




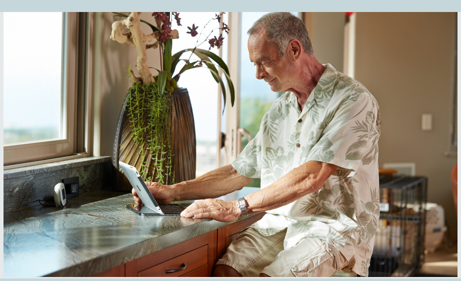


Smart Grid Roadmap Update

May 2015

Hawaiian Electric
Maui Electric
Hawai'i Electric Light

How To Use This Roadmap

This *Smart Grid Roadmap Update* described the current status of implementation a smart grid platform for all five islands served by the Hawaiian Electric Companies. In conjunction with this Update, we plan to file a smart grid application with the Hawai'i Public Utilities Commission. Upon approval of that application, we intend to fully install customized smart grid solutions for each utility and island.

The Update details the many aspects of smart grid: concept, make-up, solutions, implementation, and most importantly, benefits to our customers. Each chapter discusses one of these aspects.

1. Introduction. This chapter introduces the concept of smart grid at a high level, what it entails, and the smart grid solutions we plan to implement.

2. Our Customers Focus. This chapter explains in detail five tangible benefits that a smart grid brings to our customers. It also explains our customer outreach plan: how we plan to proactively address some concerns about smart grid, and engage our customers in our efforts to implement smart grid.

3. Our Smart Grid Roadmap. To efficiently arrive at a destination, it's good to have a roadmap. This chapter outlines the stages (if you will) that we went through to prepare for and plan our smart grid platform, and includes lessons learned, best practices, and our three core design principles.

4. Smart Grid Solutions. The smart grid we plan to implement consists of several basic solutions, while enabling future enhancements. This chapter explains these main smart grid solutions deemed to generate the most customer benefit, and summarizes several potential future solutions.

5. Smart Grid Implementation. Our roadmap consists of a Demonstration Project, which began in 2014 and is winding down, and a full implementation which we plan to start in 2016.

We have not made our decisions in a vacuum. Throughout these chapters are examples of how other utilities across the country have implemented smart grid. We have learned from these implementations to make thoughtful, strategic, and benefit-rich in designing our smart grid platform.

Table of Contents

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Executive Summary

The smart grid platform—planned and developed by the Hawaiian Electric Companies—enables a more reliable and stable electric grid and, more importantly, provides a number of tangible benefits for our customers.

THE TANGIBLE BENEFITS OF SMART GRID

Chief among these benefits are:

- **Increased Reliability.** Smart meters reduce costs by automating many manual tasks, help restore power more quickly after an outage, enable power to be rerouted around an outage site, as well as automate more accurate bills for our customers.
- **Lower Electricity Bills.** Accurate control of the level of power delivered to a customer site helps lower bills without affecting service quality; customers monitoring their usage also contributes to lower bills.
- **More Customer Choices.** Customers are empowered to better manage their energy and service through a number of new smart grid solutions and demand response programs.
- **Integrated Distributed Generation.** Increased information about the flow of distributed generation means more seamless and increased integration of customer-generated renewable energy.
- **Less Carbon Dioxide Emissions.** A smart grid enables more renewable generation—and less fossil-fuel generation—to be part of the generation mix.

Overall, smart grid gives our customers more control over how and when they use electricity, and how much they pay for that electricity, as well as increased reliability and better integration of their distributed generation.

AN OVERVIEW OF SMART GRID

A smart grid, at its most fundamental, integrates a digital communications network, including smart grid devices, with the wires, poles, and substations of our existing electric power grid.

The smart grid platform we are planning to implement is based upon a proven digital mesh communications network from our strategic partner Silver Spring Networks: Internet Protocol version 6, or IPv6. Integrated into this network are a number of smart grid solutions that improve our understanding of the electric grid, and form the foundation for a number tools from which customers can derive specific benefits.

Smart grid dramatically increases the amount of information available to us about the grid. This abundance of information centers on how, when, and where electricity is used; providing us valuable insights into the workings of our grid. We can then use this information to make informed decisions for controlling and operating the grid more efficiently. For example, we can use this information to automate manual processes, resolve outages more quickly and limit their reach, and safely integrate increasing amounts of distributed generation. Customers can use this information to better understand and manage their usage. Together, this increased productivity and management result in cost savings, and a more optimized, secure, stable, and reliable electrical grid.

Smart grid benefits are derived from the interoperability and interaction among numerous systems integrated into the power system. Business processes and customer interaction can then extract the greatest value from the smart grid platform. The smart grid solutions are interdependent and rely on the connections among the different systems, and derive the greatest benefit when all systems and solutions are implemented and operating cohesively.

While the infrastructure and implementation of our planned smart grid platform is very complicated, realizing cost savings and deriving resultant benefits is much easier.

OUR SMART GRID VISION AND ROADMAP

We prepared, planned, created, and plan to implement a smart grid platform that is most beneficial to our customers.

