U.S. DEPARTMENT OF ENERGY

Electricity Delivery & Energy Reliability

American Recovery and Reinvestment Act of 2009

Municipal Utilities' Investment in Smart Grid Technologies Improves Services and Lowers Costs

Smart Grid Investment Grant Program

October 2014

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RECOVERY ACT SMART GRID PROGRAMS

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Executive Summary

With funds provided under the Smart Grid Investment Grant (SGIG) program, 32 municipal utilities are deploying smart grid technologies and systems to improve the performance of their electric systems, provide benefits to customers, and advance U.S. grid modernization. Three utilities—Burbank and Glendale, California, and Danvers, Massachusetts—are building upon prior smart grid experiences to implement new smart grid capabilities in a comprehensive manner and push the boundaries to achieve greater performance and benefits.

Under the American Recovery and Reinvestment Act of 2009 (Recovery Act), the U.S. Department of Energy (DOE) and the electricity industry have jointly invested over $7.9 billion in 99 cost-shared Smart Grid Investment Grant projects to modernize the electric grid, strengthen cybersecurity, improve interoperability, and collect an unprecedented level of data on smart grid and customer operations.

Major Findings

The featured projects cover mid-sized cities with populations of 26,000 (Danvers), 108,000 (Burbank), and 194,000 (Glendale), respectively. Each city implemented grid modernization activities in multiple areas, including advanced metering infrastructure, distribution automation, and customer systems.

Project activities provided a number of benefits including improved operating efficiencies, lower costs, shorter outages, and reduced peak demands and electricity consumption. The impacts, benefits, and lessons learned realized by Burbank, Danvers, and Glendale are applicable to other municipal utilities considering or implementing smart grid projects.

To realize these benefits the utilities had to overcome several project challenges. These included learning how to operate new technologies and systems optimally; educating utility personnel on new businesses processes and practices; reaching out to customers to explain how to use new technologies to reduce electricity consumption and lower bills; and implementing new systems in a dynamic environment of rapidly evolving standards and technologies. The experiences of these three utilities show how challenges like these can be overcome. Table 1 summarizes key impacts, benefits, lessons learned, and future plans of the three featured projects.

Table 1. Summary of Benefits, Lessons Learned, and Future Plans		
Impacts and Benefits	i.	**Investments in wide bandwidth communications networks** help accommodate future smart grid upgrades, automate other city services (such as water and gas metering), and **deliver valuable returns for cities and taxpayers**.
	ii.	Glendale's customer programs include a home energy report and web portal program that helped 46,000 users **save an estimated 5,777 megawatt-hours** of electricity.
	iii.	Burbank's web portal programs for customers **saved an estimated 4,800 megawatt-hours** of electricity.
	iv.	Substation upgrades by Danvers enabled **deferral of $3 million of investment in distribution capacity** for up to 25 years.
	v.	Burbank's distribution automation systems led to **improvements in the major reliability indices** over a three-year period.
	vi.	Glendale's installation of smart meters reduced truck rolls by 15,000 miles, **saving approximately 6.3 metric tons of CO_2E**.
Lessons Learned	vii.	Early vetting and testing of new technologies, particularly customer systems, before the devices are widely deployed, is helpful for **resolving issues before they become major problems**.
	viii.	**Gaining management buy-in early in the planning phases** and maintaining it throughout the project's duration with frequent updates is a key success factor.
	ix.	Being well-organized in applying limited funding and allocating scarce labor resources requires **strong internal coordination and management approaches such as cross-functional teams**.
Future Plans	x.	Burbank plans to **integrate distributed energy resources** into the operation of its distribution management system.
	xi.	Danvers is **evaluating time-based rate programs**, including time-of-use and critical peak pricing, as well as distributed generation and demand response programs.
	xii.	Glendale is planning to **automate all of its 108 feeders by 2025**.

1. Introduction

The U.S. public power sector includes more than 2,000 cities, towns, and public power districts and serves more than 47 million people. This encompasses about 15% of the nation's electricity consumers. Several of the nation's largest cities are served by municipal utilities including Los Angeles, Sacramento, Seattle, Austin, and Orlando. Many smaller communities are also served; about 70% of municipal and public power utilities in the U.S. have customer populations of 10,000 or less. The SGIG program includes projects with 32 municipal and public power utilities, encompassing large, mid-sized, and small cities, towns, and communities.

SGIG investments by municipal and public power utilities typically focus on electric distribution and customer systems. Expected benefits include lower costs, better customer services, and more reliable and efficient electric system operations. These are achieved by deploying advanced communications networks; information and data management systems; distribution automation (DA) technologies; advanced metering infrastructure (AMI); and customer systems such as in-home displays, programmable communicating thermostats, web portals, and time-based rate programs, and distributed generation (DG) acquisition.

