FINAL PROJECT REPORT

GLENDALE WATER AND POWER SMART GRID PROGRAM

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Prepared by: Glendale Water and Power

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PREFACE

The California Energy Commission Energy Research and Development Division supports public interest energy research and development that will help improve the quality of life in California by bringing environmentally safe, affordable, and reliable energy services and products to the marketplace.

The Energy Research and Development Division conducts public interest research, development, and demonstration (R&DD) projects to benefit California.

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- Energy Innovations Small Grants
- Energy-Related Environmental Research
- Energy Technology Systems Integration
- Environmentally Preferred Advanced Generation
- Industrial/Agricultural/Water End-Use Energy Efficiency
- Renewable Energy Technologies
- Transportation

*Glendale Water and Power Smart Grid Program* is the final report for the Glendale Water & Power Smart Grid Regional Demonstration Program - Customer Directed Programs and Distribution Automation Project grant number PIR-10-069 conducted by Glendale Water and Power (GWP). The information from this project contributes to Energy Research and Development Division’s Energy Technology Systems Integration Program.

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For more information about the Energy Research and Development Division, please visit the Energy Commission’s website at www.energy.ca.gov/research/ or contact the Energy Commission at 916-327-1551.
This report describes Glendale Water and Power’s (GWP’s) Smart Grid program and the results achieved. With a total cost of $51.3 million, GWP was the recipient of an American Recovery and Reinvestment Act of 2009 award, which was funded in part by a $20 million U.S. Department of Energy Smart Grid Investment Grant and a $1 million grant from the California Energy Commission. GWP’s Smart Grid program modernized their operations, reduced energy waste, and improved customer service. The projects included residential and retail customer service and participation programs, distribution automation, conservation voltage reduction, IT upgrades, enterprise computer systems, communications, and cyber security. Implemented between 2009 and 2015, the program supports the City of Glendale’s sustainability goals, and allows the utility to provide cost-effective, reliable, and high quality electric and water services. Specific Smart Grid projects are described in detail in this report. These include the AMI-MDMS Project, CEIVA In-Home Displays, OPOWER Web Portal, Unusual Usage Alerts, SmartRate Engine, Behavioral Demand Response, Thermal Energy Storage, Electric Vehicles Customer Incentive and Information, Smart Customer Mobile and Portal Platform, Water Insight Programs, the Enterprise Computer Systems Smart Grid Reference Architecture, and Distribution Automation Hardware Pilot Projects. Key benefits derived from implementing the Smart Grid and lessons learned during the program are identified in this report.

GWP is a municipal utility with a 16-square mile service territory in Southern California. The utility employs approximately 310 workers and delivers power to approximately 73,000 residential, 12,800 commercial and 220 industrial customers, and water to 33,900 customers.

Keywords: Glendale Smart Grid, Glendale, Glendale Water and Power, smart meters

Please use the following citation for this report:

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EXECUTIVE SUMMARY

Introduction
Glendale Water and Power (GWP) is the municipal utility servicing the community of Glendale, California with 33,900 water customers and 86,020 electric customers. The Department of Energy through a $20 million American Recovery and Reinvestment Act of 2009 award (DE-OE0000192) provided funding for a Smart Grid Regional Demonstration Program to the GWP. The California Energy Commission provided a $1 million cost share award to partially fund the Customer Directed Programs and Distribution Automation projects portion of the larger regional demonstration program. This report is focused on the projects funded by the Energy Commission. Before 2009, GWP relied on traditional electromechanical meters to monitor water and electricity use throughout the district. The electromechanical system required manual meter reading, manual connects and disconnects, and provided limited ability to respond to tampering and outages. Additionally, the traditional system did not have support for real-time customer communication or feedback regarding use. In 2009, GWP began exploring ways to update its energy grid to better serve its customers. GWP chose Smart Grid technology and Advance Metering Infrastructure (AMI) upgrades to the electromechanical system.

Like the Internet, the Smart Grid consist of controls, computers, automation, and new technologies and equipment working together, but in this case, these technologies will work with the electrical grid to respond digitally to our quickly changing electric requirements.

Project Purpose
In early 2010, GWP launched the AMI-Smart Grid Initiative to create an integrated, digital system that increased the efficiency of GWP’s operations, increased customer engagement and awareness, and decreased energy loss and waste. Through the Smart Grid Initiative, GWP wanted to:

- Overhaul the communications system throughout the grid by introducing Wi-Fi and Fiber Optics networks
- Replace existing electromechanical water and electric meters with new smart meters for 86,020 electric customers and 33,900 water customers.
- Introduce a Meter Data Management System to provide storage for and access to the data collected by the new smart meters
- Introduce programs designed to improve GWP’s relationship with its customers, as well as provide customers with the ability to closely monitor their consumption and reduce waste.
- Install a Distribution Automation program, allowing the grid to be monitored centrally and more closely than possible with the traditional system, with greater ease of repair and less frequent service disruptions.

The Smart Grid Initiative was funded through pledged grants from the California Energy Commission and Department of Energy, totaling $21 million. GWP also engaged UtiliWorks Consulting, LLC to evaluate the potential benefits and savings associated with introducing a
Smart Grid system with AMI and Meter Data Management System. UtiliWorks Consulting concluded that a Smart Grid system could potentially add $24 million in positive value over the life of the project, with an 11.5 percent rate of return to GWP.

Project Process and Results
The Smart Grid Initiative was divided into three phases, to be implemented over a five-year period.

During Phase I, the AMI and Meter Data Management System were installed by GWP with the support from Itron and Utility Partners of America. Beginning in March 2010, Utility Partners of America installed Itron OpenWay® Smart Grid meters for the 86,020 electric customers and Itron Water SaveSource™ for the 33,900 water customers. Utility Partners of America also overhauled the communications and IT systems, providing support for the more advanced system. This process included:

- Installing a new Uninterruptible Power Supply to support the Smart Grid system.
- Installing both primary and secondary Storage Area Networks, to collect the data from the smart meters
- Improving the cyber security of the grid and Storage Area Networks.

Phase II, began in September 2011 and developed and tested customer directed programming. GWP leveraged the new capabilities of the Smart Grid to provide customers with access to information about their energy use and educate them about conservation opportunities. Phase II was completed in March 2015. Examples of the programming tested during Phase II include:

- In-Home Displays and Programmable Communicating Thermostats
- Customer Usage and Billing Mobile App and Web Portal
- Thermal Energy Storage through Ice Bear Units
- Behavioral Demand Response

Beginning January 2014, Phase III included the Enterprise Computer Systems Program and the Distribution Automation Hardware Program, which were completed in March 2015. The Enterprise Computer Systems Program implemented numerous software programs including an Enterprise Service Bus, Geographic Information System, Asset Management System, Conservation Voltage Reduction, Outage Management System, Transformer Information Load Management, Distribution Management/Modeling System), Load Forecasting System, Load Management System, Electric Vehicle Management, and a Mobile Workforce Management System. The Distribution Automation system can:

- Recognize service theft
- Localize outages remotely via re-closers and fault interrupters
- Engage in two-way communication throughout the Distribution Automation system
- Conserve energy by reducing voltage at the feeder level
Program Lessons Learned

- **Project teams must have a shared vision.** For a major project to succeed, the executive team should have a vision of the direction the enterprise is taking—and share that vision with all project and utility staff. Glendale used a video about the project and frequently asked questions (FAQs) to get the project and executive team on the same page regarding the Smart Grid Investment Grant project and its targeted outcomes and objectives. Glendale is now using the Smart Grid Maturity Model to clarify aspirations for smart grid implementation as a whole.

- **People and processes are as important as technology.** With a project of this size and scope, a team could easily overlook the importance of business process and staffing redesigns while focusing on technological changes. Glendale learned that technology is merely an enabler of processes that people execute and maintain. Attention to the process changes and the impact of those changes on human resources at Glendale ensured that the program succeeded on all fronts.

- **Resource management is key.** Hiring numerous permanent staff members for this project was not practical. Instead, Glendale leveraged an alliance of leading industry experts combined with in-house management under the governance of Glendale’s project sponsor and its Smart Grid Executive Policy Committee.

- **Details are important.** Detail-oriented individuals were an invaluable asset to the success of the Glendale Smart Grid Initiative project. Seemingly small details have the potential to turn into large problems if not addressed carefully.

- **A project management office (PMO) should be set up and properly staffed.** The Smart Grid Initiative was the largest project Glendale has ever undertaken. A project of this magnitude comes with considerable risks and rewards. It was imperative that a strong PMO be established and has sufficient resources for maximum effectiveness.

- **A project of this magnitude necessitates risk management.** Potential risks should be identified and tracked upfront. At the beginning of the project, Glendale identified a number of potential risks that could adversely affect the project and developed a mitigation plan to address these risks. Only one risk was realized and had an impact on schedule but project was still completed successfully due to risk planning.

- **The “smart” in smart grid implies a significant information technology (IT) component to the project.** Those considering smart grid projects should not underestimate the significance of associated IT work. The interfaces between Glendale’s customer information system, meter data management system, and head end systems proved one of the largest technical challenges of the AMI project. Glendale commissioned a systems architect to document the entire system and prepare a roadmap.
to migrate the utility’s systems to a service-oriented architecture with an enterprise service bus before adding all of the software needed for distribution automation. This fundamental IT task was a major endeavor.

- **Establishing and fully staffing a new AMI operation team is key.** AMI is a disruptive technology; its introduction will not allow utilities to conduct “business as usual.” AMI implementation demands that the utility adjust some or all of its operations. Attempting to staff an AMI operation though a matrix system creates an unacceptable risk. AMI operations and maintenance is primarily an IT effort—but needs to be infused with business knowledge to be effective. Co-location of the core team is an essential ingredient for the team’s success. AMI projects should establish a stable core AMI team with permanent full-time employees who report to the AMI operations project manager.

- **The Hype Cycle is real.** Glendale’s customer surveys support the Hype Cycle,¹ a description of a technology’s life cycle stages from conception to maturity and widespread adoption. Project teams should have programs ready for customers in a timely manner or be prepared to weather the “trough of disillusionment.”

**Benefits Realized**

- **Reduced meter reading and customer service costs:** Glendale realized a $3.6 million in annual cost savings—a 51% reduction in annual costs—from lower meter reading and customer service operations since 2010:
  - Meter reading errors decreased from an average of 2.82% a month in fiscal years FY2011 to 0.04% a month in FY 2015.
  - Annual total truck rolls decreased from 33,814 in FY 2010 to 5,424 in FY 2015.
  - Customer service staff was reduced by 15 staff members, from 61 in 2011 to 46 in 2015.

- **Reduced operating and maintenance costs:** Although full benefits are still to be determined, Glendale expects significant operational savings from enterprise computer system improvements, customer programs, and distribution automation programs. Total annual system benefits could exceed $10 million by the tenth year of operation.

- **CVR pilot project:** The pilot helped Glendale realize 2.95% in energy savings over the baseline on two feeders, suggesting that a full-scale program could save a minimum of 14,500 megawatt-hours (MWh) each year.

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Behavioral demand response pilot project: Three project-related events resulted in the following benefits:

- Glendale realized statistically significant savings (on-peak and off-peak) for the period from August 27–October 9, 2014, yielding 10 kilowatt-hours (kWh) saved per household for a total of 392,000 kWh.

- The behavioral demand response (BDR) indicated a benefit–cost ratio of 6.7 using a total resource cost (TRC) test for the summer 2014 program.

- The BDR remains cost-effective at a list price of $4.50 per household.

- Participants receiving BDR communications show an 85% satisfaction rate.

Reduced costs from technical and non-technical distribution line losses: Once fully deployed, GWP expects its distribution automation improvements, along with its Meter Data Analytics and Conservation Voltage Reduction Programs, will result in line loss savings equal to 1%–2% of annual sales.

Reduced greenhouse gas emissions and criteria pollutants: A Glendale contracted study suggests carbon dioxide reductions will approach 60,000 tons a year from customer care and metering, i.e. reduced truck rolls, customer demand management programs, and power delivery improvements from load balancing, voltage monitoring, and fault detection, once programs reach full implementation.

Future Plans

Glendale intends to conduct the following smart grid-related tasks:

- Implement Phase II of the BDR pilot July to October 2015.

- Implement a full-scale CVR program.

- Implement a customer information system automation platform by December 2015.

- Automate a minimum of six additional feeders each year through 2020.

- Automate Glendale key performance indicators (KPIs) by December 2016.

- Implement mobile access to data for all customers by December 2015; enroll 10,000 customers by June 2017.

- Enroll 3,000 customers in the in-home-display/home area network program for residential customers by June 2017.

- Continue piloting systems to ensure that analytics, automation, and control operate across multiple systems and organizational functions by June 2016.

- Have a fully functioning business intelligence program by June 2017.
• Implement new residential time-of-use and electric vehicle rates by June 2017.

• Fully integrate all Glendale business IT systems through the enterprise service bus by June 2019.

• Complete a functional-level business case for work and asset management by June 2017; implement effective mobile workforce and asset management by June 2019.
CHAPTER 1:  
Smart Grid Program – Summary of Projects

The three phases of the GWP Smart Grid Program-Customer Directed Programs and Distribution Automation projects were logically sequenced. The first phase, the AMI- Meter Data Management System (MDMS) Phase, provided the infrastructure that is foundational to the entire program and a pre-requisite for the Customer Directed Programs in Phase II. Phase III, the Distribution Automation phase begins with the development of the Smart Grid Architecture plan and the installation of the Enterprise Computing Systems Program, followed closely by the Distribution Automation Hardware Program.

1.1 AMI-MDMS Phase I

1.1.1 Communications Backhaul

A wide area network was necessary to allow GWP to communicate with the new meters being installed throughout the service area with a total cost of $2.1 million (Table 1). In 2009, GWP contracted with the Utility Partners of America to install an Itron Tropos, Wi-Fi Backhaul System. The wireless mesh system uses fiber optically connected gateways to facilitate end-to-end system communications via Wi-Fi radio and Ethernet/IP over Fiber. Before the development of the smart grid, GWP used a SONET protocol, which was limited in terms of network design and security. The upgrade to an advanced Ethernet system was necessary to support smart grid functionality.

Table 1: Communications Budget Summary

<table>
<thead>
<tr>
<th>Schedule</th>
<th>March 2010 – January 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budgeted Costs (December 2010):</td>
<td>$3,310,820</td>
</tr>
<tr>
<td>Amended Budget (May 2013):</td>
<td>$2,129,533</td>
</tr>
<tr>
<td>Final Costs:</td>
<td>$2,183,951</td>
</tr>
</tbody>
</table>

1.1.2 Information Technology (IT) Infrastructure Upgrades and Meter Data Management System (MDMS)

With the dramatic increase in data collected by the smart meters, GWP foresaw the need for improvements to its IT infrastructure. By installing Storage Area Networks (SANs), GWP ensured that the data storage system was both reliable and fault tolerant. A secondary SAN supports the disaster recovery system, a necessary redundancy in the system.

