	
Westar Energy, Inc.	42,526	NA	NA	NA	NA	10,505			X	

Appendix B. SGIG Consumer Behavior Studies

As discussed, DOE-OE is working with nine of the SGIG projects to conduct studies of consumer behavior in response to the implementation of demand-side programs that involve time-based rates, customer systems, and AMI. DOE-OE's interest in this topic was expressed at the outset of the SGIG program and initial guidance was included in the Funding Opportunity Announcement (FOA).[20] The guidance in the FOA included general requirements for the application of statistically rigorous randomized and controlled experimental designs in their studies.

The reason why DOE-OE is interested in having projects follow these procedures is to maximize the likelihood of the projects producing results that would be useful to a large number of interested stakeholders from across the country. In theory, evaluations of studies that employ random selection and random sampling for treatment and control groups possess more credible and precise estimates of demand impacts as compared to those that don't use these techniques, in part because of attempts to address selection bias and achieve better internal validity. Furthermore, the demand and energy impact estimates from studies employing these methods can be extrapolated with a higher degree of confidence to comparable utilities and customer groups than the estimates from studies that don't use these techniques, in part because of better external validity.

To help the projects achieve these ends, DOE-OE provided a series of 10 guidance documents to the projects that contained information on a variety of important topics including: acceptable experimental designs, methods for producing acceptable sample sizes for each treatment and control group of the study, and appropriate evaluation techniques to derive statistically valid load and energy impacts. These guidance documents are summarized below and can be downloaded from DOE-OE's SGIG website.

Guidance Document #1: Recommendations for Content of the Consumer Behavior Study Plans, July 22, 2010

> This document provides guidance to the projects for preparing Consumer Behavior Study Plans, and explains the types of information to be included in the plans including details on the experimental design and approach to random selection of participants to treatment and control groups.
>
> www.smartgrid.gov/sites/default/files/doc/files/cbs_guidance_doc_1_cbsp_outline.pdf

[20] SGIG FOA was issued on June 25, 2009. (DE-FOA-0000058)

Guidance Document #2: Non-Rate Treatments in Consumer Behavior Study Designs, August 6, 2010

This document provides guidance to the projects on the challenges and complexities that non-rate treatments (i.e., customer education and in-home displays, and automation and control technologies) can introduce to a study. It also develops a typology to help projects identify the most appropriate specific non-rate treatments to include in their study based on the project's objectives while attempting to keep the study design manageable.

http://www.smartgrid.gov/sites/default/files/doc/files/cbs_guidance_doc_2_non_rate_treatment_issues.pdf

Guidance Document #3: Use of Stratification and Sample Weights for Smart Grid Projects Using Experimental Design. August 26, 2010

This document provides guidance on the various procedures for designing appropriate and efficient samples to directly estimate hourly load profiles and usage patterns within treatment groups and explains the relative merits of alternative approaches.

http://www.smartgrid.gov/sites/default/files/doc/files/cbs_guidance_doc_3_use_of_stratification_and_sample_weights.pdf

Guidance Document #4: Rate Design Treatments in Consumer Behavior Study Designs, August 30, 2010

This document provides guidance on the different types of time-based rate programs and discusses the choices and issues associated with various rate design treatments, including DOE-OE's relative priorities for inclusion in the SGIG consumer behavior studies.

http://www.smartgrid.gov/sites/default/files/doc/files/cbs_guidance_doc_4_rate_design_2.pdf

Guidance Document #5: Techniques for Estimating Impact Measurements, August 30, 2010

This document provides guidance on the various analysis techniques that are appropriate for estimating load and energy impacts which are to be reported to DOE-OE in describing the results of the projects. It discusses the customer usage impact metrics that are to be calculated, provides explanations of the treatment variations in the experiments, and details the types of control groups that may be developed as part of the analysis, summarizes analysis techniques and their strengths and weaknesses, and provides recommendations on the preferred combinations of control groups and analysis techniques.

http://www.smartgrid.gov/sites/default/files/doc/files/cbs_guidance_doc_5_impact_evaluation.pdf

Guidance Document #6: Recommendations for Content of the Consumer Behavior Study Evaluation Reports, July 25, 2010

This document provides guidance on the information to include in the interim and final evaluation reports of the projects that are to be submitted to DOE-OE.

http://www.smartgrid.gov/sites/default/files/doc/files/CBSguidancedoc6-cbsp-evaluation-report-outline-final-2012-07-30.pdf

Guidance Document #7: Design and Implementation of Program Evaluations that Utilize Randomized Experimental Approaches, November 8, 2010

This document provides guidance for implementing randomized evaluations of time-based rate programs and explains the practical steps necessary to carry out such studies. It discusses the considerations necessary for achieving internal and external validity, which are major goals of DOE-OE for the SGIG consumer behavior studies. The document also provides background information from the research community that, when certain conditions are met, properly designed and implemented randomized control trials provide the most valid estimates of an intervention's impact on an outcome of interest.

http://www.smartgrid.gov/sites/default/files/doc/files/cbs_guidance_doc_7_randomized_experimental_approaches.pdf

Guidance Document #8: TAG and Recipient Engagement Strategy Post-CBSP Approval, February 24, 2011

To ensure proper design and implementation of the SGIG consumer behavior studies, each of the participating projects was assigned a Technical Advisory Group (TAG) of experts to provide guidance and comments on proposed study approaches. This document explains how the TAG and the projects are to work together during the implementation phase of the study.

http://www.smartgrid.gov/sites/default/files/doc/files/GuidanceDoc8-TAG_Engagement_Post-CBSP_Approval-FINAL.pdf

Guidance Document #9: Preferences for DOE Required Data Collection via Survey Instruments, July 6, 2011

This document describes the demographic and other data elements that are to be collected either during the enrollment process or via survey instruments. It explains the value of collecting high quality data on customer characteristics to address key analysis questions and policy issues. It discusses methods and preferred approaches for collecting survey data and includes sample questionnaires for both residential and commercial customers to collect the required information.

http://www.smartgrid.gov/sites/default/files/doc/files/GuidanceDoc~Survey_Data~FINAL_20110707.pdf

Guidance Document #10: Consumer Behavior Study Data Collection Requirements, July 29, 2011

This document provides guidance on the data that DOE-OE expects the projects to collect and report. Data categories include historical (pre-treatment) and current (post-treatment) customer usage, recruitment, experimental cell assignment, experimental attrition, customer characteristic, and evaluation results. This information is needed for DOE-OE analysis of the results of the SGIG consumer behavior study projects.

http://www.smartgrid.gov/sites/default/files/doc/files/GuidanceDoc10~Data%20Collection~FINAL_0.pdf