1.1 Smart Grid Priorities for Municipal and Public Power Utilities

Communities, cities, and towns across the country are striving to keep aging electric, gas, water, and transportation infrastructures operating efficiently, safely, and cost effectively. A hallmark of several municipal SGIG projects is leveraging investments in broadband communications networks and fiber optic systems to build capacity for future electric upgrades and boost local jobs creation through new business development. These networks are also being used to automate other city services such as gas and water metering. For these and other like-minded utilities, broadband communications offers an important foundation upon which communities can upgrade aging infrastructure and improve services without necessarily making extensive capital investments in new physical assets.

Under SGIG, the 32 municipal and public power projects are modernizing communications and electric infrastructure and expanding consumer participation in demand-side program for demand response, load management, energy efficiency, and electric vehicles. Many of the participating utilities report that Recovery Act funding has accelerated timetables of grid modernization investments by as much as five to ten years.

Municipal and public power deployments of distribution automation (DA) technologies and systems include: (1) automated feeder switching to shorten restoration times following outages and reduce the number of affected customers; and (2) automated controls for voltages and reactive power management to save energy from lower line losses and application of conservation voltage reductions.

Municipal and public power deployments of AMI include smart meters, communications networks for data backhauling, and meter data management systems for processing data for billing and other purposes. These investments improved operational efficiencies and reduced costs because automated meter readings and service connections and disconnections reduced the need to dispatch trucks and personnel to accomplish these services. AMI is also used for outage management because utilities can ping smart meters to determine which customers don't have power and pinpoint outage locations for quicker and more efficient service restoration.

Deployments of customer systems include time-based rate and load management programs to lower electricity costs by reducing peak demands. Web portals with customized dashboards provide feedback to customers on their electricity consumption and costs and have led to improvements in energy efficiency and lower bills. Customers are also deploying local generation through net metering and microgrid generation projects using renewable resources, co-generation, and backup generators to improve reliability and reduce operating expenses.

In addition to lowering costs and improving services, several municipal and public power projects under SGIG are leveraging smart grid investments to boost local business development and spur jobs creation. For example, the city-wide, broadband, fiber optic network installed by the Electric Power Board of Chattanooga, Tennessee is not only used to connect, communicate with, and control most of the city's smart grid equipment, it is also used for attracting new businesses and entrepreneurs via a program called GIGTANK. Now in its third year, GIGTANK recently invited smart grid innovators to submit ideas for partnering with EPB to use the network as a platform for creating and refining innovative smart grid concepts and to accelerate their market readiness. The intent is to use the network as a technology incubator and attract high-tech talent and new businesses to the community. The EPB network currently delivers the fastest internet services in the country.

Many of the nation's municipal and public power utilities represent small cities and towns with populations under 10,000. These utilities may lack resources and in-house expertise to evaluate new technologies, systems, and programs and frequently rely on the experiences of others to test smart grid equipment and identify cost-effective applications. While smaller utilities may lack public relations resources for marketing campaigns to address public concerns about smart grid deployments, many are able to take advantage of their smaller size and closer relationship to the community they serve. Through public meetings in convenient locations they can reach out to local community groups and address questions and concerns directly with customers. Face-to-face interactions are not always easily available to utilities in cities with larger populations and sprawling service territories.

Further information about the SGIG municipal and public power utility projects can be found at **DOE's website** for information on the Recovery Act smart grid projects and the American Public Power Association's **smart grid website**.

2. Overview of the Featured SGIG Projects

The SGIG municipal utility projects featured in this report include the Burbank and Glendale, California, and Danvers, Massachusetts. Based on their previous smart grid experiences, these utilities were able to leverage SGIG funds to pursue relatively comprehensive deployments of technologies and systems that include a variety of elements. The utilities gained smart grid know-how and realized impacts, benefits, and lessons learned that are generally applicable to other utilities, including smaller municipal and public power utilities with 10,000 or fewer customers.

2.1 City of Burbank, California

Utility	**Burbank Water and Power (BWP)**
Customer Base	• More than 51,000 residential, commercial, and industrial customers • 26,000 water customers
System Size	• Operates 14 distribution substations, 5 switching stations, and 138 distribution feeders. • Summer peak electricity demand is about 320 megawatts
SGIG Project Size	• Almost $51 million, including DOE funding of $20 million under the Recovery Act

In 2006, BWP began its infrastructure modernization strategy through deployment of new communication and digital technologies. Although many utilities programs at that time focused on metering systems, BWP focused on advanced communication and information systems that would enable high speed controls for a variety of tasks such as integration of renewable and distributed generation and demand response. Building on this, the overall goals for BWP's SGIG project include modernizing electric and water systems (water system upgrades are being done in parallel but are outside the scope of SGIG); improving customer services such as electric vehicle charging stations; promoting energy efficiency and demand management; and improving operational efficiencies and lowering costs. BWP generally believes these goals have been achieved.