GWP recognized the necessity to protect the data being collected by the new system once the new architecture was in place. To ensure consistent data storage even in the event of natural disaster, GWP purchased and installed an uninterruptible power supply (UPS) as part of the IT upgrades. Additionally, GWP implemented several cyber security initiatives to protect the system from external attacks. IT staff were trained according to the best practices of the Informational Technology Infrastructure Library including change management, incident and problem management, and service request management.
In addition to the IT Infrastructure Upgrades, Phase I included installing the MDMS with a total upgrade meter budget of $9.9 million (Table 2). The MDMS is the piece of the smart grid system that allows meter data to communicate across the utility, to be used for information in billing, customer service, outage management, and load management systems. GWP selected Itron OpenWay and SaveSource.

### Table 2: IT Upgrades and Meter Data Management System Budget Summary

<table>
<thead>
<tr>
<th>Schedule</th>
<th>December 2011 – January 2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budgeted Costs (December 2010):</td>
<td>$8,636,328</td>
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<tr>
<td>Amended Budget (May 2013):</td>
<td>$9,224,955</td>
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<tr>
<td>Final Costs:</td>
<td>$9,934,698</td>
</tr>
</tbody>
</table>

#### 1.1.3 Smart Meters and Installation

Once the backend systems upgrades were completed, GWP selected Itron meters and installed 84,500 electric meters and 32,500 water meters costing $22.7 million (Table 3). The smart meters feature capabilities like remote connect and disconnect of service, leak detection, and two-way communications between meters and the utility.

### Table 3: Smart Meters Budget Summary

<table>
<thead>
<tr>
<th>Schedule</th>
<th>March 2010 – June 2012</th>
</tr>
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<tbody>
<tr>
<td>Budgeted Costs (December 2010):</td>
<td>$16,074,353</td>
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<tr>
<td>Amended Budget (May 2013):</td>
<td>$23,511,604</td>
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<td>Final Costs:</td>
<td>$22,780,615</td>
</tr>
</tbody>
</table>

#### 1.2 Customer Directed Program – Phase II

As stated earlier, Phase II focused on Customer Directed Programming using the real-time information collected by the smart grid system to empower customers to make smart decisions about their energy use totaling $5.2 million (Table 4). The initial scope of Phase II included the following programs:

- In Home Displays
- OPOWER Web Portal
- OPOWER Behavioral Demand Response
- Thermal Energy Storage
- Demand Response
- Experimental Pricing Programs
- Electric Vehicle Program
• Smart Rate Engine
• Smart Customer Mobile and Portal Platform

Table 4: Phase II Customer Directed Budget Summary

<table>
<thead>
<tr>
<th>Schedule</th>
<th>May 2011 – March 2015</th>
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</thead>
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<td>Budgeted Costs (December 2010):</td>
<td>$10,153,917</td>
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<tr>
<td>Amended Budget (May 2013):</td>
<td>$5,190,101</td>
</tr>
<tr>
<td>Final Costs:</td>
<td>$5,248,352</td>
</tr>
</tbody>
</table>

1.3 Distribution Automation Project – Phase III

Phase III, the Distribution Automation project, was broken into two pieces; an Enterprise Computer Systems project, and a Distribution Automation Hardware project.

1.3.1 Enterprise Computer Systems Project

Similar to how a communications backhaul and IT upgrades were necessary to the success of Phase I, the development of the Smart Grid Architecture Plan was the first step in completing Phase III. The Smart Grid Architecture Plan provided the roadmap for its implementation and assumed the detailed designs, the business process changes, and the organizational improvements necessary for the project to be successfully implemented (Table 5). The Smart Grid Architecture was designed to be flexible, as any other architecture or system, over time as business requirements, technology and capabilities change or improve. Based on the architecture, the initial software and systems deemed necessary for this first part of Phase III were:

• Enterprise Service Bus (ESB)
• Outage Management System (OMS)
• Distribution Management/Modeling System (DMS)
• Business Intelligence/ETL and Data Warehouse
• Harris NorthStar Customer Connect Platform
• Meter Data Analytics Program
• IVR Upgrade
• AMI Based Conservation Voltage Reduction Pilot Project
1.3.2 Distribution Automation Hardware Pilot Project

This second part of Phase III involved the actual hardware upgrades that would improve GWP’s distribution system totaling $2.37 million (Table 6). The goal of any Distribution Automation system is to respond automatically to outages and disturbances in the system with the smallest amount of disruption to client service. The initial plan called for a pilot phase to confirm program objectives and goals, before proceeding with a wider deployment and included this hardware:

- Communication System
- Automated Feeder/Reclosers/Fault Interrupter
- Automated Capacitors
- Automated Regulators/Load Tap Changer (LTC):
- Remote Fault Indicators
- Disturbance Monitoring Relays
- Smart Protective Relays

Table 6: Phase III Distribution Automation Hardware Budget

<table>
<thead>
<tr>
<th>Schedule:</th>
<th>September 2010 – March 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Budgeted Costs (December 2010):</td>
<td>$3,309,051</td>
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<td>Amended Budget (May 2013):</td>
<td>$2,296,844</td>
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<td>Final Costs:</td>
<td>$2,370,585</td>
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</tbody>
</table>
CHAPTER 2:  
Smart Grid Program Budget and Management Structure  

2.1 Program Budget  

The total budget for the GWP Smart Grid program was $51,302,105, with a portion of the fund from the Department of Energy - Smart Grid Investment Grant (SGIG), a portion from the City of Glendale, and the California Energy Commission (Table 7).

<table>
<thead>
<tr>
<th>Table 7: GWP Smart Grid Program Budget</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Management Office</td>
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<tr>
<td>Project Management</td>
</tr>
<tr>
<td>Public Outreach</td>
</tr>
<tr>
<td>M&amp;V</td>
</tr>
<tr>
<td>Sub-Total</td>
</tr>
<tr>
<td>AMI-MDMS</td>
</tr>
<tr>
<td>Meters and Installation</td>
</tr>
<tr>
<td>Communications Backhaul</td>
</tr>
<tr>
<td>IT Infrastructure/Meter Data Management System</td>
</tr>
<tr>
<td>Sub-Total</td>
</tr>
<tr>
<td>Customer Directed Programs</td>
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<tr>
<td>Program Support</td>
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<tr>
<td>Smart Grid RD&amp;D Programs</td>
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<tr>
<td>Ice Energy</td>
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<tr>
<td>Electric Vehicles</td>
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<tr>
<td>In Home Displays</td>
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<tr>
<td>OPOWER</td>
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<tr>
<td>Experimental Pricing</td>
</tr>
<tr>
<td>Sub-Total</td>
</tr>
<tr>
<td>Distribution Automation</td>
</tr>
<tr>
<td>Enterprise Computer Systems</td>
</tr>
<tr>
<td>Distribution Pilot Hardware</td>
</tr>
<tr>
<td>Sub-Total</td>
</tr>
<tr>
<td>TOTAL PROJECT</td>
</tr>
</tbody>
</table>

The original December 2010 budget contemplated significant investments in a commercial demand response program and residential in home display programs. Those programs were paired down for two reasons: 1) delays in the implementation of the AMI-MDMS resulted in increased costs for that phase of the project, and funds were shifted to cover such increases; 2) GWP experienced general budgetary issues that essentially resulted in an 18 month shut down of the project and significant staff reductions. During this timeframe all customer directed
programs and distribution automation projects were put on hold, with the exception of the mitigating meter and the north fiber extension projects. Once funding was restored, GWP shifted resources to areas that could be completed with the grant timeframe. The commercial demand response program was put on indefinite hold and a smaller in-home display program was implemented.

2.2  Project Management Structure and Organization

A Program Management Office (PMO) was established by GWP. The overall program management responsibility rested with the GWP Project Sponsor, who reported to the GWP General Manager and the AMI-Smart Grid Initiative Executive Policy Committee. Figure 1 shows the Project Management Organization.

Figure 1: GWP Program Organization Chart

DNV GL (Det Norske Veritas-Germanischer Lloyd) (formerly KEMA) managed the day-to-day activities of the GWP AMI-Smart Grid Initiative. Implementation of the AMI-MDMS Program was performed by contract workers under the guidance of GWP, DNV GL, and Itron, Inc. The PMO followed the guidelines of the Project Management Institute (PMI) guide to the Project Management Body of Knowledge (PMBOK) fourth edition and the standard for Program Management second edition. The technology vendor, Itron, was responsible for the design, implementation, testing and production ready of the AMI-MDMS program systems. DNV GL managed the PMO, provided industry consulting oversight, guidance, and due diligence reviews.
CHAPTER 3: Community Outreach

Providing real benefits to our customers is the primary motivating factor in GWP’s move to the smart grid. GWP understands that outreach efforts are the key to any successful move to the Smart Grid. As such, GWP developed and funded a wide variety of outreach efforts including the use of ongoing market surveys, creative outreach programs, and traditional outreach methods to engage and educate the customer in the acceptance and use of the new opportunities offered by the Smart Grid. GWP also committed to ensuring that its 22,000 low-income customers participate in the benefits of Smart Grid and plans to develop programs to specifically target this group to ensure that happens. To ensure that others benefits from the project, GWP has consistently documented and shared its results with DOE, CEC, and other interested parties to maximize the benefits are realized by the grant funds provided.

3.1 Customer Communications

GWP engaged in numerous outreach activities during the installation of the smart grid system (Table 8).

Table 8: Community Outreach Activities

<table>
<thead>
<tr>
<th>Name/Medium</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Source (customer newsletter)</td>
<td>Bi-Monthly (customer newsletter)</td>
</tr>
<tr>
<td>City Views (customer newspaper)</td>
<td>Quarterly (customer newspaper)</td>
</tr>
<tr>
<td><a href="http://www.GlendaleWaterandPower.com">www.GlendaleWaterandPower.com</a></td>
<td>18,000 hits per month</td>
</tr>
<tr>
<td>Press Releases</td>
<td>25 over course of campaign</td>
</tr>
<tr>
<td>Glendale News-Press (ads, stories)</td>
<td>Several ads, 107 stories</td>
</tr>
<tr>
<td>GTV6 (City of Glendale’s cable station)</td>
<td>Periodically</td>
</tr>
<tr>
<td>Bill Inserts, Bill Messaging</td>
<td>Periodically</td>
</tr>
<tr>
<td>Community Meetings</td>
<td>5</td>
</tr>
<tr>
<td>&quot;Coffee in the Park&quot;</td>
<td>10 (informal community engagement event)</td>
</tr>
<tr>
<td>Community Events</td>
<td>33</td>
</tr>
<tr>
<td>Smart Grid Form</td>
<td>1</td>
</tr>
</tbody>
</table>
CHAPTER 4:
AMI-MDMS Program – Phase I

Phase I, the AMI-MDMS Program, is at the heart of GWP’s smart grid initiative. By establishing a communications network robust enough to deliver near-instantaneous data on energy use, GWP was able to gain valuable insights that touch all parts of the utility, from billing and customer service, to maintenance (Figure 2).

Figure 2: AMI System Components

Phase I included an initial Proof of Concept phase, to verify objectives and remedy and logistical issues before full-scale deployment.

4.1 Communications Backhaul

GWP is currently installing and upgrading a City-wide wireless mesh network for their AMI project. There are 339 Tropos routers presently installed with additional units planned to fill in low coverage areas. These routers can provide up to 20Mbs of bandwidth depending of the location and distance separating the routers.

The AMI system uses the Tropos routers to connect the Water CCU (Cell Control Unit) and the Electric Cell Relay units to the AMI backhaul network. This enables individual water and electric meters to communicate with the Tropos routers via 900 MHz frequency.

Figure 3 provides an example of a Tropos and CCU installation.
The Tropos routers are configured with 5.8 GHz and 2.4 GHz radios along with a 100Mbs network connection. The routers primarily communicate/mesh via the 2.4 MHz radios but have the ability to utilize the 5.8 MHz frequency as a back-up.

Figure 4 shows AMI mesh network performance. Currently, seven percent of the Tropos routers have the ability to move data at 1Mbs or less. Twenty percent of the routers are running 1 to 2Mbs. Twenty-two percent of the routers are running 2 – 3Mbs. Twenty-five percent of the router are running 3 – 5Mbs. Twenty-seven percent of the routers are running over 5Mbs. The average speed across all 339 Tropos routers is 4.35Mbs down and 4.25Mbps up.

The AMI mesh network has seven VLANs (virtual local area network) assigned to various subnets. Along with dividing the data into different sub-nets, the VLANs themselves can have their data prioritized by using a Tropos QOS (Quality of Service). The Tropos QOS has four levels of service from one to four, one being the highest level. The higher the level of QOS results in a higher priority the data from that particular VLAN receives; an example would be a
Tropos router receiving data from VLAN 502 (AMI) coming in at the same time as data from VLAN 505 (General City). The traffic from VLAN 505 would have to wait until the data from VLAN 502 was transferred. VLAN’s 501 through 507 have the ability to assign 8,190 hosts (computers, devices, etc.).

4.2 Information Technology (IT) Infrastructure Upgrades

As part of the project, GWP supported a number of upgrades to the City information technology infrastructure, including gas fire suppression, a Mitsubishi 125KVA uninterruptible power source (UPS), and redundant A/C systems, and the creation of a new Disaster Recovery site now located at the Utility Operations Center. As designed, the UPS will ensure that the new AMI systems would continue to work even in the event of power failure or natural disaster.

4.3 SAN Storage

Data storage is critical to any new AMI deployment. To support the data storage necessary for the AMI and other smart grid systems, GWP selected the EMC VMAX SAN as the storage unit to collect and retain information for the smart grid system (Figure 5). GWP placed one SAN in the City Server Room and a second SAN at its new DR site. Both SANs have been in production since 2009 to support the storage and databases for all AMI and modernization technology solutions. En Pointe Technologies was chosen as the vendor to manage all of GWP’s AMI computer resources.

Figure 5: EMC VMAX SAN
4.4 Meter Data Management System (MDMS)

Itron Enterprise Edition Meter Data Management is an enterprise-wide data management solution for interval, register and event data for residential and C&I customers. It is a scalable, open-architecture system that manages data from many different collection systems. It also provides secure, accurate, reliable data to a wide array of utility billing and analysis systems.

The Itron EE MDMS has been in operation since April of 2010. GWP initiates two meter integrations a day to collect the hourly electric interval data and register reads. On a nightly basis, the hourly water intervals and register reads are collected. Once collected, the MDMS is able to convert this data into actionable formats that can be used by various departments throughout the utility.