Preparing for Smart Grid

After submitting a smart grid application in 2008, we decided to defer its implementation. Instead, we watched the technology mature until we were certain it was proven, safe, secure, and reliable. In the meantime, we researched and selected a strategic partner in Silver Spring Networks. We made this decision based on their expertise and experience, as well as their network communication platform (called Internet Protocol version 6, or IPv6) and suite of smart grid solutions.

Planning for Our Smart Grid

Working with Silver Spring Networks, we evaluated smart grid implementations from four mainland utilities that were based of the IPv6 platform. We visited their sites, talked with them, and evaluated their smart grids. From this evaluations, we developed a set of best practices to follow in our own smart grid implementation.

We implemented a pilot Demonstration Project of core smart grid solutions on four circuits on O'ahu. We designed the pilot to test core smart grid solutions, assess risk, learn lessons, and develop best practices to employ during our full implementation of smart grid. During the project, we reached out to customers to educate and engage them about smart grid, and saw first-hand what benefits smart grid could bring to our customers. From this project, we learned a number of lessons that we employed when designing a smart grid that can deliver the most robust set of benefits to our customers.

Creating a Smart Grid Solution

From our experiences, from our lessons learned, from our best practices, and from the expertise of our strategic partner, we created our smart grid roadmap. We plan to implement smart grid through our three operating utilities, on all five islands we serve.

Our smart grid platform is based on the stable IPv6 network communications platform, and includes numerous smart grid solutions. These smart grid solutions form a core foundation for realizing the full potential of smart grid and the array of benefits it can provide. Here is a brief summary of these smart grid solutions.

Advanced Metering Infrastructure (AMI) is the foundational system for a smart grid. AMI enables smart meters and other devices to communication over the mesh network. Through AMI, we can conduct and monitor demand response programs, maximize distributed generation, and read meters. AMI also enables other smart gird solutions. A *Meter Data Management System* (MDMS) reads and records, then validates, estimates, and edits that data so that it can be easily read and understood by us and by our customers. *Remote Connect/Disconnect* enables us to turn service on and off from our back office. *Theft Detection* makes it much easier to determine usage on an out-of-service meter. All of this gives us greater control while helping reduce operating costs.

Customer Facing Solutions (CFS), though a web-based *Customer Energy Portal*, enable customers to access accurate and timely information about their energy, and to make intelligent choices about managing their energy use. Customers can also use *Prepay* to pay for electricity before it is used. CFS can be viewed on a computer, tablet, smart phone, and other mobile devices, empowering customers to take greater control of their energy consumption.

Distribution Automation (DA) provides us with more detailed information about the distribution grid (such as outages, service interruptions, and power quality issues). An *Outage Management System (OMS)* with *Fault Circuit Indicators (FCIs)* enable us to almost immediately identify and pinpoint the cause of the outage; *Remote Switching* enables us to reroute power around damaged circuits. This helps minimize the duration of outages and maintain power for more customers.

An **Advanced Distribution Management System (ADMS)** better manage the flow of electricity on our power grid. ADMS also enables *Conservation Voltage Reduction (CVR)* which conserves energy by reducing voltage on overloaded circuits, thus saving energy.

Energy Management enables us to more tightly balance supply and demand. *Advanced Analytics and Forecasting* enables us to develop more accurate demand forecasts. *Smart Inverters* allow us to remotely regulate voltage or watt output from distributed generation photovoltaic system. And our control of *Networked Street Lights* reduces energy consumption and cuts maintenance costs. Better energy management can reduce unnecessary generation, reduce energy consumption, reduce costs, and create a more stable grid.

Demand Response (DR) programs provide customers incentives to change their energy use. The *Direct Load Control (DLC)* and *Dynamic Pricing* programs encourage customers to shift their energy to times of the day when costs are lower. A planned Demand Response Management System (DRMS) enable us to better manage multiple DR programs. DR can help stabilize the grid, reduce outages, reduce energy consumption, and lower electricity bills.

Implementing our Smart Grid

While designing our smart grid platform, we simultaneously designed a viable implementation plan. This plan tailors the smart grid implementation for each island to derive the greatest benefit for island customers.

Upon approval of our application, we plan to begin strategically implementing smart grid in 2016, with tiered installations through 2019.

CUSTOMER OUTREACH

Customer understanding and appreciation of smart grid is critical to a successful implementation. Thus, we have employed a proactive, collaborative, responsive, and flexible communication effort to educate and engage our customers.

We created a communication outreach plan based on the successful efforts at other utilities. Our messages center around the three most sensitive concerns surrounding smart grid: safety, security, and privacy.

We began engaging our customers during the Demonstration Project. From that effort, we learned a number of lessons that we used to fine tune our outreach plan. we are currently engaging our customers on a limited basis. When full implementation starts and for its entire duration, we plan to start a robust and comprehensive effort to engaged and education our customers about smart grid and its inherent benefits.

Our outreach plan encompasses a number of activities:

- Community outreach, including direct mail, door-to-door canvassing, and open houses.
- Customer education, using both printed materials and online information.
- Third-part engagement, connecting with key organizations.
- Media relations, releasing details information about our smart grid plan.
- Customer research, ensuring our understanding of what customers most value.
- Employee engagement, preparing them for intelligent discussions with their friends and neighbors.
- Customer service support, clearly and cogently answering customer questions and concerns.