> An independent auditor's report found that Burbank's investments in smart grid technologies have helped them deliver "exceptional system reliability," noting that in fiscal year 2012 "…the system experienced approximately 15 minutes of service outage once every 5.4 years compared to the typical industry system of approximately 96 minutes of service outage once every 1.2 years."[1]

[1] Audited Financial Statements, Fiscal Year 2013-1013, Burbank Water and Power, Independent Auditor's Report by White, Nelson, Diehl, and Evans LLP, June 30, 2013.

The BWP project includes twelve separate but interrelated initiatives. The initiatives include system-wide deployment of advanced metering infrastructure, communications networks, and systems for meter data management; more than 50,000 smart meters; customer systems including in-home displays and programmable communicating thermostats; distribution automation equipment for more than 100 feeders; systems for integrating customer-owned ice storage systems for load management; and 11 public electric vehicle charging stations.

To upgrade its communications infrastructure (see Figure 1), BWP deployed an Ethernet Switched Services Network (ESSN) for smart meters and other data backhauling, and integrated this with a 2.4/5.8 GHz Wi-Fi mesh network to serve as a field area network, supporting feeder devices and smart meters. The Wi-Fi network consists of 410 field nodes and 60 fiber gateways. The AMI mesh network includes 200 collector radios for electric meters, and 10 collector radios for water meters.

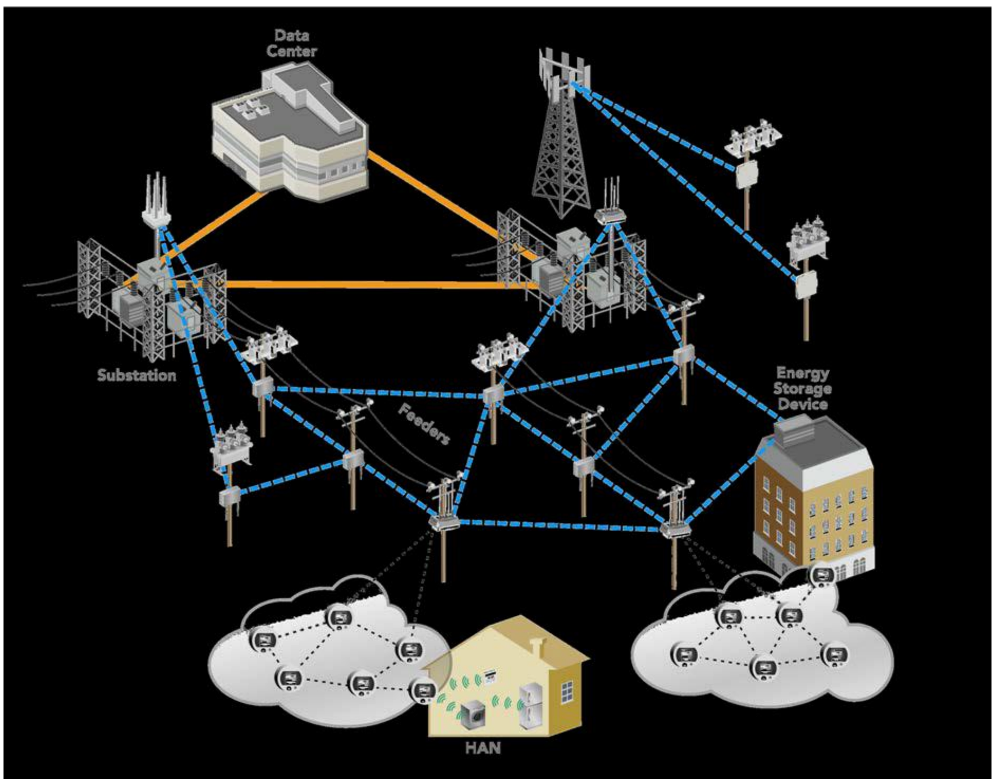

Figure 1. A conceptual model of BWP's fiber/wireless communications network.

BWP is leveraging excess capacity in these systems by offering high speed secure data communications services (e.g. Internet access, communication transport services, and virtual private LAN services) to commercial customers. The ONE (Optical Network Enterprise) Burbank program began offering services in 2010, and is the mechanism that uses surplus communications capacity. Services include: (1) internet services on secure, fully redundant, fiber-to-the-business, with port speeds of 20 to 1,000 megabytes per second; (2) virtual private local area networks to connect geographically dispersed facilities; (3) secure, fully monitored, high capacity, point to point connections, and (4) communications transport services for high quality, composite video signals. Many of these services are being used by entertainment industry customers in Burbank.

BWP deployed smart meters to all of their electric customers and, through a non-SGIG project, to all of their water customers. The smart electric and water meters use the same communications networks and meter data management systems, lowering costs for the utility and its customers. Smart meter features enabled by BWP include remote connection and disconnection, outage detection, voltage and power quality monitoring, and tamper detection.