The Itron EE Meter Data Management (MDM) solution provides consistent processes and interfaces regardless of the meter data’s source or destination. This simplified environment significantly reduces the likelihood of errors in the business processes that use meter data. At the same time, Itron EE MDM allows GWP to change how and when data is collected, and allows GWP to deploy the most cost effective meter reading technologies without affecting the billing processes. Now GWP can capitalize on the wealth of meter data to improve access to information used for decision-making and analysis. Some more capabilities of the Itron EE MDM are:

- Send its collected data to the MDM for billing purposes
- Increased quality of data from operating a single, central repository, instead of separate inconsistently managed systems.
- Reduced IT implementation and maintenance costs from improving the interoperability of applications.
- Improved data reliability with consistent and enforceable processes.
- Reduced manual manipulation of data for your largest, most demanding customers.
- Support for simpler, faster, and less expensive rollout of AMR technologies gained by reducing the number of maintained interfaces between collection and billing systems.
- Improved security and accountability through consistent auditing and versioning of all data

4.5 Customer Care

Itron Enterprise Edition Customer Care is a Web-based application tool that presents historical and comparative interval usage and cost data to end-use customers housed in the MDM. Utility customer service representatives can access the most up-to-date information to assist more efficiently customers—service reps view the same data as end-users in near real-time (Figure 6).
The Customer Care application includes the following applications and capabilities:

- **Load Analysis** – provides interval load profiles to better understand usage characteristics
- **Usage Analysis** – allows users to understand power loss, compare usage to prior periods
- **Trending Analysis** – allows GWP to view demand or usage data for one or more meters
- **Energy & Cost Benchmark** – allows GWP to compare facilities side-by-side and identify high energy users
- **Cost Variance** – allows GWP to compare total costs over like periods for one or more meters
- **“What If?” Cost Analysis** – allows customers to see how shifting loads to off-peak hours can effect cost

### 4.6 OpenWay System

OpenWay is the Itron Advanced Metering Infrastructure (AMI) solution (Figure 7). It is a standards-based, open architecture smart metering solution that features two-way wireless communication to state-of-the-art electricity meters at homes and businesses. OpenWay is designed to meet a broad set of customer energy management requirements and can affect every component of a modern Advanced Metering Infrastructure. This can includes smart appliances in a home area networks (HAN) and all the components up to the client’s meter data management (MDM) system. It can provide near-time meter reads and management to the utility company as well as real-time energy communications with smart appliances like thermostats that use ZigBee™ technology.
The OpenWay Collection Engine collects meter data and manages meters through remote, two-way communications using the C12.22 protocol, while most upstream communications is managed through Web services. Collected meter data is passed through the Collection Engine to the utility’s application (such as an MDM system) for storage and manipulation. The OpenWay Collection Engine is not a repository for collected meter data. The retained information relates only to the configuration of registered meters. This stored information includes the identification of the Cell Relay to which the meter reports, the meter's communication path, group assignments and firmware versions.

The core functions of the OpenWay Collection Engine are:

- Meter provisioning and registration
- Interactive read
- Meter interrogation
- Firmware download
- Configuration and Time of Use (TOU) download
- Event and alert notifications
- Meter disconnects and reconnects
- Home Area Network (HAN) communication

### 4.7 SaveSource System

SaveSource is an Itron Advanced Metering Infrastructure solution for water utilities, a collection engine that reads data from endpoints attached to water meters, both residential and commercial (Figure 8). The SaveSource Collection Engine collects meter data, both consumption
and interval, on a regular basis from its CCUs. It will store up to 40 days of information, and compare how usage varies over time, as well as retrieving the most recent read and/or older read data. Nevertheless, the MDM system remains the repository for long-term data storage.

Figure 8: SaveSource Collection Engine

The core functions of the SaveSource Collection Engine are:

- Collect endpoint consumption and interval data reads through its CCUs
- Process on demand read
- Issue a variety of endpoint and CCU reports (alarms, leaks, tampers, etc.) based on its analysis of the received data
- Send its collected consumption and interval data reads to the MDM for billing purposes.
- Forward leak data collected from installed leak sensors to MlogOnline.

4.8 Smart Meter Installation

GWP intended to hire one company to provide a turnkey solution that included the MDMS, meters, and meter installation. Given California’s contracting laws, that was not possible. This required GWP to coordinate installation activities between GWP employees, Itron personnel, and UPA installation personnel. The complexity of the process called for a detailed number of documents to ensure everyone knew what they jobs were. The first step installation called for the development of a comprehensive Scope of Work and list of Project Assumptions for the installation contractor. This was followed by the development of responsibility matrixes that were agreed to be all three parties as part of the contracting processes, including Project Management, Work Order Management Tools, Meter and Module Deployment Services, Material Matrix, and Meter and Route Acceptance. Finally, the team worked together to develop an Inventory Control Program, Installation Quality Program, Inventory Tracking and Resolution Program.
4.8.1 Scope of Work
The scope of work for this installation services project included the following tasks:

- Schedule installation appointments with customers after notification by GWP Customer Service Department.
- Install and test approximately 1000 electric AMI endpoints, 500 water AMI endpoints, 100 MLOG devices, 5 OpenWay electric cell relays, 5 water meter collectors and up to 300 HAN devices for Proof of Concept phase.
- Install approximately 88,000 new Itron AMI equipped electric meters. Install approximately 150 collectors for electric meters.
- Install approximately 30,000 new Badger water meters with Itron endpoints, retrofit approximately 3,000 Badger meters with ADE encoder and AMI node. Install approximately 50 collectors for water meters.
- Install MLOG leak detection units at approximately 5,800 Itron specified locations.
- Install power and network connections to the collectors for water and cell relays for electric.
- Install up to 300 Home Area Network (HAN) devices at premise sites specified by GWP.
- Install Tropos Wi-Fi Network equipment at GWP designated and specified sites.
- Collect site-specific information at the time of install for GWP. Information to be collected will be provided by GWP ahead of start of project and will include GPS coordinates.
- GWP will provide written procedures for reporting theft of service, damaged meters, or unsafe conditions.
- Provide details of issues found on City side of meters to GWP for review. GWP will review on a case-by-case basis and may allow Installation Contractor to make repairs.
- Return defective equipment and removed electric and water meters to GWP.
- Report problems and furnish reports (in Itron/GWP required format).
- Assign one Project Manager to be main contact for the duration of the contract. Responsibilities will include conveying GWP’s needs and expectations to the Installation Contractor’s staff and monitor the installation schedule to ensure timely installation and testing of all meters.

4.8.2 OpenWay CENTRON Meters
The GWP system is 100% OpenWay CENTRON (Figure 9). OpenWay CENTRON meters feature open-standards architecture, modular design for flexibility in communications, and extensive features and functionality, the OpenWay CENTRON supports the most demanding smart grid business requirements today and well into the future.
A key component of any advanced metering or smart grid initiative, the OpenWay CENTRON meter is a truly smart device used to collect, process and transmit vital energy information to utility systems. Rather than simply inserting a network communication card into a standard meter, Itron developed an advanced meter where calculations and usage data are calculated within the meter itself, allowing utilities to leverage time based rates, demand response, home networking and many other smart grid applications.

Specifically, the OpenWay CENTRON has the following features:

- **Time-of-Use and Critical Peak Pricing**
  - The OpenWay CENTRON supports four TOU rates as well as CPP
  - TOU registers may be displayed on the meter’s display

- **Load Profile**
  - Four channels of configurable load profile data are available in the following default parameters: (1) single channel 30-minute data 753 days; (2) two channels 30-minute data 501 days
  - Modified parameters are available via configuration download
  - The OpenWay CENTRON module provides over one year of 15-minute load profile data storage

**OpenWay RFLAN Module**

- Two-way, unlicensed RF module

- Adaptive-tree RFLAN architecture provides easy installation and self-healing capabilities

**Home Area Network (HAN)**

- Every OpenWay CENTRON meter includes a ZigBee radio for interfacing with the HAN, in-home displays and load control devices
Bi-Directional Metering

- The OpenWay CENTRON measures and displays active energy (kWh) delivered, received, unidirectional and/or net or apparent energy (kVAh) delivered and/or received

Disconnect/Reconnect with Load Limiting

- The OpenWay CENTRON forms 1S, 2S, 12S network, and 25S is available with a 200 amp remote disconnect/reconnect switch as an optional feature. The switch can be operated on demand, or automatically as part of a service-limiting configuration

Tamper Detection

- Tamper indications can be communicated regularly through the OpenWay system
- Tampers include: inversion, removal and reverse power flow
- SiteScan Diagnostics (advanced polyphase register only)

Non-Volatile Memory

- All programming, register, TOU, and load profile data are stored in the EEPROM during a power outage. A battery maintains just the clock circuitry during a power outage

Voltage Monitoring

- Instantaneous voltage
- Voltage monitoring system

Standard Features

- Electronic LCD display
- Polycarbonate cover
- Optical tower
- Test LED

Register Capabilities

- 4 energies, 1 demand:
  - Wh (delivered, received, net, unidirectional)
  - VAh (delivered arithmetic, received arithmetic, Lag)
  - W (max delivered, max received, max net, max unidirectional)
- Configurable event log
- All programming, register, TOU, and load profile data are stored in the EEPROM during a power outage. Battery maintains the clock circuitry during a power outage
Option Availability

- Identification/accounting aids
- Remote disconnect/reconnect
- Multiple WAN options including GPRS and CDMA
- Option slot for additional communications options

Meets applicable standards:

- ANSI C12.20 - 2002 for Hardware 2.0 and 3.0 (American National Standard for Electricity Meters - 0.2 and 0.5 Accuracy Classes)
- ANSI C12.20 - 2010 for Hardware 3.1 (American National Standard for Electricity Meters - 0.2 and 0.5 Accuracy Classes)
- ANSI C12.22 - 2008 (consult Section 9 of the standard)
- ANSI/IEEE C62.41.2-2002 (Characterization of surges on Low-Voltage AC Power Circuits)
- IEC 61000-4-2
- IEC 61000-4-4
CHAPTER 5:
Customer Directed Programs – PHASE II

GWP realized early on that to realize the full benefits of a smart-grid system, it needed “smart” customers. Education and outreach played an important role to the success of the program. Though the initial scope of the program called for more projects, due to the budgetary adjustments made, the following represent the programs undertaken:

5.1 CEIVA In-Home Displays (IHDs)

GWP began by inviting 132 homes to participate in a program that would install in-home devices (IHDs), manufactured by CEIVA. The IHDs work on a customer’s existing internet connection, via Wi-Fi or Ethernet, and communicate with the digital meters (Figure 10). The devices then display information like energy consumption, notifications of peak events, and tips for conservation and reduction in energy costs. All of this data is displayed along with personal photos of the customer’s family. Though still in pilot-phase, the IHDs have already shown tremendous promise, and the pilot will be expanded to 500 residents in FY 2014-2015.

The expanded pilot program would add smart thermostats for additional customer energy savings, as well as remote provisioning and web portal software. Integrating smart thermostats with the digital frames and remote provisioning and web portal software will provide customers the added capability to:

- Remotely adjust set points, monitor temperature, and control system status
- Manage thermostat schedules remotely via web and mobile applications
- Automatically respond to demand response events
- Receive customized energy conservation tips and notifications via digital frame
- Provide GWP with the capability to call Demand Response (DR) events during critical periods thus reducing system load.
CEIVA Homeview bridges the Smart Meter’s SEP network with the customer’s Wi-Fi network. This bridge gives GWP customers the flexibility to monitor their home from mobile apps, control Smart Thermostats/Smart Plugs, and take advantage of CEIVA’s picture sharing service. CEIVA Homeview also gives GWP a new and effective way of engaging with their customers. Whether it is conservation and community messages delivered among customer’s personal photos or the real-time view into electricity demand, GWP is empowering customer in ways never before possible.

The first step towards helping customers manage their use of resources is giving them the information to do so. The CEIVA Homeview delivers information directly into customers’ lives – in a place that already has their attention. A customer that glances at a wedding photo and sees a GWP conservation tips show up may end up changing their thermostat or adjusting their irrigation.

Initial energy savings from the program is anecdotally impressive. The “real-time plus feedback” energy data approach has been shown to reduce energy consumption by up to 12% by American Council for an Energy- Efficient Economy and this program anticipates supporting energy reductions around this level. GWP is currently awaiting specific energy and water reduction results from the program, which it can share later. The program is poised for widespread expansion in the coming months.

In the first four months of 2013, GWP saw impressive feedback from program participants via customer surveys and additional feedback, including:

- Participant knowledge of electricity use jumped nine-fold.
- 95% of participants reported that installing the Homeview was easy.
- 90% stayed in the program—an impressive program retention rate.
• 88% reported liking Homeview messaging.
• 83% experimented with their home energy use after installing Homeview, revealing that targeted information directly drives behavior change and energy reduction.

One GWP customer commented, “I learned that the space heater in the bedroom is an energy hog. I won’t be using it next year.” Another customer added, “I really love the frame; it is an elegant device. It is nice to have something that looks good, and I really like having my photos.”

Customers enjoy and actively engage with the CEIVA Homeview frame, which delivers personal, instantaneous information to help them reduce energy cost and use. Even more important to many consumers, Homeview delivers personal photos sent via the cloud from anywhere in the world – phones, digital cameras, Facebook, Instagram, etc. The photos, energy data, and messages are all accessible via a “glanceable” display that has already been successfully commercialized as a picture frame.

Lastly, GWP has the ability to communicate targeted conservation and community messages directly to the community. In addition to helping GWP fulfill municipal requirements, these messages build awareness and good will towards the utility and its community involvement.

Like all utilities, GWP has faced ongoing budget challenges and has to meet set energy efficiency targets of 1.0 percent of annual retail sales. This initial deployment demonstrates a compelling opportunity to reduce energy costs via demand-side management and efficiency initiatives that can reduce expenses while improving customer relations. CEIVA provides a way for utilities to capitalize on their Smart Meter deployments in a way that gives back to the customer. The GWP program with CEIVA serves as an example to other utilities of a scalable solution that can help meet proliferating efficiency mandates, reduce costs, implement demand-side management, and engage customers.

The expanded pilot program would add smart thermostats for additional customer energy savings, as well as remote provisioning and web portal software. Integrating smart thermostats with the digital frames and remote provisioning and web portal software will provide customers the added capability to:

• Remotely adjust set points, monitor temperature, and control system status
• Manage thermostat schedules remotely via web and mobile applications
• Automatically respond to demand response events
• Receive customized energy conservation tips and notifications via digital frame
• Provide GWP with the capability to call Demand Response (DR) events during critical periods thus reducing system load.
• Improve efficiency and conservation, provide device/appliance management for continuous improvement on energy management and energy decisions, tools to pay their bills and report an outage. By modernizing customer engagement through this type of technology, GWP will be at a competitive advantage within the utility market.
5.2 OPOWER Web Portal

GWP began providing home energy reports via OPOWER in 2009 (Figure 11). Initially, this program provided customers with bi-monthly billing comparisons to like households. With the introduction of the smart grid, GWP saw an opportunity to complement the program to include the customer access to hourly, weekly, and monthly data through a new web portal. The new web portal allows GWP customers to access information about their usage, forecast unusually high bills based on consumption and react appropriately. Reports include actionable steps for each household to help them reduce their electricity consumption. The program integrates billing data and a wealth of external data sources to educate customers on how they can save energy. Customers also have access to the GWP - OPOWER website where they can review their energy usage and learn more about ways to save energy.