SMART GRID: NOW AND IN THE FUTURE

When designing our smart grid, we pursued three fundamental design principles. These design principles not only create a solid foundation for implementing smart grid now, but also enable us to easily integrate future smart grid benefits.

First, a *common communications network platform* enables us to build a sold smart grid platform today as well as build upon it in the future. Second, *broad device connectivity and an open software interface* makes it easier to accommodate a wide array of devices and software solutions. Third, an *open analytics platform* enables the robust communication inherent in smart grid from current and future smart grid solutions. Taken together, these three design principles enable us to extract the most benefit from smart grid now, and in the future.

The breadth of these fundamental design principles create an incredible value that is ultimately larger than the smart grid platform we intend to implement. It enables us to view our smart grid investment both in the short term and, more importantly, in the long term as a solid asset on which to build an increasingly robust electric grid that keeps pace with the ever evolving shift in our generation portfolio and the need to make smarter, quicker decisions, and to continue delivering increased benefits to our customers.

1. Introduction

WHY WE NEED A SMART GRID

So what exactly is a smart grid?

A smart grid, at its most fundamental, overlays a digital communications network on the existing electric grid—the wires, poles, and substations. Some equipment on the grid is upgraded to better handle the smart grid while some equipment, including advanced smart meters, is added to modernize the grid.

An increased level of grid-related information and operational data is gathered through this digital communications network. This abundance of information, centered on how, when, and where electricity is used, provides a better look at how the grid is operating.

What can be done with this information?

This 'smart' information, can increase our control, and thus the efficiency, of the electric grid, and enhance our ability to respond to current conditions. More specifically, we at the Hawaiian Electric Companies can use this information to improve productivity by analyzing the smart grid operational data and automating some processes to better deliver electricity. Customers can use it to better understand and manage their usage. Together, increased productivity and management result in a more optimized and efficient electrical grid.

A variety of hardware and smart grid solutions can be connected to the network to enhance the reliability and efficiency of the electric grid while helping lower costs. These smart grid solutions include advanced metering technology at homes and businesses, online customer tools, and grid management tools that enable us to optimize the performance and reliability of the grid. Emerging smart grid solutions can also be added in the future.

Together, this digital communications network, new and upgraded hardware, and the smart grid solutions form the smart grid platform.

Ultimately, a smart grid modernizes our electric grids; enables more renewable energy; reduces outage times; increases the efficiencies of our operation; reduces costs; and, most importantly, delivers tangible benefits to our customers.

Our Smart Grid Roadmap

The Hawaiian Electric Companies propose to implement smart grid through all three of our operating utilities, on all five islands we serve: O'ahu, Maui, Lana'i, Moloka'i, and Hawai'i Island.

Our overarching goal is to successfully implement a smart grid that brings the greatest benefit to our customers: financial benefits that lower costs through better productivity and energy use; operational benefits that increase the efficiency and reliability of delivering electricity while reducing outages; empowering benefits that enable our customers to take greater control over their energy consumption and cost; and intangible benefits of improved worker safety, service quality, economic output, environmental impact, and customer satisfaction.

Implementing a smart grid, efficiently and cost effectively, is a challenging venture. Smart grid brings enormous changes for us, for our customers, and for the state of Hawai'i. Our plan—this Roadmap—reflects our understanding of the complexity of this undertaking.

The details presented in this Roadmap reveal our understanding and appreciation of the many benefits smart grid brings to delivering, maintaining, and using electricity. The Roadmap describes our process for preparing, planning, developing, and implementing the most beneficial smart grid. The Roadmap also explains how our business systems and our planned smart grid platform can work together to achieve the greatest synergy of services and benefits that we can attain for our customers.

This Roadmap's goal, then, is to cogently explain the technical details entailed in developing and implementing a robust smart grid for all Hawai'i energy stakeholders. Our stakeholders include the Hawai'i Public Utilities Commission; the Division of Consumer Advocacy, Department of Commerce and Consumer Affairs (Consumer

Advocate); the Department of Business, Economic Development, and Tourism; the Hawai'i State Legislature, the many state and county policymakers; consumer advocacy groups; environmental organizations; and, above all else, our customers.

Finally, the Roadmap is a living document—we will update it as our plan for implementing smart evolves and continues to become reality. These updates can then keep the Commission, other stakeholders, and customers informed on the progress of our smart grid plan.

Our Business Case

We initially developed a high-level business case that measured the costs and benefits for implementing our smart grid. Applying a four-part methodology, we defined the scope, identified costs and related benefits, collected utility-specific relevant energy data, and compared our results with national industry averages. We are now developing a more refined mid-level business case.

That business case will be included in our smart grid application which we plan to file with the Commission in early fall, 2015.

Reports and Plans Related to Smart Grid

The Hawaiian Electric Companies have recently filed several reports and plans related to our smart grid plan.

The *2013 Integrated Resource Planning Report* contains an entire chapter on our initial plans for implementing a smart grid.

The *Smart Grid Roadmap & Business Case* discusses our initial implementation and financial plan for smart grid.

The *Enterprise Information Systems Roadmap* describes the approach to upgrading and implementing information technology systems and technologies.