BWP's DA activities include microprocessor-based relays and automatic reclosers on all 93 of its 4 kilovolt feeders and 40 of 45 of its 12 kilovolt feeders. The only feeders not included are completely underground. The relays have the capability to detect faults and automatically reclose circuit breakers after momentary faults clear. The main purpose of BWP's DA activities is to improve reliability and public safety, while reducing the duration of outages and subsequent economic losses by customers.

BWP's customer systems activities include deployments of thermal energy/ice storage units, energy usage reports, in-home displays, web portal displays, and electric vehicle charging stations. The ice storage activities include 29 systems installed in commercial buildings to lower peak air conditioning demands. The energy usage reports and web portal are available to all residential customers and provide customized information and feedback on electricity consumption and costs. In-home displays also provide customized information and feedback but were deployed on a pilot basis to 50 customers to test their acceptance and effectiveness. Eleven public electric vehicle charging stations were also deployed and evaluated.

2.2 Town of Danvers, Massachusetts

Utility	**Danvers municipal utility** (located northeast of Boston)
Customer Base	• About 13,000 customers, nearly 11,000 of which are residential
System Size	• Operates 10 distribution substations and 34 distribution feeders • Summer peak demand is approximately 80 megawatts
SGIG Project Size	• About $17 million, which includes DOE's share of about $8.5 million

Danvers began smart grid planning in 2006 with goals to enhance customer service capabilities, improve the efficiency of their infrastructure and business operations, and expand capabilities of their existing electric distribution systems. When SGIG started, Danvers had already made smart grid-related investments in electric distribution infrastructure and management systems, including Supervisory Control and Data Acquisition (SCADA), geographic information systems

(GIS) for outage management, and engineering analysis to increase capabilities for data processing, management, modeling, and analytics.

SGIG funds enabled Danvers to accelerate its grid modernization plans by several years. The overall goals for the project include improving customer services for more timely and accurate billing; improving the efficiency of distribution operations and outage management; ensuring the interoperability and scalability of implemented systems; offering customers more control of their energy use through efficiency and renewable generations programs; and deferring costly upgrades to the utility's main substation. Danvers generally believes these goals have been achieved.

Danvers deployed approximately 13,000 smart meters to all of its electric customers. The utility implemented customer systems activities, which include web portals, net metering applications for distributed generators, and time-based rate programs. The web portal is hosted on Danvers' website and provides customers with daily and hourly consumption history and supporting information such as weather trends. The portal also accepts online bill payments. Net metering activities use 15-minute, interval, load data from the smart meters to determine onsite generation levels and transfers into the grid. Net metering using smart meters is a new activity and Danvers expects participation rates to grow.

Danvers' distribution automation activities include deployment of automated feeder switches, capacitors, reclosers, and monitors. They also feature substation upgrades with human-machine interface devices and Supervisory Control and Data Acquisition (SCADA) technologies for the company's distribution management system (DMS). New applications include fault location, isolation, and service restorations, and power factor corrections. Expected benefits include faster service restoration following outages, lower cost distribution operations, and deferral of distribution capacity additions.

In a separate effort, Danvers also deployed more than 10,000 smart water meters that leverage the communications network and meter data management system deployed for electric grid modernization, resulting in cost savings for the utility and its customers. Danvers is developing water system services similar to the services deployed with the electric AMI system.

Systems integration has been a major project focus. Successful efforts have enabled Danvers to reduce the number of redundant field devices, ensure interoperability and consistency, and maintain scalability and flexibility for future smart grid deployments. Ongoing integration efforts include integrating the company's customer information systems and smart meter location data with both GIS and OMS systems.

2.3 City of Glendale, California

Utility	**Glendale Water and Power (GWP)** (municipal utility located adjacent to Burbank, and northeast of Los Angeles)
Customer Base	• Almost 84,000 electric and more than 32,000 water customers
System Size	• Operates 12 distribution substations and 108 distribution feeders
SGIG Project Size	• More than $51 million, which includes DOE's share of $20 million

GWP started its planning for smart grid upgrades in 2007 with the initial aim of assessing the business case for the deployment of smart meters for electric and water services. This was expanded to distribution automation, implementation of peak demand reductions, customer systems activities, and electric vehicle development when the SGIG project was implemented. See Figure 2 for the GWP distribution automation pilot service area.

GWP deployed smart meters to all of its electric customers, and also supplied supporting communications and information management systems. Enabled meter features include remote connections and disconnections, outage detection, and tamper detection. As of June 2014, GWP completed its full scale deployment of AMI systems and roll-out of customer systems programs such as a customer-wide AMI-enabled home energy report and web portal program, and smaller-scale, mobile application and in-home display pilots. More recently, GWP began piloting a behavioral demand response program that showed peak reductions of between 4% and 6% for 40,000 residential customers for its first three events.