Figure 11: OPOWER Web Portal

5.3 Unusual Usage Alerts

GWP and OPOWER have partnered to launch Unusual Usage Alerts (UUAs) to all GWP customers that sign up for the service. UUAs are designed to help customers to save energy and money when they are likely to consume more energy than usual for a billing period. Before the end of a billing period, UUAs inform customers that they are likely to have high-energy use, and they provide insights to help customers reduce their consumption before the billing period ends.
5.4 SmartRate Engine

GWP and OPOWER have partnered to launch a rates engine that will allow GWP customers to perform a "what if?" analysis to better determine which rate is best for the customer.

5.5 Behavioral Demand Response

GWP partnered with OPOWER again to design a behavioral demand response program. Using pre- and post-event messaging, the goal of the program is to motivate customers to adjust usage during peak events, translating to less stress on the system, and lower bills for the customer.

The idea behind a behavioral response is that it relies on customer behavior rather than complex rate systems or additional devices.

This program began with a pilot of 40,000 people in the summer of 2014. After three events, the following benefits were realized:

- OPOWER analytics team found statistically significant savings (on peak and off peak) for the period of 8/27 - 10/9, yielding 10 kWh saved per HH for a total of 392,000 kWh of EE
- BDR TRC of 6.7 for summer 2014 program
- BDR still cost effective at list price of $4.50 per HH
- 85% satisfaction from participants that recalled receiving BDR communications

5.6 Thermal Energy Storage

The thermal ice storage program was facilitated through an ice energy contract with the Southern California Public Power Authority (SCPPA). The project installed Ice Bear units on city facilities throughout the GWP service area. The units store energy at night (off-peak hours, when energy is cheaper) through the production of ice, and deliver that energy during peak hours to cool a building through its air conditioner. The pilot phase saw the installation of 28 units. Full deployment calls for installing 254 units with162 already installed.

The Ice Bear unit shifts the energy and demand of a package commercial air conditioning unit (“Package Unit”) from on-peak to off-peak times for at least six hours daily (Figure 12). Expected operations are ten hours of off-peak storage and six hours of on-peak discharge. The Ice Bear unit shuts off the electrical energy supply to the Package Unit’s compressor, which is an inductive motor load, when scheduled to do so by the utility and automatically dispatches an equivalent amount of stored cooling energy from the Ice Bear unit. Permanent Load Shifting (PLS) can provide a substantial benefit to the California electric grid by transferring load from congested peak times to over-generating off-peak times. PLS is supplied in the Service Territory by Ice Energy locating qualifying buildings, obtaining licenses from the building owners granting Ice Energy permission to install and operate Ice Bear units, installing the units in accordance with standard HVAC practices and all permits, and selling the units to GWP as each is commissioned. The 1.2 MW is an aggregated summation of the PLS capacity of installed individual Ice Bear units.
Ice Bears do not use any new science or unproven technology. They are based on robust, thoroughly understood direct-expansion AC technology, because they are required to be proven and no-risk for customers. Ice Bear has a special design and engineering that delivers the most efficient distributed energy storage at the lowest cost and with extraordinary reliability.

The operation of Ice Bears will have well-defined environmental benefits. First, reductions in peak loads will allow lower operation of GWP’s peaking generators during high temperature periods, typically in the summer. For example, operating 10 MW of storage from this project is expected to reduce local peak power generation by over 2,520 MWh annually. This will reduce NOx, Particulate, and CO2 emissions by 932 lbs., 335 lbs., and 1,103 metric tons per year, and 10.4, 3.7, and 27,594 metric ton over the life of the proposed project (Table 9). Additionally, the proposed project includes replacing older air-conditioning technologies with new, high-efficiency units that would use R410A instead of R22 refrigerant, which will provide significant additional environmental benefits.

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Peak MWH Reduced</th>
<th>Emissions Factor per MWH</th>
<th>Annual Emissions Reduction</th>
<th>Life of Project Emissions Reduction</th>
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</thead>
<tbody>
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<td>2520</td>
<td>0.370</td>
<td>932.4 lbs</td>
<td>10.4 MT</td>
</tr>
<tr>
<td>Particulates</td>
<td>2520</td>
<td>0.133</td>
<td>335.2 lbs</td>
<td>3.7 MT</td>
</tr>
<tr>
<td>CO2</td>
<td>2520</td>
<td>0.438</td>
<td>1,103.8 MT</td>
<td>27,594.0 MT</td>
</tr>
</tbody>
</table>

The City of Glendale has a peak demand of just over 300 MW. Typically, one third of a utility’s peak demand is attributable to the package air conditioning units for which the Ice Bear was
designed. The team did a full survey of every commercial building, which confirmed more than 100 MWs of peak-demand could be reduced by Ice Bear projects. From start to finish, a MW scale deployment was completed in Glendale in six months.

Ice Energy first contracts and trains local agents to conduct site surveys and sign-up building owners. This process goes quickly: owners are generally easy to sign-up, because they receive, free of charge an Ice Bear, which lowers their utility bill, and often a new air-conditioner as well as part of the Ice Bear installation.

In parallel, Ice Energy partners with and trains local HVAC contractors, who perform the installation work as sites are identified and building owners signed up.

Ice Energy has capacity to manufacture 10MW per month of Ice Bears, and a city such as Glendale typically has HVAC contractors sufficient to install 3-5MW per month.

Ice Bears bring together diverse value streams from across the grid, such as:

- Adding peak capacity to the grid
- Reducing or eliminating the need for feeder and other distribution system upgrades
- Improving grid reliability
- Backing intermittent resources such as wind and solar
- Reducing transmission-system line losses and load factor
- Reducing customer electricity bills
- As most of these values are primarily captured by utilities, Ice Bears are sold or contracted to the utilities that can then pass on the value to their customers.

5.7 Electric Vehicles Customer Incentive and Information

5.7.1 Market Research

In April 2011, PA Consulting and GWP concluded market research, which suggests that there is significant commercial and residential customer interest in purchasing or leasing electric vehicles (EV). PA conducted research on, and/or interviews with 15 utilities and two charging station providers to gather information on the EV landscape in the US. PA also interviewed City of Glendale personnel, potential charging station location managers such as the Galleria Mall, and fleet operators such as Disney Corp. PA developed a financial model to evaluate six scenarios that included various EV strategies that GWP could consider. The modeling framework took into account various cost structures, rate assumptions, demand levels, and customer behavior possibilities, and calculated a Net Present Value (NPV) estimate for each scenario. Demand is expected to grow after 2015 and in California at twice the national rate.

PA Consulting anticipates 1,405 EVs by 2015, 3,805 in 2018, and 6,025 by 2020 excluding transient demand in GWP’s service territory. The spike in EV sales is expected to occur in the 2018-2020 timeframe. EV charging is expected to have limited impact on GWP’s load. In 2020, PA expects that the total impact on energy demand attributed to EV charging will be roughly 16.31GWh. This is roughly 1.4% of GWP’s total forecasted energy demand of 1,200GWh in 2020.
While all scenarios considered represent a positive NPV ranging from $210,000 to $6.71 Million, the business case for pursuing various EV strategies is driven by value gained from understanding customer behavior, rate structure elasticity, and the value gained by being seen as a supporter of EVs in the community.

5.7.2 Customer EV Incentive Program

GWP is currently offering an EV charging station rebate of $200 to the first 100 residents of single-family homes who purchase an electric vehicle and install a Type II charging station. Currently, 60 customers have participated in this program. GWP’s online materials are being updated to reflect new information about the EV program, including charger installation rebates, publicly accessible charging station locations, and other relevant information.

5.8 Smart Customer Mobile and Portal Platform

In 2014, GWP worked with SUS to develop and pilot the product for up to 2,000 residential customers. The pilot focused on a testing hosted customer-facing app built on an expandable platform that could support additional utility specific business intelligence applications. That pilot was very successful. Since December 2014, over 1,800 residential customers have downloaded and are using the app to pay bills, access electric and water usage, etc., and that number has been growing by an average 150 customers per month.

The SUS Smart Customer Mobile and Portal Platform is a complete customer engagement platform that offers multiple configurable modules and provides customers the ability to manage their energy use, secure bill pay, set individualized budget goals with alerting features (email, push, & text), make service requests, and receive outage notifications and more (Figure 13).
Table 9 - GWP Smart Customer Mobile and Portal Platform Modules

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
<th>Success Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>My Account</td>
<td>View service account contact information, addresses, rate plan, &amp; EV. Ability to update email and phone and add/modify/delete credit card/bank info for processing of payment information and functions through the GWP e-Care Payment site. Modify settings specific to email and budget notifications, rate plan (residential and electric vehicle rates).</td>
<td>Customers are provided account maintenance information that is unique to them.</td>
</tr>
<tr>
<td>Billing</td>
<td>View current monthly charges for power, water, sewage, trash, usage view and modify budget my bill, Ability to pay bill via credit card/bank (functionality will be provided through the GWP eCare Payment site), View history of prior Power monthly bill</td>
<td>Customers are provided access to the GWP eCare Payment system through a secure login process.</td>
</tr>
<tr>
<td>Function</td>
<td>Description</td>
<td>Success Criteria</td>
</tr>
<tr>
<td>----------</td>
<td>-------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Usage</td>
<td>View usage information in kWh/$$$ for hourly, daily, and monthly intervals for Power and Water, view solar generation as applicable</td>
<td>Customers are provided real-time usage information that is unique to them.</td>
</tr>
<tr>
<td>Service Request</td>
<td>Submit requests for services based on service type (i.e. On/Off/Transfer, Meter Accuracy Test, HAN Service, EV Service, etc.).</td>
<td>Customers are enabled to provide GWP real-time service request information that is unique to them.</td>
</tr>
<tr>
<td>Connect Me</td>
<td>Access GWP social media sites (Facebook &amp; Twitter) as well as GWP provided contact information (phone, email).</td>
<td>Customers are provided access to GWP social media sites, and access to GWP contact information.</td>
</tr>
<tr>
<td>Notifications</td>
<td>View service related notifications, view safety, billing, outage push notification from GWP</td>
<td>Customers are provided real-time notification information that is unique to them.</td>
</tr>
<tr>
<td>Electric Vehicle</td>
<td>View charging information related to rate plan, daily charging usage, time of day pricing information related to charging, and public charging station locator.</td>
<td>Customers are provided rate plan, daily charging usage, time of day pricing, and public charging station location information that is unique to them.</td>
</tr>
</tbody>
</table>

### 5.9 Water Insight

GWP is conducting a pilot of WaterSmart’s WaterInsight Program. The pilot offers personalized Home Water Reports and access to an interactive web portal with an AMI interface. The goal is to educate and engage 17,000 residential customers on their water use while reducing water consumption. There are three components to the program: 1) Utility Analytics Dashboard, 2) Customer Online Portal, and 3) Home Water Reports. WaterSmart and GWP began working on program implementation in June 2014.

The primary water conservation and engagement element of this program is the personalized, bi-monthly Home Water Report, which provides customers with their water use in gallons per day. The report also includes a WaterScore, which compares residents’ water consumption with other households with similar characteristics. The web and mobile Customer Portal provides an in-depth understanding of household water use. The resident can understand where the water use is highest (irrigation versus indoor use) and then breaks down the indoor use by appliances.

The water consumption data is detailed hourly, which allows GWP and residents detect leaks. The program also includes e-mail leak alerts to notify customers of possible leaks. WaterSmart’s customer-engagement platform includes paper and electronic Home Water Reports, a Consumer WebPortal for residents, and a Water Efficiency Dashboard for utility Staff. The City of Glendale program would include:

**Home Water Reports**

- Monthly emailed home water reports for customers
- Quarterly paper reports mailed to customers without email address on file
- Reports would include personalized water consumption and score
- Reports would include social “neighbor” comparisons and targeted recommendations and promotions
Water Insight Web Portal Available to GWP Water Utility Customers

- “Neighbor” comparisons
- Actual water use and historical trend analysis
- Pie chart illustrating estimated water usage in different areas of home.
- Targeted recommendations, alerts, and personalized “My Action Plan”

Utility Water Efficiency Dashboard for GWP

- Customer relationship management
- Business intelligence and reporting functions
- Program management
- Water use analysis
- Feedback and tracking
- Spatial analysis
- Leak and high use alerts

GWP and WaterSmart are pioneering behavioral science in the water industry. Improved water-use efficiency from the WaterInsight engagement program reduces GWP’s costs for marginal water supplies, electricity, and treatment chemicals. The program’s conservation gains will extend asset lifetimes and reduce future capital expenditures through downsized storage and treatment requirements.

The program benefits the environment, the utility, and the residents of Glendale. By reducing residential water demand, the need for future capital expenditures is delayed; less fossil fuel is consumed to pump, transport, and treat water; and residents will save money on their water bills. Moreover, the disaggregated water-use information, which shows estimated consumption by various appliances/activities, allows residents to make more informed decisions about their water use. Finally, the program provides a tool that, if continued and expanded, can help GWP meet the state-mandated 20% per capita urban water use reduction by the end of 2020.

Currently, the GWP program has directly benefited 2,715 people who have registered to have access to their online Customer Portal to learn more about their water use and ways to save both water and money.

To date, about 8,227 customers have received email alerts about possible leaks equating to over 9.3 million gallons of water. More than 10 percent of Glendale’s customers indicated, through the WaterInsight portal, that they have investigated those leaks, which cumulatively showed more than 1.3 million gallons of lost water.

Reductions in water use have already been observed. In the first seven months of implementing the program customer saved an estimated 48,082 HCF, which is about three percent of our five percent projected reduction. It is too early in the program to conclude that 5% reduction will be achieved. A statistically significant efficiency study will be conducted in several months to
verify the final savings volumes. Within the next three months, GWP anticipates to meet and/or exceed the typical 5% water reduction results because the programs is proceeding as it has in other municipal water utilities.
CHAPTER 6:
Distribution Automation – Phase III

By introducing distribution automation (DA), GWP sought to decrease the frequency and length of outages throughout its service area. The value of such capabilities is clear; there is less energy wasted, increased customer satisfaction, and increased ability to manage load and voltage throughout the system. Further, by automating these processes, there are decreases in costs associated with substation management and capital expenses for feeders and substations.

6.1 Enterprise Computer Systems Project

GWP is implementing Smart Grid technology and processes which will significantly transform the utility and its personnel and have a tremendously positive impact on customer satisfaction and utility operations. Within the next 3 to 5 years, GWP will implement a new Advanced Metering Infrastructure (AMI), distribution monitoring and control systems for power and water, enterprise data management systems and a significant capability to interact with its water and power customers. This Smart Grid Architecture is an overall guide for the acquisition and implementation of these systems and data designed to which will ensure GWP has a consistent, secure, and reliable set of technologies and interactions that will make information available when and how it is needed by GWP systems, employees, consumers, and stakeholders.

To refine its project plan, GWP hired UISOL to prepare a multi-year Smart Grid Architecture plan. Using the Smart Grid Maturity Model, as well as other strategic plans and information GWP established goals and objectives for each of the domains identified in the GWP conceptual model.