The *Integrated Demand Response Portfolio Plan* (IDRPP) lays out the structure of a number of Demand Response programs, all of which can be integrated into our smart grid platform.

The *Distributed Generation Interconnection Plan* (DGIP) explains how smart grid can be used to better manage distributed generation.

The *Integrated Interconnection Queue* (IIQ) describes how various smart grid assets can be implemented and monitored.

The *Power Supply Improvement Plans* (PSIPs) explain how smart grid fits into our overall generation plans.

The *Distribution Circuit Monitoring Program* describes the kinds of circuit information that a smart grid can collect.

As a group, these documents described the approach to updating, upgrading, and implementing information technology systems and technologies, as well as approaches to developing our smart grid. They discuss how our business system operations can be integrated with smart grid in order to achieve the smoothest transition and greatest benefits.

Taken together, these documents form a foundation for our smart grid Roadmap.

AN OVERVIEW OF SMART GRID SOLUTIONS

A number of smart grid solutions offer features and benefits that can improve the operation of our electric power grid. Chapter 2: Our Customer Focus (page 13) discusses the benefits derived from these smart grid solutions; Chapter 3: Our Smart Grid Roadmap (page 29) explains how we chose them as part of our smart grid platform; Chapter 4: Smart Grid Solutions (Page 57) describes them in detail and how they interconnect with our electric power grid; and Chapter 5: Smart Grid Implementation (page 91) explains how and when we plan to implement them.

Here is a brief description of the smart grid solutions that are part of our smart grid platform.

Advanced Metering Infrastructure (AMI)

Advanced Metering Infrastructure (AMI) is the foundational system for a smart grid.

Smart meters, installed at homes and businesses and linked to the communication network, form the basis of AMI. Data gathered through AMI allows us to improve operations and customer service, as well as to automate many current manual processes. For example, through AMI, we can conduct and monitor demand response programs, maximize distributed generation on a circuit, and read meters.

A **Meter Data Management System (MDMS)** receives the incredible amount of data gathered from smart meters and transmitted over the digital communications network. The MDMS reads and records data from multiple channels; then validates, estimates, and edits that data into an understandable format.

AMI can also perform **Remote Connects/Disconnects** of electrical service. This reduces operating costs by reducing the number of field visits (or "truck rolls"), speeds turning on and turning off service, and makes for more accurate and timely bills.

Smart meters also enabled increased **Theft Detection**. All smart meters are registered in the AMI, making it much easier to determine when usage occurs on an out-of-service meter.

Customer Facing Solutions (CFS)

Various web-based tools and mobile apps—called **Customer Facing Solutions (CFS)**—enable customers to access accurate and timely information about their energy, and to make intelligent choices about managing their energy use. Customers can also monitor a repair's status and view outage locations.

Through an enhanced customer **Billing** solution, we can monitor, estimate, and create customer bills with increased accuracy on more tightly controlled billing cycles, and offer more payment options.

Through the web-based **Customer Energy Portal**, customers can access, monitor, and adjust their private, personal energy consumption. They can view detailed information about their energy usage, estimate their monthly usage, and receive tips for decreasing their energy consumption. A **Prepay** option allows customers to pay for electricity before it is used while obviating the need for a deposit.

Customers can also access and download energy information using a nationally standardized **Green Button** data format.

Distribution Automation (DA)

Distribution Automation (DA) links points along the electric grid with our back office systems. This connections provides us with more detailed and specific information about the distribution grid such as outages, service interruptions, and power quality issues. In addition, Distribution Automation enables us to better understand the impact and condition of distributed generation to improve its integration into the grid.

An **Outage Management System (OMS)** can help us quickly restore power to our customers after an outage. **Fault Circuit Indicators (FCIs)** enable us to almost immediately identify and pinpoint the cause of the outage. **Remote Switching** enables us to reroute power around damaged circuits and relays not affected by the outage.

Advanced Distribution Management System (AMDS)

An **Advanced Distribution Management System (ADMS)** takes full advantage of the AMI and smart meters to better manage the flow of electricity on our power grid. ADMS also enables **Conservation Voltage Reduction (CVR)** which, as its name implies, conserves energy by reducing voltage. CVR accurately monitors and reduces the average voltage across distribution feeders, optimizing voltage and reactive power, thus saving energy.

Energy Management

Energy Management enables us to more tightly balance supply and demand, thus saving energy. **Advanced Analytics and Forecasting** provides more detailed, immediate information about how energy is being used within a customer location, which enables us to develop more dynamic demand forecasts. **Smart Inverters** allow us to remotely regulate voltage or watt output from distributed generation photovoltaic system.

Networked Street Lights can be remotely controlled to run more intelligently and efficiently, reducing energy consumption and cutting maintenance costs.

Demand Response (DR)

Through **Demand Response (DR)** programs, we can provide customers incentives to change their energy use. This helps the grid operate more efficiently and making the best use of distributed wind and solar generation. Two such programs—**Direct Load Control (DLC)** and **Dynamic Pricing**—encourage customers to shift their energy to times of the day when costs are lower.