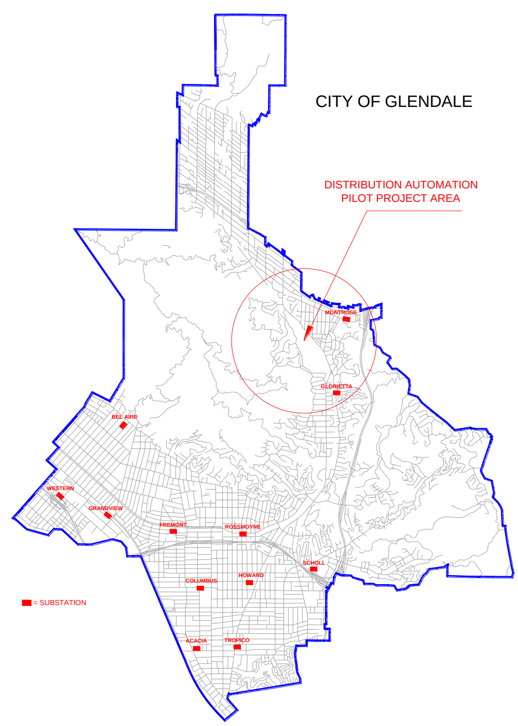

Figure 2. GWP service territory with the distribution automation area highlighted.

Project goals include improving operational efficiencies and cost savings from automated metering services, reducing capital requirements from fewer vehicle purchases, increasing revenues from more accurate meter reads and less electricity theft, faster restoration of services following outages, better electric distribution efficiencies and lower line losses from automated voltage controls, and lower electricity costs from reductions in peak demand. GWP generally believes these goals have been accomplished.

GWP's customer systems activities include using customer-owned thermal energy storage systems for peak demand reductions; in-home displays; a mobile app for customer access to electric and water data and bill payments; web portals to empower consumers with information on electricity consumption and costs; and charging stations for electric vehicles. As of October 2013, there was approximately 1.2 megawatts of thermal energy storage capacity under control by GWP including about 167 thermal storage units (see Figure 3) at more than 50 locations (13 city buildings and more than 40 local business locations.) GWP's pilot program for in-home displays currently involves 75 customers with plans to expand the program to up to 2,000 customers.

Figure 3. Examples of the thermal energy storage units under control by GWP.

In addition, GWP's new mobile app will allow customers to view current and historical bills as well as make payments, set budget goals and alerts, submit service requests, view/report outages, send messages directly to GWP, and obtain electric vehicle or solar panel usage information. The app will also enable GWP to monitor real-time data and predict customer behavior. The pilot program is free and will be offered to the first 2,000 Glendale residential customers who download the app.

GWP is implementing an electric vehicles program that provides financial incentives for the installation of charging stations. A recent study indicates there could be as many as 6,800 electric vehicles in GWP's service territory by 2020 and they are collaborating with other local utilities on a comprehensive electric vehicle plan for the greater Los Angeles area.

Like Burbank and Danvers, Glendale also deployed smart water meters in a parallel and separate project, which leveraged the communications and meter data management systems for electric grid modernization, resulting in cost savings for the utility and its customers.

GWP's distribution automation activities deployed reclosers, capacitor bank controllers, and feeder protection relays for four feeder lines to improve reliability by reducing the duration of outages. One of the criteria for feeder selection was that they have at least one tie point to adjacent feeders. GWP is installing four capacitor banks with advanced controls with the objective of testing voltage controls and reactive power management to improve power factors and reduce line losses.

GWP is also piloting a conservation voltage reduction (CVR) program that uses smart meter voltage data to improve feeder efficiency and provide significant energy efficiency benefits to customers. GWP estimates that a full-scale CVR project can achieve energy savings of between 2% and 4% on 65% of GWP feeders, or between 14,000 and 28,000 MWh per year.

3. Impacts and Benefits

Cost savings, efficiency improvements, and enhanced customer service have been the primary benefits observed in these three smart grid projects.

3.1 Burbank

Reduced consumption and lower customer bills. BWP estimates that it saved a total of about 4.8 gigawatt hours, and reduced per customer usage by 1-2%, between September 2011 and 2014 as a result of customers using the BWP energy usage reports and interactive web portal.

Fewer field visits and faster customer response. Before AMI, BWP averaged about 2,500 field service requests every month for off-cycle meter readings or service connections and disconnections. With AMI, such requests have been reduced 87% to approximately 300 per month, resulting in 13,200 fewer field visits, and allowing BWP to reduce the metering staff by seven positions. BWP can now respond to metering-related customer requests in 15 minutes or less, which is faster by hours or days than was possible before AMI. Customer satisfaction is higher as a result.

Improved efficiency and quality of call center operations. BWP's call center receives an average of 7,000 customer calls per month. With timely access to more detailed energy and water usage information using AMI and supporting meter data management systems, customer service representatives can now address many billing questions and problems instantly rather than having to call customers back. Positive feedback from customer surveys has doubled.