6.1.1 Smart Grid Maturity Model (SGMM)

The Smart Grid Maturity Model (SGMM) developed by IBM and managed by the Carnegie Mellon Software Engineering Institute (SEI) provides a framework for understanding the current state of smart grid deployment and capability within an electric utility and provides a context for establishing future strategies and work plans as they pertain to smart grid implementations. It is composed of eight model domains, or groups, with six defined levels of maturity, ranging from Level 0 (lowest) to Level 5. Groups are logical groupings of eight smart grid related capabilities and characteristics:

1. Strategy, Management, and Regulatory (SMR)
2. Organization and Structure (OS)
3. Grid Operations (GO)
4. Work and Asset Management (WAM)
5. Technology (TECH)
6. Customer (CUST)
7. Value Chain Integration (VCI)
8. Societal and Environmental (SE)

While the SGMM is initially intended for electric utilities, GWP used the model to define current state, goals and objectives for both water and power services and identified the GWPs current operations and what GWP plans to achieve in three years and five years. GWP is identifying owners for each of these groups and assembling teams to manage the transition from current organization to the three and five year goals. GWP aligned the SGMM groups to respective GWP departments shown in Table 10. For simplification purposes, the GWP Smart Grid Architecture will be based on adapted NIST domains that align with the SGMM groups are:

<table>
<thead>
<tr>
<th>Groups</th>
<th>NIST Domain(s)</th>
<th>GWP and City Department(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy, Management and Regulatory (SMR)</td>
<td>N/A</td>
<td>Office of GM</td>
</tr>
<tr>
<td>Organization and Structure (OS)</td>
<td>N/A</td>
<td>Office of GM</td>
</tr>
<tr>
<td>Grid Operations (GO)</td>
<td>Electric Operations</td>
<td>Electric Services Division</td>
</tr>
<tr>
<td></td>
<td>Electric Distribution</td>
<td>Water Services Division</td>
</tr>
<tr>
<td></td>
<td>Water Operations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water Distribution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water Supply</td>
<td></td>
</tr>
<tr>
<td>Work and Asset Management (WAM)</td>
<td>Electric Distribution</td>
<td>Electric Services Division</td>
</tr>
<tr>
<td></td>
<td>Water Distribution</td>
<td>Water Services Division</td>
</tr>
<tr>
<td>Technology (TECH)</td>
<td>Data flows between domains and information systems within domains</td>
<td>City ISD and GWP IS</td>
</tr>
<tr>
<td>Customer (CUST)</td>
<td>Customer Service</td>
<td>Customer Support &amp; Service</td>
</tr>
<tr>
<td>Value Chain Integration (VCI)</td>
<td>Electric Market</td>
<td>Sources of Power</td>
</tr>
<tr>
<td>Societal and Environmental (SE)</td>
<td>N/A</td>
<td>Sources of Power</td>
</tr>
</tbody>
</table>

Table 11 lists the goals and objectives of each group were derived from the SGMM model and served as a basis for discussion during the Smart Grid Domain workshops that are elaborated in the next section.
Building on the SGMM, as well as other strategic plans and information, goals and objectives are established for each of the domains identified in the GWP conceptual model.

6.1.1.1 Technology Domain

The following are goals & objectives for the Technology domain as derived from the series of workshops focused on Information Services:

**AMI/MDMS**

- **Meter Data** – AMI and MDMS are implemented for all GWP meters and providing data to the GWP enterprise and customers with an accuracy, availability and reliability suitable required by the users. (NOTE: The specific performance levels, organization, and tools to meet these performance levels are not being discussed).

- **Infrastructure** – The AMI and MDMS infrastructure is supporting all GWP initiatives, including outage support, electric vehicles, distribution sensors (both electric and water).

- **Infrastructure** – The AMI and MDMS infrastructure is providing communication and control to electric customers through HAN, demand response and remote disconnect of service.

- **Security** – The AMI and MDMS infrastructure and data are operating without unauthorized access or security breaches.

- **Data** – The AMI and MDMS data and interfaces conform to GWP standards for data modeling and transmission.

- **Data** – The MDMS is the source of power and water consumption data for all GWP service points, including unmetered and non-billing services.
ESB/Data Modeling

- **Infrastructure** – A Federated ESB, consisting of multiple ESB domains working together to form a single logical ESB, is in place serving water and electric operations and centralized services.

- **Application** – Real-time data transfers and data access is in place for all systems and business processes, as needed to meet the business needs.

- **Security** – All information systems are integrated to the ESB with data access governed by common security policy.

- **Data** – A Data Model based on industry standards is implemented across GWP applications and used as a requirement for future system acquisitions.

- **Governance** – A centralized Data Architecture Group evaluates all new integrations and systems to ensure consistent application of standardized architecture, integration, and data governance.

Data Center Operations, LAN/WAN, and Communications

- **Infrastructure** – GWP data centers use a common information architecture with a centralized approach to monitoring and maintenance (24x7 with appropriate uptime metrics) of the network and systems.

- **Security** – A disaster recovery and business continuity plan covers all critical, and future, information system and is regularly updated and tested.

- **Infrastructure** – The Citywide communications network is in place with 24x7 monitoring and maintenance. This network is appropriately segmented to ensure each user is receiving the appropriate QoS and security as necessary for the business operations.

- **Security** – A common Active Directory and Identify Management capability is utilized by all enterprise systems for user management.

- **Service Delivery** – IT responsiveness and service meets or exceeds customer operations requirements

Security

- **Security** – A comprehensive security policy and procedures based on industry standards is maintained and utilized throughout the organization.
- **Security** – An information asset classification program is in place and regularly maintained.

- **Security** – Information security controls conform to applicable NIST standards, as well as applicable regulations such as PCI, GLBA, and California SB 1386.

- **Security** – Policies and procedures are meeting all goals enumerated in the GWP Cyber Security Plan, as submitted to the DOE.

- **Security** – A comprehensive strategy for addressing security issues across the enterprise is maintained and includes provisions for:
  - Identification and authentication of all entities
  - Authorization and access control
  - Confidentiality and integrity protection of data at-rest and in-motion
  - Privacy protection of all data
  - Traceability and non-repudiation
  - Auditing and logging

6.1.1.2 Electric Operations and Electric Distribution Domains

The following are goals & objectives for the Electric Operations and Distribution domains derived from the series of workshops focused on Electric Services:

**Electric Operations & Planning**

- Smart grid information (AMI, sensors, outage, etc.) is captured, validated, and available across most functions and systems. This Smart Grid information is used in strategic planning.

- Operational mix of Smart grid monitoring and control systems (DMS, OMS, Historian and Load Analysis) is deployed and has improved decision making across most or all line-of-businesses.
  - Many analytics-based decisions are being automatically executed to support decision making within protection schemes
  - Distribution Automation, based on an initial DA pilot project, is rolling out to all circuits and the data is being utilized for load modeling
- Historical system model and state easily accessible and readily available for analysis outside of operations

- Smart grid data has provided support for impact studies on Electric Vehicles, Distributed Energy Resources, and Demand Response.
  - Electric Operations supports EV, DER and DR as part of normal operations

- System planning and transformer load management is fully integrated with AMI systems and GIS for fact-based operations planning and optimization.

- Grid data is being used to support physical and cyber security through situational awareness and diagnostic activities comprehensively across grid.

- Safety programs and training are in place, with ongoing enhancement, accounting for the new technology and automation.

- New customer service delivery is typically accomplished within two days.

**Workforce and Asset Management**

- The majority of the types of field assets are fully monitored or routinely inspected and managed to reduce unnecessary maintenance, downtime, and customer impact.

- Failure of smart grid assets are detected in advance of actual failure and, when failures occur, the cause of failure and the corrective actions are fully captured and analyzed.

- Workforce is deployed efficiently and the latency between problem identification and problem resolution is reduced through automation that identifies probable failure location and automatic workforce notification.

- SAIFI (< 1.0), SAIDI (< 20 minutes), and CAIDI (< 20 minutes) metrics are routinely reviewed so that monitoring and maintenance programs can be modified periodically to address any measured change based upon root cause analysis.

**6.1.1.3 Water Supply, Water Distribution, and Water Operations Domains**

The following are goals & objectives for the Water Supply, Operations, and Distribution domains derived from the series of workshops focused on Water Services:

**Water Operations**

- Automation (AMI) of all water meters is completed and data is fully integrated with operational and planning systems.
• New water SCADA system is operational and fully integrated with GIS, AMI and water operational systems.
  
  o Tropos wireless network is expanded with water distribution and monitoring points.
  
  o Electric metering deployed at all pumping stations

• Enterprise GIS complete and maintained with CityWorks module fully operational.

• Integrated systems provide enterprise data to field and engineering resources for more efficient operations.

• Distribution losses (M-LOG) and usage management (Aquadapt and Demand Response) are minimizing costs.

• Customer conservation plans and new rates (TOU, tiers, etc.) are enabled as business needs dictate.

**Workforce and Asset Management**

• All field assets are fully monitored and managed to reduce unnecessary maintenance, downtime, and customer impact.

• Failure of smart grid assets are detected in advance of actual failure and, when failures occur, the cause of failure and the corrective actions are fully captured and analyzed.

• Workforce is deployed efficiently and the latency between problem identification and problem resolution is reduced.

**6.1.1.4 Electric Market Domain**

The following are goals & objectives for the Electric Market domains derived from the series of workshops focused on Energy Supply:

**Energy Procurement**

• Electric usage (based on 2009 levels) is reduced by 7% and rates are 35% below SCE.

• GWP’s energy portfolio is balanced with renewables, customer generation (DER, PV, etc.) and demand response programs.

• Load forecasts are accurate and reliable based on integrated information from Electric Operations and Distribution.
• Automation and systems have eliminated manual workarounds and activities in the energy procurement processes.

6.1.1.5 Customer Services Domain
The following are goals & objectives for the Customer Service domains derived from the series of workshops focused on Customer Support:

Customer Support and Web Presentment
• All GWP customers are enabled with AMI and provided with energy and water consumption information. Customer self-service is available to any GWP customer at any time of day.
  o Customer leaks and other service issues are automatically brought to the customer attention through several communication media.
• GWP web presence uses available utility information and a Web 2.0 (social networking) framework.
• GWP personnel utilize the AMI for remote connection and disconnection of service and the real-time access to meter data for verification of billing and power.
• GWP customer service personnel are able to fully answer customer questions or concerns through integrated access to operational and historical information. This includes notification of outage and restoration information.
• Customers are consistently and quickly notified of power and water issues and other activities using multiple communications media (web, IVR, text, etc.).

Billing and Revenue Protection
• Inaccurate and estimated bills are reduced to less than 1% of total.
• Revenue losses (estimated at 6% in 2010) are reduced and collectibles from diversion or unauthorized usage are increased by use of Smart Grid data.
• New and dynamic rates are available to customers as regulatory and business environments call for these. Customers can easily and quickly understand and change to new rates.

Demand Response and Marketing
• Residential and Commercial customers have multiple demand response and pricing options that allow participation in various programs. Customer participation in these programs is equal to, or above, regional averages.
Customers with EV and DER can easily enable these devices on GWP’s system and acquire services from GWP.

GWP is able to assess and rollout new programs targeted at specific customers quickly and easily based on customer demand, market conditions, and business drivers.

GWP is able to create new revenue sources from new products and services

6.2 Smart Grid Reference Architecture

The Smart Grid Architecture is a component of GWP’s overall Smart Grid effort and will not, on its own, achieve GWP’s business goals and objectives. Business process improvement, organizational change management and significant education and training are also required to achieve GWP’s vision. The Smart Grid Architecture will enable the automation of business processes, however the review, documentation, and development of these business processes to ensure that they meet the business requirements must be performed, or the applications and architecture will not realize their potential. The GWP organization will also need to change with these new business processes and capabilities to best use the applications and data to the benefit of the customer and improve the operation of the utility.

This Smart Grid Architecture is the first step in the realization of the valuable opportunity that Smart Grid offers. It provides a roadmap for its implementation and assumes the detailed designs, the business process change, and the organizational improvements will also be implemented. The Smart Grid Architecture is also flexible and should be maintained and evolve, as any other architecture or system, over time as business requirements, technology and capabilities change or improve.

This Smart Grid Architecture makes many recommendations and provides a roadmap for its implementation. A summary of the high-level recommendations is shown below:

- Implement standards for applications, database, messaging, and data. GWP should develop a common data model and establish a standard for messaging which can be used to guide the acquisition and implementation of all systems. Additionally, GWP should establish an architectural guideline for applications and databases to improve maintainability and reduce costs.

- Establish an Architecture Review Board to track and evaluate new technologies and systems and ensure alignment with standards and the overall architecture.

- Implement an Enterprise Service Bus (ESB) across all GWP and City applications to provide a standardized integration platform and reduce ongoing integration and maintenance expenses.

- Implement new and enhanced applications as already planned (DMS, OMS, Water SCADA) leveraging established standards
• Evaluate the use of, or enhancement of, existing systems (CityWorks, GIS, and PeopleSoft) for Work Management and Asset Management requirements, rather than purchasing and implementing new systems.

• Implement a Data Warehouse (for enterprise data) and Data Historian (for electric and water operational data) and reporting tools.

• Formalize IT support operations (both practices and tools) using best practices based on Information Technology Infrastructure Library (ITIL). Implement a common 24x7 infrastructure and application monitoring and maintenance capability.

• Formalize security and monitoring standards across GWP and City organization, including the establishment of a Security Architecture Review Board.

• Initiate a Business Process Improvement program to document “as is” and “to be” business processes and high-level business process map.

• Initiate an Organizational Change Management program to establish roles, responsibility, and organization to best leverage the SGA and realize benefits.

The Reference Architecture for GWP Smart Distribution Network is shown in Figure 14. This architecture shows the systems, interfaces, and interactions and uses a federated Enterprise Service Bus (ESB) for messaging and real-time integrations.

**Figure 14: GWP Smart Grid Reference Architecture**
The reference architecture was developed with the support of UISOL using industry best practices and input from all areas and levels of the GWP organization. Consequently, this architecture reflects the future state of the utility systems, which satisfy GWP’s strategic objectives and initiatives, provides a roadmap to achieve this future state from the current state and identifies the challenges and opportunities GWP will encounter moving to this future state. This architecture is based on industry standards and practices, such as NIST (National Institute of Standards and Technology) and the Smart Grid Maturity Model from Carnegie Mellon Institute.

GWP’s current state of technology is one of siloes and manual processes where basic utility operations are achieved through applications that are not integrated to support automation of processes and where employees have little access to information from other operational areas. The data security and user access management capabilities have been minimal with respect to cyber security practices and standards. In the past, the infrastructure and applications were managed and supported by individual sections with little consistency and standards.

The Smart Grid Architecture supports GWP’s business strategy as well as the ARRA funding requirements. It is composed of four architectural domains (data, applications, infrastructure, and security) and describes state of the art technology, process, policies, and standards.

6.2.1 Enterprise Service Bus

The Smart Grid Reference Architecture shown in Figure 8 above shows a fully integrated set of applications using a common integration platform and is the smart grid architecture base.