A planned **Demand Response Management System (DRMS)** can aggregate multiple DR programs so that they are seen as a single asset. This coalescence forecasts potential energy reduction, assesses how an energy reduction affected the grid, and provides tools to optimize energy savings across all—residential and commercial—DR programs.

Future Smart Grid Solutions

A number of currently available and emerging smart grid solutions can be added to our smart grid platform as their need arises. These solutions include:

- Volt/VAR (Volt-Ampere Reactive) Optimization
- Electric Vehicle Charging
- Energy Storage
- Microgrids for Critical Customers
- Automated Circuit Sectionalization
- Phasor Measurement Units
- Transformer Maintenance Monitoring
- Printed Energy Reports
- Line Monitoring
- Demand Response (DR) Ancillary Services
- Data Analytics Platform
- Decentralized Neighborhood Controllers

For details, refer to Other Smart Grid Solutions on page 87.

2. Our Customer Focus

At its very essence, a smart grid modernizes our electrical grid and increases our understanding on how the electric grid operates, bringing a number of tangible benefits to our customers.

CUSTOMER BENEFITS

The Hawaiian Electric Companies' smart grid program, after fully implemented, delivers these benefits to our customers:

- **Increased Reliability.** Smart meters reduce costs by automating many manual tasks, help restore power more quickly after an outage, enable power to be rerouted around an outage site, as well as automate more accurate bills for our customers.
- **Lower Electricity Bills.** Accurate control of the level of power delivered to a customer site helps lower bills without affecting service quality; customers monitoring their usage also contributes to lower bills.
- **More Customer Choices.** Customers are empowered to better manage their energy and service through a number of new smart grid solutions and demand response programs.
- **Integrated Distributed Generation.** Increased information about the flow of distributed generation means more seamless and increased integration of customer-generated renewable energy.
- **Less Carbon Dioxide Emissions.** A smart grid enables more renewable generation—and less fossil-fuel generation—to be part of the generation mix.

Figure 1 (page 14) details these benefits and some of the smart grid solutions that enable them.

Benefits	Smart Grid Solutions	Description
Increased Reliability	Advanced Meter Infrastructure & Distribution Automation:	Enables automated billing for customers, reducing meter reading costs, as well as acts as a sensor for outage detection and many other solutions.
	Outage Management Fault Circuit Indicator	Helps utilities find outages on the grid to restore power to customers more quickly.
	Remote Switching	Enables devices in the field to be remotely controlled to get an outage fixed more quickly.
Lower Electricity Bills	Conservation Voltage Reduction	Allows utilities to more accurately control the level of power delivered to the end-consumer.
	Customer Energy Portal	Allows customers to monitor their bills and usage patterns to reduce energy consumption.
More Customer Choices	Prepay	Provides customers the flexibility to pay as they use electricity to avoid deposits and help budget spend.
	Connect–Disconnect	Enables customers to quickly reconnect or disconnect power.
	Demand Response and Direct Load Control	Shapes energy demand to ensure the grid can safely manage variable energy sources such as renewable wind or solar.
Integrated Distributed Generation	Energy Management and Smart Inverters	More detailed analytics, better forecasting, and improved grid management lead to increases distributed generation.
Less CO_2 Emissions	Smart Grid Platform	A smart grid facilitates the connection and better management of increased amounts of renewable generation.

Powered by Silver Spring Networks Smart Energy Platform (Secure Communications Network)

Figure 1: Smart Grid Benefits

Increased Reliability

Our planned smart grid platform improves the reliability of our service by enabling us to quickly resolving outages and routine service interruptions.

Currently, we rely on customers to report service interruptions. Advanced metering infrastructure (AMI) automates this reporting. It provides us with more timely and accurate information about distribution system outages. Integrating smart meters through our Outage Management System (OMS), together with fault circuit indicators (FCIs), quickly identifies and pinpoints the location of most outages.

Through remote switching, we can control devices in the field from our utility offices, reducing truck rolls and speeding the resolution of outages. In addition, we can reroute power around an outage so that some customers can continue to have power while we resolve the outage.

Other utilities have benefited from these smart grid solutions. In the wake of Hurricane Irene, Delmarva Power used AMI-based outage detection to restore power to customers in Delaware who lost electricity during the height of the storm. Delmarva Power identified approximately 1,300 outage events, cancelling 30% of them by remotely querying the meters through the AMI network (which also eliminated the need to dispatch crews to those locations).

Smart grid also helps handle more routine service interruptions. Smart grid enhances the effectiveness of Distribution Automation (DA) technology by employing networking sensors on the grid which utility crews use to quickly identify the problematic section of a circuit. Once identified, utility personnel can remotely use networked switches to isolate and re-route power around outage points, so fewer customers experience a sustained service interruption. These Distribution automation solutions improve reliability.

A December 2012 report from the US Department of Energy—*Reliability Improvements from the Application of Distribution automation Technologies: Initial Results*—showed up to a 43% improvement in the System Average Interruption Duration Index (SAIDI) on distribution feeders where these type of smart grid solutions had been implemented.

These are the kinds of reliability enhancements smart grid can provide.

Lower Electricity Bills

Two benefits drive lower electricity bills: savings and productivity improvements in utility operations, and savings due to better management of energy use by customers.