Reliability index improvements. BWP's deployment of distribution automation technologies and systems produced positive results in two commonly used reliability indices: System Average Interruption Frequency Index (SAIFI) and System Average Interruption Duration Index (SAIDI), as shown in Table 2.

Table 2. BWP Results for Electric Reliability Improvements

Fiscal Year	SAIFI	SAIDI
2009 – 2010	0.34	27.8
2010 – 2011	0.33	27.4
2011 – 2012	0.21	23.6
2012 – 2013	0.19	14.9
2013 – 2014	0.24	9.5

3.2 Danvers

Figures 4 and 5 provide examples of the visualization tools Danvers is providing to customers and grid operators to enable better customer management of consumption and costs, and operator management of distribution systems.

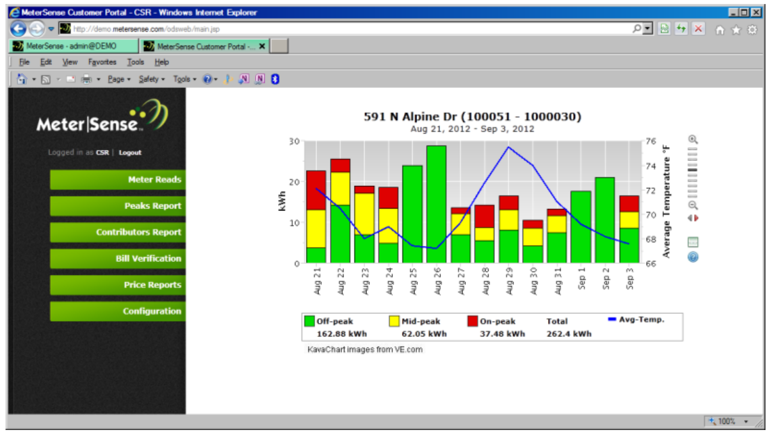

Figure 4. Example screen shot of customer web portal used by Danvers' customers.

Significant increases in meter accuracy. As a result of automated meter reading through AMI, Danvers estimates the volume of customer service calls decreased by about 75% after the meters were on-line and fully operational. Danvers estimates improved meter accuracy has resulted in $240,000 per year of cost savings.

Improved billing operations efficiency, improved cash flows, and lower costs. The AMI system has reduced the number of estimated bills from 1.1% in 2010 to 0.2% in 2013. The new system also enabled Danvers to increase the number of bills with durations of 28 to 32 days from 70% to 99% in 2010. AMI also eliminated billing issues from incorrect meter readings. Prior to the SGIG project, there were over 100 such cases on an annual basis.

Reduced actual meter operations costs in 2013 by 40% from the estimated baseline. Danvers reduced its annual truck rolls by nearly 1,000 by decreasing the need for meter re-reads and eliminating the need for manual connections and disconnections. Danvers estimates that the deployment of distribution automation systems and substation upgrades is enabling them to defer an estimated $3 million of distribution capacity investment for up to 25 years.

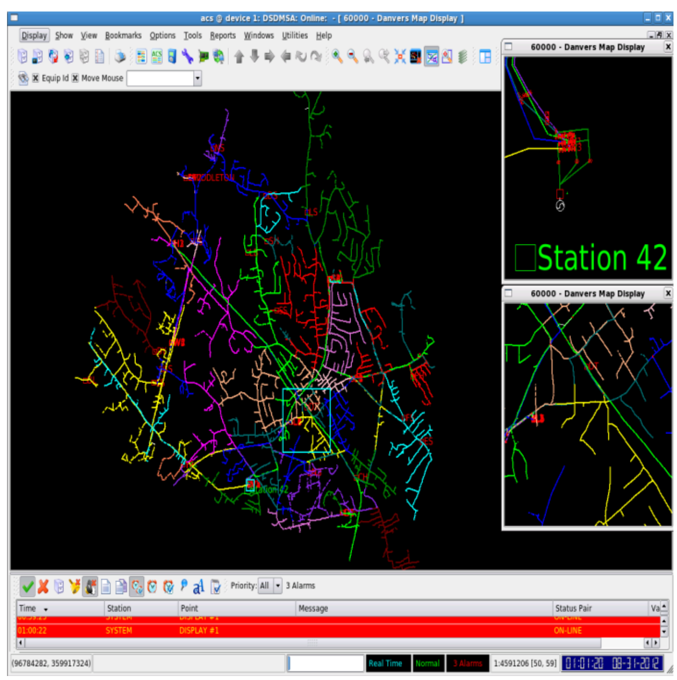

Figure 5. Distribution automation software used by Danvers.

Improve customer experience and faster reconnections. Almost 3,500 customers used their web portals, and more than 5,100 customers chose to pay their bills online. Additionally, service reconnections can be accomplished in one hour instead of the 12 hours it took before smart meters were in place.