The following project timeline was adopted for GWP’s implementation of the Enterprise Service Bus:

6.2.1.1 2011 – Piloting

The Enterprise Services Bus in a foundational element of the architecture and it is an essential step to determine an implementation plan and demonstrate inter-application domain connectivity. In addition, the Architectural Review Board extends governance oversight across multiple initiatives. Key personnel in the ISD department should undertake ITIL training as support operations would soon be complicated due to the nature and number of new, highly integrated systems. Laying the foundation for Identity and Access Management as described in the security roadmap begins with enhancing/consolidation Active Directory services

- Develop selection requirements and review criteria for the ESB
- Select ESB vendor
- Pilot selected ESB using use cases from MDM and DA applications
- Provide ESB training to key development resources in both operations and enterprise domains
- Implement baseline ESB development environment with capabilities identified in the messaging service layer
- Undertake ITIL v3 fundamentals training
• Define initial architecture review board
• Define application performance monitoring approach

6.2.1.2 2012 – Initiating
Early interface development begins to adopt the ESB to broker transactions. Environment federation is enabled to support multiple project development efforts. An integration strategy is generated to apply SOA principles where applicable and expertise integration becomes essential. Piloting application performance monitoring (APM) technologies should also commence with focus on the operations domain.

• Adopt an integration strategy based on SOA principles
• Develop preliminary SOA integration competency center and staff with internal resources to perform ESB support and interface development
• Develop integration patterns, design guidelines, and best practices
• Scale ESB DEV environments to support multiple project domains
• Pilot complex orchestration technology in the messaging service layer
• Build initial set of common operation services for logging, auditing, error & exception handling, routing, and message security
• Build initial ESB QA & PROD environments for early application adoption in the operations domain
• Implement a design time service repository
• Enhance service request management at the Help Desk following ITIL procedures and best practices
• Implement a formal change management and tracking system along with an ITIL-adapted change management process
• Implement release management procedures based on best practices for maintenance and deployment activity
• Implement incident and problem management procedures based on ITIL best practices
• Pilot APM functionality, enhance 24/7 data center support capability for DA project go-live

6.2.1.3 2014 – Integrating
This phase corresponds to the bulk of interface development activity. New capabilities that are available in the integration product stack offer opportunities for event driven use cases. Operational support of the integrated application also requires a high degree of service management capability due to the growing number of new environments.

• Scale enterprise QA & PROD ESB environments for fault tolerance and redundancy
• Staff integration competency center staff to support concurrent project development demands and on-going operational support
• Pilot technologies in the data services layer as part of the data architecture roadmap
• Pilot complex event processing (CEP) and business process management (BPM) technologies in the processing services layer
• Implement release management procedures based on ITIL best practices
• Implement a run time service registry with operational monitoring & reporting capability
• Extend APM pilot to other domain use cases

6.2.1.4 2015 – Optimizing
Re-use of data payloads is facilitated by implementing a data services layer. The organization is also now shifting from development to support operations. Opportunities to improve 24/7 support operations and predictive monitoring functionality are pursued.

• Implement a data services layer
• Implement a processing services layer
• Pilot business activity monitoring technologies in the information services layer
• Pilot end to end application performance monitoring technology
• Evolve SOA capability into an event driven architecture
• Adopt ITIL configuration management capability
• Implement an enterprise application monitoring and performance tracking system

6.2.1.5 2016 – Running the Event Driven Enterprise
The majority of the Smart Grid application have been delivered and there is considerable attention on operation service level management to ensure that the business KPI’s are being met. End to end system and application performance monitoring becomes essential.

• Implement an information services layer
• Enhance service operations management capability with ITIL performance and event management processes

6.2.2 Data Warehouse
The Data Warehouse provides for long-term data storage of meter data as well as CIS information for reporting and data analysis and will be integrated with, and available to, the GWP enterprise using ETL (extract, transform, and load) tools to capture data from the MDMS, CIS, and GIS. The typical integrations utilize web services for data access and database-to-database interaction for data loading. Reporting tools associated with the Data Warehouse will support the analysis and reporting from the data housed within the Data Warehouse. GWP presently uses Crystal Enterprise for reporting based on snapshots provided from CIS. Moving
the reporting tool to a Data Warehouse will simplify and standardize reporting and enable trend analysis much more readily than can be done with the present approach.

6.2.3 Outage Management/Distribution Management System

The distribution automation project reduces outage recovery time and realizes improvements in the electric system reliability by applying new software and intelligent devices. The project will be completed in two phases. The first phase is the pilot program in which GWP is installing intelligent devices on four feeders and integrating new OMSDMS software to control the devices. GWP has completed the planning process and the installation of new hardware, and City Council has already approved the purchase of the new Outage Management/Distribution Management System (OMS-DMS) software. Once fully integrated through GWP’s Enterprise Service Bus (ESB), the new OMS-DMS will allow GWP to collect and analyze distribution system data in real time so that GWP personnel can take the necessary actions to control the field devices in the electric distribution system and more quickly restore power. The new OMS-DMS will also improve outage management functions including response and outage resolution times. The second phase is a long-term project to complete the installation of intelligent devices throughout the GWP distribution system. This phase is expected to be completed over the next ten years.

Completing the Distribution Automation Pilot will require procuring external system integration services to fully integrate the new software with GWP operational systems including the Automated Metering Infrastructure, Geographical Information System, Customer Information System, Interactive Voice Response, Supervisory Control and Data Acquisition, and others. The OMS/DMS project work plan assumed a project start of mid-November 2013 and a completion in March 2015.

The work plan included the following phases, milestones, and deliverables:

6.2.3.1 Phase 1 - Project Restart Scoping and Initiation

This phase resumes the project from the point of stoppage in August 2012. Activities associated with this phase are project management and detailed planning, architecture finalization, ESB infrastructure re-orientation, and development scale readiness. Deliverables include:

- Integrated Project Plan with ACS
- Detailed Project Budget
- Solution Architecture Document
- Final Infrastructure Configuration for Server Builds
- ESB Development Readiness Checklist

6.2.3.2 Phase 2 - DMS Pilot CIS and GIS Data Upload and Configuration

This phase focuses on an initial export and import of customer and electric model GIS data to the DMS test module to support pilot deployment and initial DMS user orientation activities. Deliverables and activities include:

- Initial Integration with GIS for Electric Model Import
• Bulk Upload of CIS Data
• DMS Product Data Validation Oversight

6.2.3.3 Phase 3 - DMS / DA Pilot Go-Live and Implementation Review
This phase focuses on an initial deployment of DMS functionality to a targeted pilot area of DA control and automation for proof of concept activities. Deliverables and activities include:
• Project Management and Oversight of ACS Service Delivery for DA Pilot Phase
• Infrastructure Architecture Oversight of Pilot Infrastructure Delivery and Installation
• DMS Product Training Support Augmentation for Pilot
• Definition of Pilot Success Criteria and Post Implementation Review

6.2.3.4 Phases 4A - 4D: OMS DMS Integration Development for AMI, CIS, and GIS Interfaces
UISOL will finalize detailed integration designs based on the endpoint specifications of the OMS/DMS product with the Itron AMI, NorthStar CIS, ESRI GIS, Teleworks IVR, Call Overflow, External Weather Service, and OSI PI systems. UISOL will develop the integration solution for these using the TIBCO ESB platform, develop the common services layer, unit test, and configure the ESB for deployment and operations. Deliverables and activities include:
• Systems Integration Project Management and Architecture Oversight
• Detailed Integration Designs
• Developed ESB Code for Integration with OMS DMS
• Developed Common Operational Services in ESB for Logging and Exception Handling
• Integration Testing
• ESB Configuration and Deployment Management

6.2.3.5 Phase 5 - OMS DMS Integration End to End QA Testing and UAT Oversight
This phase will incorporate end-to-end testing and production scale readiness for the full OMS DMS rollout. Deliverables include
• Installation and Configuration of ESB QA Environment
• ESB Administration for QA Testing
• Integrated QA Test Plan and Test Cases
• Integration End to End Testing (E2E)
• Integration Performance Testing
• Defect and Resolution Management
• Oversight of ACS UAT for OMS DMS Full Scale Deployment

6.3.2.6 Phase 6 - OMS DMS Full Deployment and Go-Live
This phase Project Management and Oversight of ACS Service Deliver OMS DMS Full Roll Out
• Deployment and Release Management Plan
• Installation and Configuration of ESB PROD Environment
• Implementation of ESB Monitoring Tools
• Oversight of OMS DMS Training Delivered by ACS
• ESB Code Migration and Production Deployment
• Integration Go Live Support and Defect and Resolution Management
• Integration Post Go-Live Support two week STORM period

6.2.4 SCADA Upgrade
The SCADA was purchased and installed in the 2008-2009 timeframe. The software was approaching end of its useful life and needed an upgrade to support the new OMS/DMS systems.

6.2.5 OSIsoft - PI Historian
The upgrade to the SCADA system and installation of a new Outage Management/Distribution Management System required new reporting and historian capabilities. GWP procured OSIsoft PI Historian software from OSIsoft for electric data storage and reporting.

6.2.6 IVR Upgrade
GWP’s Tele-Work’s Integrated Voice Recognition (IVR) Software was integrated with the Harris Computer’s NorthStar Customer Information and Utility Billing System and eCARe Online website in January of 2004. The Tele-Works IVR provides City customers the opportunity to review and verify their account balance, account status, and pay their utility bill over the phone seven days a week, 24 hours a day in three different languages; English, Spanish and Armenian. The GWP Customer Service Department can also send bulk outbound messages and important notifications through the IVR to customers.

The nine-year old IVR handles an average of 98,000 incoming calls, processes over 37,453 credit cards and 9,095 e-check payment transactions and collects annual revenue of $13,153,496 annually. Upgrading to the new Tele-Works Inc. Summation 360 IVR platform was necessary for the new ACS Outage Management System GWP is deploying to fully function.

The new system provides a variety of customer service requests that revolve around the handling of outage management. Features include the ability for customers to report outages, listen to known outage details, requests for City follow-up status, and automated call back.

The Telework Summation 360 Platform upgrade includes:

• Tele-Works Voice Platform
  o Certified Communication Server
  o 24 Port Licensing
  o Text-to-Speech Resources
- Professional Voice Recordings
- Native VoIP/SIP Connectivity

- Utility works IVR Upgrade
  - Integration to NorthStar Real-time Utility Billing Account Access
  - English and Spanish
  - Credit Card and Check Payment

- Outage Management IVR
  - Real-time Outage Reporting Information
  - Integration to ACS via MultiSpeak-based API
  - Outage Management - Caller Identification
  - Outage Management - Outage Information
  - Outage Management - Automated Callback
  - Standard Reporting

- Alertworks – Premise
  - Outbound Call-outs
  - Email Notifications
  - “Press 2 to Pay” Feature
  - Access to Hosted Alertworks Outbound Notification System

6.2.7 Meter Data Analytics

GWP’s Detectent Meter Data Analytics Program solution will maximize benefits from the Glendale’s investment in Utility Modernization by providing GWP with the ability to integrate the large amounts of customer-related data it is now receiving from various intelligent devices it has installed in the field to enhance customer program efficiencies and reduce costs.

A key area for improvement is revenue assurance. According to recent American Public Power Authority surveys, technical and non-technical losses for the best public utilities of similar size and U.S. region average four percent a year. Since 2002, GWP energy losses have averaged ten percent a year. GWP believes that between two and four percent of its losses are non-technical in nature, and can mitigate through an effective Meter Data Analytics Program. Successfully mitigating these losses could significantly increase GWP revenues each year.

In addition to Revenue Assurance, the proposed Meter Data Analytics Program will support:

- Load Disaggregation - Use of powerful data mining techniques to understand the specific equipment being used at a residential, commercial or industrial premise and
specifically identify when it is being used so that GWP can more effectively design and market customer energy and water efficiency programs.

- Billing - Ensure customers are meeting the criteria for the assigned rate and demand classification, including the combining of multiple accounts to the same premise to ensure that total consumption at a premise is consistent with the assigned rate and demand classification.

- Metering Services - Identify meters off system as well as the identification of failed or failing meters in a timely manner to ensure that customer's service is metered correctly.

- Customer Programs - Target customers with specific messages about their individual energy consumption and benchmark each customer against logical peers.

- Call Center - Quick and easy access to simplified views of a customer’s disaggregated load profile to GWP customer service representatives; providing information they need to assist GWP customers with high usage calls and inform the customer of conservation and efficiency opportunities that are specifically applicable to that customer.

- Customer Experience - Assess the potential impact of GWP customer programs based on summarizations of disaggregated customer loads to bring a whole new level of accuracy and granularity to the utility's ability to deliver a positive customer experience.

6.2.8 Conservation Voltage Reduction

One of the major benefits of Glendale’s investment in utility modernization is its ability to use the data generated by the new digital meters to reduce power costs by increasing the efficiency of GWP's distribution system. An effective Conservation Voltage Reduction program is one way to do just that.

Conservation Voltage Reduction, or CVR, has been around the utility industry for over 30 years. Utilities are required to deliver electricity to customers within the specified ANSI band that is between 114V and 126V. CVR conserves electricity by operating electric customer voltages in the lower half of the ten percent (10%) voltage band required by ANSI equipment standards. Independent industry studies, i.e. EPRI Green Circuits and Pacific NW Labs, show an average reduction of approximately 0.8% in energy consumption for every one percent (1%) reduction in circuit voltage. Based on these studies, DVI estimates that GWP should see energy savings of between 2% and 4%. Assuming a full-scale program that includes 68,000 GWP meters, this implies energy savings between 14,430 and 28,378 MWh per year. Further assuming GWP’s current value of saved energy of $50 per MWh, and an average annual program cost of $250,000 over five years, a full scale, five-year program could net GWP power cost savings of between $470,000 and $1.2 million per year.

Historically, two of the main obstacles to successfully implementing CVR have been: (1) developing a practical method of controlling voltage that is adaptive to the dynamic changes that typical distribution circuits undergo and (2) measuring the energy saved when the circuit is operating in the more precise lower voltage band. In the past, CVR has relied on state estimation or simulation modeling techniques to control voltage and measure the energy saved. Neither of those methods has been very effective.
Techniques that control voltage using state estimation rely on primary level sensors and can only approximate the voltage drop on secondary conductors and service transformers affecting the customer meter. Simulation modeling techniques fail to keep up with the dynamic nature of the distribution system and typically have difficulty modeling the proliferation of technologies such as electric vehicles, distributed generation assets, and home area networks. Modeling approaches also have difficulties continuously representing circuit dynamics such as penetration of demand-side management programs, new customer additions, seasonality of loads, and other changes that occur unpredictably on a distribution circuit.

One major feature of the DVI adaptive voltage control solution is that it uses the most recently developed AMI technology, along with SCADA measurement of operational data, to monitor the dynamic nature of the distribution system in real time, make voltage decisions based on that real-time information, and measure the energy savings that result from those decisions. The second major feature of this technology is its ability to integrate into the existing planning process for the utility. DVI's EDGE solution enables the use of AMI readings offline to be incorporated into a number of key processes, including the planning process for improving CVR savings and the CVR control configuration process. Incorporating the EDGE planning process into GWP's energy efficiency program creates a sustainable process for planning the continuous improvement of the distribution circuits. The third feature of DVI's EDGE product is its ability to calculate and document the energy savings for the circuit. This feature continuously tracks and reports the level of improvement attained by the planning and management process using a statistical technique that measures the savings and documents any circuit upgrades that might lead to improved voltage control performance.