Savings and Productivity Improvements in Utility Operations

Customers could see more efficient delivery of electricity as a result of several smart grid innovations.

Smart grid allows us to remotely perform numerous field operations—reading meters, connecting and disconnecting service, diagnosing outages, and sectionalizing distribution network during outages—reducing work crews in the field and saving money, which would be passed onto our customers.

For example, Pacific Gas and Electric, a northern California utility that connected 5.1 million customers as part of its smart grid program, has been able to remotely perform more than 600,000 annual field operations that would have previously required an on-site visit from a technician.

Smart grid enables enhanced versions of Conservation Voltage Reduction (CVR) on distribution feeders. The average distribution feeder voltage must be maintained within tariff specifications; CVR could bring those voltages closer to optimal levels.

CVR is enhanced with smart grid. Appliances run more efficiently, reducing the waste heat produced by excess voltage, ultimately requiring less electric power to operate. Lower and more uniform distribution voltages reduce system losses. Thus less energy is generated to meet customers' demands. Lower voltages also reduce the energy used by customers' appliances which reduces their monthly bills.

For example, at Dominion Power in Virginia and North Carolina, CVR implemented through the smart grid resulted in average energy savings of 2.5%. Hypothetically, if the same savings of 2.5% were to be realized at the Hawaiian Electric Companies, the 20-year value of energy savings would be approximately $135 million (in today's dollars). We have contracted with Electric Power Research Institute (EPRI) who will verify the potential savings through CVR before we fully implement smart grid.

CVR is being implemented as part of our smart grid platform. Implementing CVR at the transmission level, however could yield superior value for a smaller investment (particularly on Hawai'i Island).

Savings Due to Better Management of Energy Use by Customers

Smart grid solutions enable customers to access their energy usage through an online Customer Energy Portal. Customers can see detailed information about their electricity use and make informed decisions to change their behaviors and lower their electricity bills.

According to a recent study from the American Council for an Energy Efficient Economy(*Advanced Metering Initiatives and Residential Feedback Programs*), customers who receive this kind of daily or weekly information reduce their energy use between four percent (4%) and eight percent (8%), resulting in a direct reduction in their electricity bill.

More Customer Choices

Smart grid solutions together with a Web-based Customer Energy Portal give customers more payment options, enabling them to exercise tighter control over their energy usage.

Prepay, a smart grid solution, allows customers to pay for an allotment of electricity before they use it. The Customer Energy Portal helps customers track their energy usage and their remaining prepaid balance. Prepay also eliminates the need for customers to pay a deposit on their account before receiving service.

Through remote connects and disconnects, we can more quickly reconnect customers whose service was shut off when their prepay balance reaches zero. Customers can also request service be remotely connected or disconnected as needed.

By using Prepay, the Sacramento Municipal Utility District (SMUD) significantly extended its payment hours and reduced the number of customers who had their service disconnected due to nonpayment. SMUD customers now have until 11:45 PM to pay their bills and avoid a next-day service interruption. Smart grid solutions also helped SMUD reconnect customers more quickly, typically within twenty minutes after payment. The Distribution Automation smart grid solution (planned for the full implementation of our smart grid platform) increased same-day reconnections by 50%, allowing SMUD to connect up to 500 customers in a single day.

Demand Response programs enable customers to voluntarily participate in programs that curtail their energy use when demand peaks, generation cost are high, or as a contingent resource when there are delivery constraints in the grid. Appliances (such as air conditioners and hot water heaters) can be controlled to cycle on and off, balancing the energy system while minimally impacting customer comfort. We would offer financial incentives to customers to participate in these voluntary curtailments, providing another way to help decrease their electricity bills.

As an example, Oklahoma Gas and Electric (OG&E), through its SmartHours Dynamic Pricing program, aims to reduce peak demand to avoid building two 165 megawatt peaking generation plants. As of May 2014, OG&E had enrolled 91,000 customers in the program—more than 10% of its customer base—with the goal of increasing that number to 120,000 participants. The program resulted in an average annual savings of $139 per customer in 2013 while having the capability to reduce peak demand by 123 megawatts. These results were achieved despite the fact that average residential electricity rates for OG&E (excluding SmartHours) are less than 30% of those in Hawaiʻi.

Before implementing our smart grid platform, we will calculate the potential savings gained from reducing peak demand, deferring capacity, and reducing operational costs to determine the cost to benefit and value of Demand Response. We anticipate realizing these reduced costs and system benefits for those distribution circuits that have high-cost peaking generation or the need for additional capacity.

Integrated Distributed Generation

The total percent of energy from renewable sources across the consolidated Hawaiian Electric Companies systems was 13.9% in 2012, 18.2% in 2013, and is projected to be approximately 25% by the end of 2015. Customer-sited rooftop solar connected to distribution circuits contributed significantly to these totals, and was the major reason for renewable energy growth in the past few years. We expect the growth in distributed generation to continue as more customers install rooftop solar, including systems producing substantially more energy than customers consume during the daytime hours.