3.3 Glendale

GWP engaged UtiliWorks Consulting, LLC (UWC) to evaluate the potential benefits and savings associated with the introduction of its smart grid system with AMI and MDMS. UWC concluded that the GWP project could potentially add $24 million in positive value, with an 11.5% internal rate of return.

Improved operational efficiency and lower costs from smart metering. Remote meter reading has allowed GWP to avoid more than 54,000 truck rolls to date. Over the next six years, UWC anticipates that avoided truck rolls could reduce CO_2E by close to 50,000 tons annually.

Satisfied customers and energy consumption behavior change. GWP's customer systems programs are received favorably by users. For example, 83% of the in-home program participants are using the information provided through their in-home displays and say they have changed their energy consumption behaviors and reduced energy and water use. GWP estimates the 46,000 customers participating in its AMI-enabled home energy reports and web portal program are saving as much as 5,700 megawatt-hours of electricity per year.

Estimated energy savings between 2% and 4% from a conservation voltage reduction pilot program. At full scale, the program will include 68,000 GWP meters and save an estimated 14,430 to 28,378 MWh per year. Assuming GWP's current value of saved energy of $50 per MWh, a full-scale, five-year program could net GWP power cost savings of $470,000 to $1.2 million per year.

Real-time distribution system data analysis to improve restoration times. GWP's DA pilot program is installing intelligent devices on four feeders and integrating new OMS-DMS software for device control. This will allow GWP to collect and analyze real-time distribution system data and enable operators to take rapid actions to control field devices and restore power more quickly. The new OMS-DMS will also improve outage management functions, including response and outage resolution times.

Informing customers to increase peak event load reduction without pricing incentives. GWP recently partnered with software-as-a-service provider Opower to launch a pilot that notifies customers of "peak events" and asks them to reduce energy consumption during peak hours. To date GWP has called three peak events as part of this pilot. Post-event, the program uses AMI data to show customers how their performance compared to similarly sized homes nearby and how their performance changed over time, while providing simple ways to use less energy during a peak period. The three peak events produced an average overall load reduction of 4.1% during peak hours across 38,000 homes, all without offering a pricing incentive.

Glendale has also developed approximately 1.2 megawatts of thermal energy storage through 167 thermal storage units at more than 50 locations across its service area.

4. Lessons Learned

The experiences of Burbank, Danvers, and Glendale provide several lessons learned that can be useful to other utilities interested in smart grid investment programs and projects.

4.1 Management Approaches

Internal collaboration and coordination was essential. Because municipal utilities typically operate with minimal overhead and staff expenses, labor resources are often at a premium. Many smart grid projects, particularly those involving customer systems and demand-side solutions, cut across functional areas and require well-organized staffing plans and inter-departmental teams to play critical roles. Often project contributors will be available for smart grid activities on a part-time basis, requiring frequent meetings to coordinate availability and activities. At the same time, key positions for managing programs, projects, and key activities require dedicated staff whose only responsibility is ensuring that work proceeds on time and budget.

Getting buy-in from senior management and other utility staff members is critical to success. Approvals play an important role in securing appropriate levels of funding and labor resources. The utilities found that this generally involved ongoing activities and regular updates and was not accomplished all at once at the outset of projects.

High bandwidth communications networks constitute the backbone of not only a smart grid, but also smart cities. All three utilities offer electricity and water services. In mapping out their smart grid strategies, they adopted long-term, comprehensive approaches that included building communications networks with capacities for handling future smart grid applications and with bandwidth for accommodating other city services than electricity. Smart grid communications networks can be leveraged to provide additional customer services such as internet access, high-speed data access, and corporate intranets for companies with geographically dispersed facilities, as has been accomplished by Burbank.

4.2 Technologies and Equipment

Project plans must allow for technology evolution as well as changes in standards and regulatory requirements. All three utilities deployed smart grid technologies and systems that were new to their companies and to many in the industry as a whole. In some cases, lack of technology maturity of equipment and software required continuous testing, improvements, and software updates. It was helpful to build testing and refinement periods into project schedules.

Increased coordination is required among partners that previously worked independently. For example, vendors can be valuable partners, but it requires time and effort to provide detailed guidance and product specification requirements. (Figure 6 shows the "picture frame" IHD deployed by Burbank and Glendale, which was developed for them by a local vendor.) The utilities found that their smart grid deployments typically involved changes to business processes, workflow, and logistics. This is typical of most major new software and information management systems. Management of these new system deployments also requires coordination of multiple stakeholders across several departments and divisions that used to operate as stand-alone entities. This is driving changes to organizational structure and behavior. The utilities found it valuable to set priorities for IT implementation, and to support transparent methods for change control.

Figure 6. Example of an in-home display.