By leveraging GWP’s AMI investment and integrating voltage data into the circuit planning process, DVI’s EDGE solution would assist GWP with planning, managing and validating its energy efficiency program in a practical way. Seamless integration into the utility’s DMS/SCADA, AMI, and planning processes enable the continuous improvement process for the distribution energy delivery system.

After researching various CVR technologies, GWP staff has concluded that the DVI solution is the only solution in the market place that can take full advantage of its investment in AMI and with the potential to deliver the maximum energy savings for GWP and its customers. DVI is a subsidiary of Dominion Energy Holdings, Inc. and is backed by the financial strength of Dominion Resources, Inc., one of the nation’s largest producers and transporters of energy. DVI’s Edge platform was developed in conjunction with Lockheed Martin. Other CVR systems require the installation of additional equipment to regulate voltages to maintain a constant output level. DVI’s patented approach is the only CVR Voltage Optimization solution on the market that solely uses AMI data to conserve energy.

At this stage, GWP proposes to enter into an agreement with DVI to conduct a six-month CVR demonstration project. The CVR demonstration project will consist of one (1) distribution substation transformer ("EDGE Nodes") under EDGE CVR control. The objective of CVR demonstration will be to confirm through verifiable statistical analysis that the expected energy savings for the identified circuit are being achieved. At the conclusion of the demonstration project, DVI will provide an energy savings report that will quantify the CVR factor and
average energy savings per customer performance as well as provide in-depth information on
the calculation methodology.

6.3 Distribution Automation Hardware Pilot Project

6.3.1 Introduction
GWP defines Distribution Automation (DA) as “The smart integration of software, applications,
systems and devices to collect and process information to:"

- Improve reliability
- Manage system assets
- Operate system centrally
- Enhance safety
- Increase system efficiency

An effective Distribution Automation system will provide an intelligent and systemic response
when a problem is detected in the delivery system. It will process the information from the
available collection points (meters, sectionalizers/reclosers, fault locators, remote switches, feeder circuit breakers, etc.) to identify the source of the system disturbance. It can provide
useful information to the System Dispatchers and Troubleshooters before they set out to the
field to make the necessary repairs to restore power to the affected area. A Distribution
Automation system is a key building block for a Smart Grid System. A fully functional DA
system, when all the components have been fully integrated, can automatically isolate or sectionalize the affected area and automatically restore power to the rest of the system.

6.3.2 Distribution Automation Strategy and Roadmap
Glendale’s Distribution Automation project is divided into two major phases. The first phase is
a Pilot Project to install, integrate, test, and evaluate the program by March 2015. The second
phase is a System Wide Deployment Project to integrate Glendale’s distribution system into
Distribution Automation with the goal of having a fully automated distribution system by 2026.

6.3.3 Distribution Automation Pilot Project
The DA planning group identified the following steps to develop a Pilot Project to install,
integrate, test, and evaluate various components for the DA program:

- Select DA Pilot Project Area
- Procure/Install Intelligent Field Devices

6.3.4 Select Pilot Project Area
Two feeders were selected from Glorietta and Montrose substations using the following criteria:

- The feeder has at least one tie point to adjacent feeders.
- The feeder has overhead and underground segments of the distribution system.
- Existing ties to alternate feeders need to have reserve capacity in excess of 25% during
  peak times.
• Feeder serves diverse profile customers (residential and commercial).

Figure 15 shows the area selected for the Pilot Project.

**Figure 15: Selected Area for DA Pilot Project**

6.3.5 Procure and Install Intelligent Field Devices

In this step, GWP will procure and install the Intelligent Field Devices (Table 12). These devices are described in detail below.

- Automated Feeder/Reclosers/Fault Interrupter
- Automated Capacitors
- Disturbance Monitoring Relays
- Smart Protective Relays
### Table 12: Intelligent Field Devices

<table>
<thead>
<tr>
<th>DA Component</th>
<th>Estimated Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated Feeder/Reclosers/Fault Interrupters</td>
<td>27</td>
</tr>
<tr>
<td>Automated Capacitors</td>
<td>4</td>
</tr>
<tr>
<td>Disturbance Monitoring System</td>
<td>1</td>
</tr>
<tr>
<td>Smart Protective Relays</td>
<td>4</td>
</tr>
<tr>
<td>Communications System</td>
<td>TBD</td>
</tr>
</tbody>
</table>

#### 6.3.6 Procure and Install Intelligent Field Devices Communication Network

This step is to procure and install the communication devices and develop the communication links.

The communication network will comply with the Cyber Security requirements.

This step was completed in June of 2014.

#### 6.3.7 Testing and Evaluation

All DA components and systems will be tested and evaluated in this step to verify their functionalities.

The expected results from this Pilot Project are the ability to:

- Monitor field conditions in real time (i.e. device status, loading, etc.)
- Remotely control all automated field devices
- Detect and isolate faults automatically
- Restore power to unaffected outage area automatically

It is scheduled to complete testing and evaluating the DA Pilot Project by March 2015.

#### 6.3.8 System-wide DA program Implementation

Upon completion of the DA Pilot Project, a System Wide DA Program will be implemented.

GWP’s distribution system consists of 42-12kV and 69-4kV feeders. The initial phase in this process is to automate the existing 12kV feeders at a rate of six feeders a year. The estimated average cost is $1 million per feeder.

The second phase of the System Wide DA Implementation is to reconstruct/convert and automate the existing 4kV feeders at an average rate of seven feeders a year. The estimated average cost is $1.6 million per feeder.

The system wide DA Program will be completed by July 2026. The system wide DA Program will be completed by July 2023.

#### 6.3.9 DA Components

The following items are the components of the distribution automation project:
6.3.10 Intelligent Field Devices
The following hardware is contemplated as part of the accelerated and expanded GWP SGIG project:

- **Automated Feeder/Reclosers/Fault Interrupter**: Three-phase reclosers/fault interrupters that operate automatically to isolate faulted line segment(s) to localize outages so that customers who are outside the affected areas will continue to receive power. The reclosers are capable of re-energizing the circuit and reduce the duration of outages caused by momentary faults. This shall improve the reliability of the GWP Distribution System. Installed reclosers/fault Interrupters will have full communications and control to minimize the number of customers affected by circuit operations. These devices can be used to monitor loading conditions in real-time at various points on the distribution system.

- **Automated Capacitors**: Three-phase capacitor banks are required to compensate for the reactive power (VARs) over a circuit improving the feeder power factor. All capacitor banks will be equipped with advanced controllers with communication devises to be remotely controlled via the SCADA/DMS system.

- **Disturbance Monitoring Relays**: Microprocessor based relays/devices that have the capability to provide automated event notifications or store historical event data. These relays/devices should be remotely accessible to help in the diagnosis of circuit problems.

- **Smart Protective Relays**: Microprocessor protective relays that have the capability to protect feeders and are able to store historical event data and monitor feeders. These relays will replace existing electromechanical relays.

6.3.11 Communication Network
A citywide communication network is required between all controllable intelligent field devices and the Control Center. DA communication network would include the use of fiber optics and/or wireless media. Security of GWP infrastructure is a priority. Therefore, GWP will comply with all Cyber Security requirements.

6.3.12 Applications/Software
The following systems are required for the DA program:

- **Distribution Management System (DMS)**: An application software which utilizes the data from Intelligent Field Devices, GIS, AMI, SCADA, TILM, and AMS to have the ability to:
  
  - Get dynamic status of all automated field devices (i.e. status change, fault indication, loading, etc.);
o Display/monitor field conditions including all available metered data (Volts, Amps, etc.);

o Remotely control field devices, collect and store historical data, generate reports;

o Provide and display alarms/contingencies on screen and send proper notifications to assigned parties;

- Outage Management System (OMS): This application will aid in an early detection of outages, isolation, and recovery. The system model will be integrated with this application to recommend optimal switching procedures for system recovery based on collected data.

- Transformer Information Load Management (TILM): This software integrates the data collected from the AMI meters to the distribution transformers. The TILM program evaluates transformer loading at all times, predicts potential overload conditions, and identifies transformers that are underutilized.

- Asset Management System (AMS): An asset management system will aid in inventory, maintenance, and replacement programs of devices based on usage and loading to improve efficiency and reliability.

- Work Force Management System (WFMS): This application will help GWP field workforce in automated scheduling and resource optimization, dynamic routing and workflow management.
CHAPTER 7: Smart Grid Program Benefits

This section is a summary of the expected benefits of the GWP Smart Grid program, organized by project phase (Table 16). In 2013, GWP engaged the services of UtiliWorks, Inc. to do a high-level analysis of expected benefits from the GWP project. That endeavor found significant potential positive benefits in three areas: 1) Customer Care and Marketing, Power Delivery, and Water. The analysis suggests that $24 million in positive value can be created by automating the Glendale system, with an annual internal rate of return of 11.5% once the project is fully operational. Annual system benefits are projected to exceed $10 million by the tenth year of operation.

Table 13: Projected System Benefits

<table>
<thead>
<tr>
<th></th>
<th>Customer Care and Marketing</th>
<th>Power Delivery</th>
<th>Water</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPV ($MM)</td>
<td>$15.7</td>
<td>$6.6</td>
<td>$1.5</td>
<td>$23.8</td>
</tr>
<tr>
<td>IRR</td>
<td>15.2%</td>
<td>8.7%</td>
<td>9.3%</td>
<td>11.5%</td>
</tr>
<tr>
<td>Ten-Year Cumulative</td>
<td>$31.9</td>
<td>$37.1</td>
<td>$5.8</td>
<td>$74.8</td>
</tr>
<tr>
<td>Benefits ($MM)</td>
<td>$28.1</td>
<td>$38.1</td>
<td>$6.9</td>
<td>$73.1</td>
</tr>
</tbody>
</table>

7.1 Customer Care and Metering

A key element for Glendale will be to integrate dedicated energy demand management programs onto the metering infrastructure.

The customer care and metering initiative is focused on programs that are tied to automated metering functions and customer engagement efforts. There are three targeted programs, with key value sources listed:

Advanced Metering Infrastructure – using advanced meters to automate the billing function and support operational functions:

- Meter Reading – reducing labor costs associated with meter reading function
- Read-To-Bill – reducing the time between bill read and bill payment
- Tamper – enhancing billing on potential tamper accounts
- Call Center – enabling call center operators with real-time data to increase efficiency
- Back Office Reporting – using system efficiencies to reduce costs in back office functions
- Special Reads – using the real-time ability of advanced meters to reduce the number of special read requests
- Other Labor – eliminating truck rolls associated with “OK on arrival” calls
• Fleet – reducing the need for meter reading fleet
• Emissions – reducing the carbon emissions associated with meter reading vehicles
• Connect/Disconnect – using an automated process to turn on or off service without the need to dispatch a serviceman
• Labor Reduction – reducing labor currently required to perform connect/disconnect functions
• Bad Debt Reduction – reducing portion of bad debt by proactively disconnecting delinquent accounts
• Emissions – reducing the carbon emissions associated with connect/disconnect activities

Energy Demand Management – using advanced meters as a vehicle to support customer-facing energy management programs:
• Customer Revenue – evaluating the potential impacts to system revenue based on customer participation
• Peak Capacity Reduction – using energy management program to reduce system peak
• Emissions – reducing the carbon emissions associated with distribution operations

Figure 16 shows potential customer care and metering benefits.

**Figure 16: Projected System Benefits (Customer Care)**
7.2 Power Delivery

Power Delivery – The power delivery field involves programs that evaluate the impact of distribution automation functions. There are four key programs evaluated as part of the power delivery field:

- Fault Detection – using automated sensors and communications devices to dynamically monitor the grid and respond to system events
- Feeder Outages – reduce labor costs associated with feeder related outages
- Distribution Element Failure Detection – proactively address potential system issues in order to reduce overtime in the event of distribution element failures
- Transformer Optimization – using system data to proactively identify system issues and extend the life of distribution transformers
- Conductor Repair – reducing the costs associated with conductor splicing
- Outage Management – responding to outages more effectively and turning service to customers back on more rapidly
- General Outages – reducing labor costs associated with system outages

Substation Monitoring – using sensors at distribution substations to support additional functionality:

- Measurement Labor – reducing labor costs associated with substation monitoring through the use of automated systems
- Avoided Capacity – using distribution automation functions to support reductions in annual capital outlays for feeder and substation expense

Voltage Monitoring – using automated sensors, reclosers, and capacitors to reduce operating costs:

- Loss Reduction – reducing line losses through system automation
- Capacity Reduction – reducing capital expenditures for distribution upgrades
- Nominal Voltage Optimization – using volt/var program to effectively reduce end of feeder voltage on a dynamic basis where called for
- Emissions – reducing carbon emissions through reduced system usage

Phase and Load Balancing – using dynamic systems to balance phase and load issues:

- Loss Reduction – using enhanced phase and load balancing to reduce system losses
- Emissions – reducing carbon emissions through reduced system usage

Figure 17 shows potential power delivery benefits.
7.3 Water

Water: The water component of the analysis accounts for four programs that can create value for Glendale’s water utility operation:

Time-of-Use – Engaging customers through dynamic signaling to periodically modify consumption patterns during certain peak periods

- Electric Rate Reduction – using time-of-use signals to reduce system peak and thereby reduce peak electric charges
- Emissions – reducing carbon emissions by reducing electric peak demand

Conservation – using sensors to monitor system leaks:

- Water Conservation – reducing the amount of water lost through system leaks
- Emissions – reducing carbon emissions by reducing overall water resource requirements

Metering – automating water meter reading process:

- Meter Reading – reducing labor costs associated with meter reading function

SCADA – automating supervisory control functions in support of water operations

- Capital Maintenance – reducing annual capital maintenance costs through enhanced system efficiency
- Electric Charge – reducing electric charge on water operations through enhanced system efficiency
Figure 18 shows potential power delivery benefits.

**Figure 18: Projected System Benefits (Water)**

![Projected System Benefits Graph](image-url)
CHAPTER 8:
Smart Grid Benefits to California

Several key lessons learned from this program are identified and may be helpful to other utilities involved in system modernizations.

8.1 General Program Lessons

8.1.1 Shared Vision
GWP believed to succeed the executive team must have a shared vision of the direction the enterprise is taking. GWP developed a video about the project and answers to frequently asked questions to get the executive team on the same page regarding AMI. GWP is now using the SEI Smart Grid Maturity Model to clarify the entire goals for the Smart Grid.

8.1.2 People and Processes
With a project of this size and scope, a team could easily overlook the importance of business process and staffing redesigns, while focusing on technological changes. GWP learned that technology is an enabler of processes that must be executed and maintained by people. Attention to the process changes and human resources at GWP ensured that the program succeeded on all fronts.

8.1.3 Resource Management
GWP took the view that hiring a great deal of permanent staff for this project was not practical. Instead, GWP used an alliance of industry leading experts combined with in-house management under the governance of GWP’s project sponsor Craig Kuennen and its Smart Grid Executive Policy Committee.