Hawaiʻi has the one of the nation's most aggressive programs for increasing renewable resources. Our Renewable Portfolio Standards (RPS) requires 40% of total energy needs to be met by renewable resources by 2030. Based on the current pace of rooftop solar installations combined with proposed utility-scale renewable energy projects, we expect that target to be met on time.

The Hawaiian Electric Companies are working to accommodate increased customer demand for rooftop solar (and other distributed generation systems such as micro-hydroelectric turbines). The challenge, however, is that a growing number of our distribution circuits now have a high percentage of distributed generation. During daytime hours, sometimes more power is being generated than consumed on certain distribution circuits. Under these circumstances, an engineering analysis is required to determine the mitigation measures and design requirements to avoid power quality and reliability problems.

To mitigate the effects of these potential unsafe operating conditions, we are installing protective upgrades to circuits (or requiring customers to install protective equipment as part of their systems) and, in some cases, limiting the amount of rooftop solar connected to a given distribution circuit (which is understandably unpopular with customers). Without more precise power flow and voltage information at customer locations on a distribution circuit, we impose these restrictions by relying on historical estimates of customer use and the design specifications of their rooftop-solar systems.

Smart grid can help better manage distributed generation on two fronts, both enabling use to safely and reliably manage the power grid.

First, smart grid solutions, in particular AMI, feed accurate information on power flow and generation from both individual customers and distribution circuits. This usage information allows us to make better assessments as to whether more rooftop-solar capacity can be accommodated on a distribution circuit without risking unsafe operating conditions.

Smart grid solutions provide our system operators more accurate, near real-time information about customer-sited demand and generation. Immediately knowing the amount of variable generation on distribution circuits also helps system operators observe the contribution of distributed solar to the total system generation. This can be useful in allocating reserves or demand assets to balance system generation. Visibility of distributed solar production can be used to improve solar power forecasting tools by providing actual distributed generation output to correct forecasting models. Improved forecasting is essential in helping our system operators optimize the dispatch of transmission-connected generation, which could reduce the costs incurred by uncertainty in the forecast that exist today.

Second, this same information can help customers assess their own energy usage. Accurate information will be particularly beneficial during the daytime hours for customers attempting to consume energy generated by their rooftop-solar systems.

Taken together, we expect these operational improvements to increase the reliability and integration of renewable energy from distributed generation.

As more smart devices (such as smart inverters, smart electric vehicle charging systems, and smart distribution equipment) become interconnected to the grid, system operators might be able to further optimize generation for the benefit of customers. Moreover, as customer use patterns become better understood, system operators might be able to reconfigure customer loads through demand response and generation sources among distribution circuits to alleviate overloaded circuits.

Reduced Carbon Dioxide Emissions

The smart grid promotes energy conservation and more optimal energy use by customers while reducing losses in the distribution of power to meet customer demand. The smart grid can facilitate engineering analysis required for distribution-connected renewable energy, and can help system operators manage the system with renewable energy produced from distributed generation. Both factors contribute to less reliance on non-renewable energy resources.

Increasing renewable generation on the grid means less generation produced by centralized fossil-fuel (primarily oil) power plants. A 1% reduction in power output from a fossil-fuel-fired plant results in an annual reduction of approximately 45,000[1] metric tons in carbon dioxide (CO_2) emissions. Based on the experiences of smart grid implementations at other utilities nationwide, we can expect a 1–3% reduction in fossil-fuel-fired generation, resulting in corresponding reductions in CO_2 emissions of 45,000 to 135,000 metric tons per year. This would need to be evaluated on the island systems with large amounts of transmission-connected renewable energy which can be displaced by distributed energy, particularly Maui and Hawai'i Island.

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1 Based on the combined emissions from Hawaiian Electric, Maui Electric, and Hawai'i Electric Light's major sources of greenhouse gas emissions for calendar year 2012 which is about 4.5 million metric tons of carbon dioxide.

CUSTOMER OUTREACH

The Hawaiian Electric Companies believe a proactive, transparent, and sustained communication effort to educate and engage our customers is critical to our smart grid implementation. Our efforts to reach out to our customers underscore our commitment to continually improve customer service, modernize the grid, and integrate renewable energy.

We inform customers about installing smart meters, educate them about smart grid benefits, and address their related concerns. Key to this effort is helping customers understand that, at its core, smart grid technology offers them more information about their energy use than ever before and give them tools and programs to help them control their energy use. They can then use these tools to lower their electricity bills.

Through a multi-pronged approach, we build interest from the outset, address questions and concerns, and engage customers in understanding the benefits of smart grid. Working with trusted third-party groups, we engage customers in direct conversations wherever they are—at home, in their neighborhoods, and online. That said, some customers haven't been able to or declined to engage with us.

Our customer outreach program is based on tested and proven industry best practices, and is customized based on research conducted in this market on how to best reach our customers. Our approach engages our customers with information tailored to their specific needs and questions. Our program employs established communication guidelines to proactively address customer concerns and engage them in various ways.

We began our ongoing customer outreach program during a smart grid Demonstration Project that started in 2014. (For more on this, see Creating a Smart Grid Demonstration Project on page 43.) We continue to evaluate the effectiveness of that program, and make adjustments as necessary. We intend to continue our more refined customer outreach program through the entire duration of our smart grid implementation, timing certain message to correspond with the time and rollout of various smart grid solutions, and on customer questions and interests at that time.