4.3 Consumer Engagements

Conducting outreach and education for customers was valuable to encourage their involvement in web portal feedback programs and tools, and to raise awareness about smart meter deployments and counter misinformation about health effects and data privacy. Outreach efforts typically began early in the project and included educational programs with video and mailing components. Customer service representatives received focused training to effectively address customer questions and concerns. Public meetings with community groups increased the understanding of the utilities about customer needs and concerns, and enabled informative dialogs and discussions.

5. Future Plans

All three utilities plan to expand cost-effective smart grid applications to improve services, lower costs, and address aging infrastructure issues in their service areas based on the benefits realized from their smart grid investments.

5.1 Customer Systems and Programs

With system-wide installation of smart meters, Burbank, Danvers, and Glendale are considering ways to expand customer systems and programs. The utilities envision growing levels of customer participation in demand-side programs involving more customer technologies, tools, and techniques for improving energy efficiency, accomplishing load management, and enabling larger numbers of renewable and other distributed generation systems and electric vehicles.

- **Burbank** plans to explore new pricing options and incentives for public charging of electric vehicles based on data from operation of 11 stations. They also plan upgrades to their web portal offerings to provide greater amounts of information and tools for managing electricity consumption and costs.

- **Danvers** plans to explore ways to leverage smart meter data and capabilities and expanding demand response program offerings including time-of-use and critical peak pricing.

- **Glendale** plans to expand its in-home display program to include up to 2,000 customers; the long-term goal is to recruit up to 30,000 participants. Glendale is also considering new programs for commercial and industrial customers that provide information and analysis tools for managing demand in ways that are beneficial for both utilities and customers.

- **Glendale** plans new offerings to make customer usage and cost data accessible by smart phone, and demand response programs using programmable communicating thermostats. Glendale is developing web-based educational materials and tools to increase customer awareness of energy efficiency and water conservation techniques, which could be beneficial given the persistence of drought conditions in California.

5.2 Distribution Automation

Distribution automation investments helped improve services, reliability, and restoration times but further opportunities remain for cost-effective upgrades. A major target involves further efforts to integrate various information systems to enhance outage management, accelerate response times, and reduce the duration of outrages. This includes continuing activities for using smart meter data in outage management systems through the integration of smart meter data and GIS, and through new visualization and mapping tools for repair crews. These enable quicker assessments of affected customers and better pinpointing of outage locations.

Expanded equipment upgrades are also being planned.

Figure 7. Example of GWP substation automation equipment.

- **Danvers** plans to refurbish its 5 kilovolt circuits to improve reliability.
- **Glendale** plans to fully automate all of its 108 feeders, subject to budget availability. Figure 7 shows substation automation equipment deployed by GWP. The utility plans to automate existing 12 kilovolt feeders at a rate of six feeders per year with an estimated cost of about $1.0 million per feeder. It also plans to reconstruct, convert, and automate existing 4 kilovolt feeders at a rate of seven feeders per year with an estimated cost of about $1.6 million per feeder.
- **Burbank** plans to integrate distributed energy resources into the operation of its distribution management system, and upgrade voltage and reactive power management with new automated capacitor banks and voltage regulators.

6. Where to Find Additional Information

To learn more about national efforts to modernize the electric grid, visit DOE's Office of Electricity Delivery and Energy Reliability's **website** and **www.smartgrid.gov**. DOE has published several reports that contain findings on topics similar to those addressed in the two projects featured in this report; web links are listed in Table 3.

Table 3. Web Links to Related DOE Reports		
SGIG Program, Progress, and Results	**i.**	**Progress Report II, October 2013**
	ii.	**Progress Report I, October 2012**
	iii.	**SGIG Case Studies**
SGIG Analysis Reports	**iv.**	**Demand Reduction from the Application of AMI, Pricing Programs, and Customer Based Systems – Initial Results, December, 2012**
	v.	**Application of Automated Controls for Voltage and Reactive Power Management – Initial Results, December, 2012**
	vi.	**Reliability Improvements from Application of Distribution Automation Technologies – Initial Results, December, 2012**
Consumer Behavior Studies	**vii.**	**Lessons Learned: Customer Engagement, Updated January, 2014**
	viii.	**Analysis of Enrollment Patterns In Time-Based rate Programs, July, 2013**
	ix.	**Quantifying the Impacts of Time-based Rates, Enabling Technologies, and Other Treatments in Consumer Behavior Studies: Protocols and Guidelines, July 2013**
Recent Publications	**x.**	**Smart Meter Investments Yield Positive Results in Maine, February 2014**
	xi.	**Smart meter Investments Benefit Rural Customers in Three Southern States, March 2014**
	xii.	**Control Center and Data Management Improvements Modernize Bulk Power Operations in Georgia, August 2014**
	xiii.	**Using Smart Grid Technologies to Modernize Distribution Infrastructure in New York, August 2014**
	xiv.	**Automated Demand Response Benefits California Utilities and Commercial & Industrial Customers, September 2014**
	xv.	**New Forecasting Tool Enhances Wind Energy Integration in Idaho and Oregon, September 2014**