8.1.4 Attention to Detail
Detail-oriented individuals were an invaluable asset to the success of the GWP Smart Grid project. Seemingly, small details have the potential to turn into large problems if not addressed carefully. For example, the GWP meter database was unreliable at times regarding the lay length of water meters in the GWP service area. GWP’s water department fortunately recognized this fact early and contracted with a firm to perform a complete audit of our water meter data, avoiding confusion and time wasted during the installation process. This is one small example of the thousands of details that are critical to a successful project.

8.2 Project Management Lessons

8.2.1 Set up and properly staff a Project Management Office (PMO)
Implementing the smart grid is the largest project ever undertaken by GWP. The risks and the rewards are high with a project of this magnitude. For that reason it is imperative that a strong PMO be established and the PMO must be provided sufficient resources to be effective.

GWP contracted with KEMA for a professional project manager and Subject Matter Experts to augment the internal resources we committed to the project.
Rather than staffing this project with individuals who had bandwidth, GWP took the opposite approach and committed many of its best managers to lead teams comprised of many of its best resources. This has proven to be a successful formula.

8.3  AMI-MDMS Program

8.3.1 The “Smart” in Smart Grid means that this is a major IT project
GWP underestimated the magnitude of IT work associated with this project. Ultimately, GWP had to employ a structural engineer to determine if the Data Center floor could support the additional weight of new equipment. It was necessary to reinforce the elevated floor, add power circuits and improve cooling and backup power. The interfaces between our Customer Information System (CIS) and the MDMS and head end systems proved to be one of the largest technical challenges of the AMI project. GWP has commissioned a systems architect to document the entire system and prepare a roadmap to migrate our systems to a Service Oriented Architecture with an Enterprise Service Bus before GWP can add all of the software it will need for Distribution Automation. This will be a major undertaking.

8.3.2 Adopt guiding principles for IT and make all sections of the company adhere to them
The initial set of architectural principles adopted by GWP is introduced in this section. These are general rules and guidelines for the use and deployment of IT resources and assets across the Smart Grid Environment. Architectural principles serve as a foundation to effective technology governance as they serve as a guide to decision making by helping to establish a set of selection criteria when evaluating vendor products and serve as a filter to avoid analysis of unacceptable choices. Principles also assist in the transition to new technology by assessing the alignment of existing systems with future directions.

Other California utilities should build upon these principles that are driven by the domain objectives and architectural goals. Consensus among the domains is essential for viability and sustainability of the guiding principles. An architectural principle should have a short title, a supporting statement, an explanation of importance, a description of the impact it has on the environment.

8.3.2.1 Technology Consistency and Standards Compliance
Future Smart Grid projects should adhere to this architectural direction and be implemented using IT and Utility Industry standards to the extent possible. GWP has learned that it must begin to align on standards in order to reduce the degree of complexity and manageability of competing information technology solutions. The benefits of IT standardization range from support cost reduction to deployment efficiencies. IT Standardization should be considered a best practice.

8.3.2.2 Buy and Integrate vs. Build
It is best for other utilities to implement “best of breed” vendor-provided packaged solutions in the Smart Grid domains rather than develop custom-built applications. The “buy vs. build” decision is influenced both by the resource requirements associated with the activity and the availability of solutions that meet the business needs. Many of the best of breed Smart Grid applications are available through vendor solutions, the use of which should eliminate the need
to pursue resource-intensive custom-built applications. The ability of GWP to align on operational best practices helped ensure that packaged solutions met its set of operational requirements through configuration rather than custom coding.

8.3.2.3 Interoperability and Integration

New solutions and enhancements to legacy systems should measure interoperability and integration capability as key decision criteria when weighing alternative approaches. Smart Grid projects will require a high-degree of information sharing across the various domains. The ability of the selected technology to integrate seamlessly across GWP should be viewed as a mandatory requirement. This includes the use of common infrastructure capabilities such as user and access authentication. Deviation from this principle, which implies either a solution contained in a silo or integrated by custom application program interfaces (API) that are costly to implement and support, will require an overwhelming business case justification.

8.3.3 Establishing and fully staffing a new AMI Operation Team is Key to Success

AMI is a disruptive technology. Its introduction will not allow utilities to conduct “business as usual.” It demands that utility operate differently.

- Attempting to staff an AMI operation though a matrix system creates an unacceptable risk.
- AMI Operations and Maintenance is primarily an IT effort it needs to be infused with business knowledge to be effective.
- Co-location of the core team is an essential ingredient for the success of the team
- The Core AMI Team needs to be full time and permanent employees reporting to the manager of AMI/MDMS Operations.
- The full time employees assigned to the AMI/MDMS Operations core team need to possess the following characteristics:
  - The right aptitude; they need to be capable of learning everything needed to be fully competent in their position.
  - The right attitude; they need to be enthusiastic about the job and willing to actively learn and participate as a member of a team.
  - They need to be willing to commit to two years in their role to avoid the deleterious effects of a revolving door that precludes ever-attaining full competence.
  - The need to be willing to cross-train in multiple roles to provide some redundancy on the team.
  - They should possess knowledge of the business when possible.
8.4 Distribution Automation Project

Implementing the OMS/DMS requires extensive IT support specially when intergrading with various systems such as GIS, MDMS, and IVR. GWP contracted with UISOL (Utility Integration Solutions, Inc.) to take on this task. Lessons learned include:

- One of the key components to getting anything right the first time is good planning. In an effort to plan effectively, GWP conducted the following workshops:
  - Project Implementation
  - Modeling and Standards
  - OMS and DMS
  - Integrations
  - Network Model Review
  - As-Is and To-Be Processes

- Visit utilities with OMS/DMS. Ask about:
  - Lessons learned
  - Data issues they encountered
  - How they maintained the data model and kept it up to date
  - Enterprise Integrations

- Any system is only as good as the data you feed it. This is why data preparation was a key component to getting it right. The following data was prepared and updated to support the new OMS/DMS system.
  - GIS: Connectivity model, Load flow model, Element attributes
  - IVR: Product upgrade for better data
  - AMI: Firmware upgrade for accurate timestamps
  - CIS: Service addresses, Phone numbers

- As a utility going from no OMS or DMS to a new integrated solution for both, it was important to establish the operational processes for our organization.
  - Update call taking process
  - Review procedures for GIS updates
  - Review procedures for customer data

- Sometimes the best-laid plans go awry. This is why quality testing along the way helped ensure that the system was coming together correctly. The following quality tests were/are being conducted.
As part of the quality testing, we had to do the following tests to validate that the system interfaces functioned properly.

- String testing of each enterprise system interface
- Site Interface testing all enterprise system interfaces
- End to End testing
- User Acceptance Testing
- Load and Performance testing

For successful implementation of OMS/DMS systems, it was essential to integrate with other enterprise systems. GWP decided to enable integrations using Tibco Enterprise Service Bus using industry standards like CIM and MultiSpeak.

- AMI: Power On, Power Off, Meter disconnect and reconnects
- IVR: Customer reported outages
- CIS: Customer data
- CIS: Outages entered by CSR
- GIS: Network Model

### 8.5 Risk Management Lessons

Identify and track potential risks upfront. At the beginning of the project, GWP identified a number of potential risks that could adversely affect the project. Only one of these risks, GWP Funding, turned into an issue.

#### 8.5.1 Public Opposition

Nature of the Risk: Strong Public Opposition could result in the premature termination of the project. A survey of GWP customers shows that more than half have a favorable impression of the AMI smart grid program but few understand it very well. Given the unfortunate (though isolated) cases of high bill complaints at other utilities that have led to spectacular headlines and press coverage, and a tendency of some individuals to use any opportunity to draw attention to themselves and who foster fear, uncertainty and doubt (FUD) among the public for their own personal or political purposes, GWP was particularly attentive to the risk of public opposition.
While every large public endeavor entails some risk of public opposition, our project plan contained a large effort intended to mitigate the risk through the following means:

- Creating and maintaining two-way communications with all stakeholders.
- Using the four languages commonly spoken in Glendale.
- Using the press, internet, public meetings, mailings, video, telephone, and email.
- Responding to all stakeholder questions and concerns promptly and with one voice, using clear and simple language.
- Proactively addressing concerns that have arisen at other utilities.
- Taking advantage of lessons learned from other utilities and improving on those actions to engage the public in positive ways.
- Providing customers with the knowledge needed to take full advantage of the benefits afforded to them by the AMI Smart Grid.

GWP continues to be committed to earning and maintaining public trust and is investing human and financial resources commensurate with the importance of this matter.

Despite the best efforts of all parties, human errors are likely to occur. When these errors occur, GWP’s ability to retain or restore public confidence has to do with additional mitigation strategies including:

- Proactive treatment of common problems.
  - For example, old water meters have the potential to under-report actual water usage. When replaced with new highly accurate meters the actual use will be recorded. The customer is likely to view the increase in their bill as an error. In anticipation of this event, GWP is testing 100% of the water meters replaced during our Proof of Concept (POC) period. Customers with defective old meters will be informed that their new, accurate meter is likely to result in a higher bill but they will not be retroactively charged for the free water that they may have been receiving for a very long time.

- Early discovery of the problem.
  - A number of early detection mechanisms were implemented to trap errors before they impacted the customer.
  - GWP provides a number of convenient ways for customers to raise concerns, complaints or claims.

- Rapid and effective correction of the problem.
  - Additional resources were on hand during the initial deployment of any customer facing activity to ensure rapid and effective corrective action.

- A customer service attitude on the part of all customer-facing personnel.
8.5.2 Security Breach
Nature of the Risk: A significant security breach could terminate the project and have adverse consequences for all AMI smart grid projects. Even a slight breach could fuel negative public sentiment and thereby exacerbate risk one above.

This risk is so high that every conceivable measure required to reduce the probability as close to zero as possible is being employed. This risk is interrelated with the public opposition risk. Even a minor and in real terms, inconsequential breach can be used to inflame public opposition.

GWP’s approach is a defense-in-depth approach that employs all of the leading practices in the fields of cyber, personnel and physical security. This comprehensive approach to security serves to:

- Harden the target to the maximum level possible.
- Detect any attempt at intrusion and stop it.
- Contain and confine any possible breach.
- Rapidly recover from any possible breach.
- Constantly improve and evolve our security as new information or threats develop.

8.5.3 Failure to Meet DOE Requirements
Nature of the Risk: Chronic or severe failure could result in an inability to obtain the funds available through the grant.

GWP’s level of project and metric maturity at the beginning of this effort was below the level required to fully satisfy DOE reporting requirements. A concerted effort to move up the maturity scale and augmentation by contract, PMP resources are being employed to mitigate this risk. Executive support and constant project personnel effort will be required to attain and sustain adequate project and metric maturity. This risk is complicated by the fact that those best able to support reporting requirements are also those best equipped to perform and manage other project priorities.

8.5.4 Problematic Application Interfaces
Nature of the Risk: Interface problems if intercepted in testing are likely to impact schedule and possibly cost. Interface problems that emerge during production could result in operational problems.

Interfaces between the legacy Customer Information System (CIS) and the new commercial off the shelf applications (COTs) are being custom developed. Any custom development effort carries inherent risk. Mitigation efforts include:

- Development of the interfaces is being performed by the provider of the CIS system. This vendor has a long-standing relationship with GWP. Executives of both GWP and the vendor are devoting their best resources to this effort and both have made successful completion of the interfaces a priority.
- Progress of the interface development is being closely monitored and any impediments to progress are receiving priority treatment.

8.5.5 Customer Directed Program Adoption

Nature of the Risk: The success of the Customer Directed Programs is based on customer acceptance of the technologies.

Customer acceptance will be influenced by cost of participation, risk tolerance, and familiarity with the new technologies.

8.5.6 GWP Funding

Nature of the Risk: Completion of the project within project schedule is contingent upon GWP securing bond financing and/or a rate increase to store its capital budget.

GWP developed and implemented a comprehensive plan to mitigate this risk by summer 2013 that included:

- Completion of a Cost of Service Study
- Conducting a broad outreach program to gain public support for issuance of electric revenue bonds and/or an electric rate increase
- Securing City Council approval to issue electric revenue bonds
- Securing City Council approval to raise electric rates
- Securing City Council approval to restore the capital budget

8.6 Retail Customer Service Lesson

8.6.1 Gartner Hype Cycle

Customer surveys showed that the Gartner Hype Cycle is real (Figure 19). It is essential to have programs ready for customers in a timely manner or be prepared to weather the “trough of disillusionment.”

![Figure 19: Gartner Hype Cycle](image-url)

• Peak of Expectations – 2011 final meter installation, customers and staff expected to reap the benefits of the newly installed system.

• Trough of Disillusionment – one year delay in going live with the system, the 2012 – 2013 budgetary shut down, and corresponding delays in implementing customer programs had a significant adverse impact on the customer experience and pushed the project into the Trough of Disillusionment.

• Slope of Enlightenment – 2014 budget fixes and restart of distribution automation program, and roll out of new smart grid enabled customer pilot programs ended the Trough the of Disillusionment and started the project on the Slope of Enlightenment.

• Plateau of Productivity – 2015 and beyond, GWP is confident that full scale implementation of distribution automation and customer programs will move the project onto the Plateau of Productivity.
## GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>AMI – Advanced Metering Infrastructure</td>
<td>OS – Organization and Structure</td>
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<td>AMR – Automated Meter Reading</td>
<td>PHV – Plug-in Hybrid Vehicle</td>
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<td>AOBA – Apartment and Office Building Association</td>
<td>PMU – Phasor Measurement Unit</td>
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<td>ASR – Automated Sectionalization and Restoration</td>
<td>RFID – Radio-Frequency Identification</td>
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<td>BPL – Broadband Over Power Line</td>
<td>RFP – Request for Proposals</td>
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<td>CBM – Condition-Based Maintenance</td>
<td>ROI – Return on Investment</td>
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<td>CIM – Common Information Model</td>
<td>RTU – Remote Terminal Unit</td>
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<tr>
<td>CUST – Customer</td>
<td>SCADA – Supervisory Control and Data Acquisition</td>
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<tr>
<td>DG – Distributed Generation</td>
<td>SE – Societal and Environmental</td>
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<tr>
<td>DOE – United States Department of Energy</td>
<td>SEI – Software Engineering Institute</td>
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<td>DR – Demand Response</td>
<td>SGMM – Smart Grid Maturity Model</td>
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<tr>
<td>GIS – Geospatial Information System</td>
<td>SLA – Service Level Agreements</td>
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<tr>
<td>GO – Grid Operations</td>
<td>SMR – Strategy, Management, and Regulatory</td>
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<tr>
<td>HAN – Home Area Network</td>
<td>TECH – Technology</td>
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<tr>
<td>IED – Intelligent Electronic Devices</td>
<td>VCI – Value Chain Integration</td>
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<td>LOB – Line of Business</td>
<td>SPA – Source Provided by Author</td>
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<td>LTC – Load Tap Changing</td>
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<td>MDMS – Meter Data Management System</td>
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<td>NETL – National Energy Technology Laboratory</td>
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<td>NIST – National Institute of Standards and Technology</td>
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<td>OMS – Outage Management System</td>
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