Communication Guidelines

Our efforts to engage our customers—indeed, all our stakeholders—is guided by four fundamental communication guidelines:

Proactive: Anticipate stakeholder needs and develop approaches to meet those needs.

Collaborative: Work with stakeholders to design and improve the experience, products, and services they receive.

Responsive: Respond promptly, openly, and transparently to all inquiries.

Flexible: Expect and accommodate continual process and communication improvements.

Educating Customers about Smart Grid

Our engagement efforts focus on educating customers on the benefits of smart grid, particularly in three areas:

- Providing customers with more information about their energy use to help them better manage their electricity bills.
- Making electric service more reliable and providing more timely information on power outage and restoration.
- Modernizing the grid to help integrate higher amounts of renewable energy—especially distributed generation—and reduce Hawai'i's dependence on oil.

Studying Other Smart Grid Implementations

In recent years, a number of national utilities have implemented smart grid programs. We have studied many of these implementations to learn from their experiences. Silver Spring Networks—our strategic partner in smart grid—has also shared with us their experience gained from working on customer engagement programs with other utility clients.

We have reviewed these utility implementations and accompanying engagement programs:

- Maui Smart Grid pilot program
- Kaua'i Island Utility Cooperative (KIUC)
- Florida Power and Light (FPL)
- Pacific Gas and Electric (PG&E)
- Sacramento Municipal Utility District (SMUD)
- Oklahoma Gas and Electric (OG&E)
- Commonwealth Edison (ComEd)
- American Electric Power (AEP)

Through this review, we identified a variety of best practices and adapted those ideas for our island communities and our specific smart grid implementation.

We learned many lessons. We learned the importance of engaging customers early and often. We learned that smart grid initiatives need to be treated as customer projects rather than infrastructure projects. We learned that a higher level of consumer engagement is necessary because smart grid solutions offer customers more options and more information about their energy use. We learned to inform customers as soon as possible so that they have more opportunity to learn about the benefits of smart grid solutions. Finally, we learned that early engagement consistently resulted in higher rates of customer acceptance.

Proactively Addressing Customer Concerns

While researching other smart grid implementations, we found that customers and the news media consistently raised concerns about three issues:

- Safety of smart meters and radio frequency emissions.
- Security of the communications network infrastructure.
- Privacy of customer data.

We are diligently identifying industry experts and related research so that we can better address these and other concerns raised by our customers and the media. We intend to provide our customers with educational information on these three issues.

Safety. Safety is our highest priority. Studies indicate all Silver Spring Networks-enabled devices present an extremely low-level of radio frequency exposure when compared to the regulatory limits established by the Federal Communications Commission (FCC) for safe operations. Smart meters transmit for only a fraction of the day for short durations and actual radio frequency emissions are less than commonly used devices such as cell phones and microwave ovens.

Security. We take the security of our communications and information technology systems very seriously. Maintaining secure systems is an ongoing process. Modern smart grid systems, such as the system we plan to implement, incorporate proven cyber security solutions. Unfortunately, no complex data network can be made completely secure. As we implement new smart grid solutions, we will work to incorporate further enhancements to our cyber security solutions.

Privacy. We are committed to ensuring the privacy of our customers' data. Our privacy policy includes the following commitments:

- We do not sell, rent, or license personal information.
- We treat customer information as confidential, consistent with legal and regulatory requirements.
- We only share your information with your consent, or as provided for in our privacy policy.
- We require any person or organization we share data with to protect customer information.
- We do not allow any person or organization acting on our behalf to use our customer information for their own marketing purposes.
- We only track aggregated statistics to improve our products and services. We do not track online behavior at an individual's level.
- We only use customer data for customer service, billing, planning, and grid management. We limit data gathering to the usage data recorded by the smart meter, unless given permission to measure this data in more detail (such as signing up for one of our special programs).

How We Plan to Engage Our Customers

This plan specifies tactics, tools, and schedules for customer engagement activities in a number of categories:

- Community Outreach
- Customer Education
- Government Relations
- Third-Party Engagement
- Media Relations
- Customer Research
- Employee Engagement
- Customer Service Support

We are already engaging our customers by employing the following tactics and activities during a demonstration smart grid project. We will continue The expect to continue this plan during the full implementation of our smart grid platform.

Community Outreach

We endeavor to inform and engage communities directly impacted by smart grid in meaningful, open discussions through the mail and through personal and group interactions. And we plan to continue to do so early and often. Through these personal discussions, we hope to better understand customers' concerns and respond to them directly.

We give our customers information that allows them to make informed decisions. Our information, tailored for both residential and commercial customers, explains the components and benefits of a smart grid. We want them to know the important role they play in shaping our future smart grid plans.

Direct Mail

Our direct mail pieces explain the smart grid project and its implementation, as well as smart meters, and direct customers to where they can gather more information (such as contacting us and finding information online).

Door-to-Door Canvassing

Our employees, as well as representatives and volunteers from supporting third-party organizations, canvass our customers door-to-door. During these personal conversations, we answer questions and gather feedback and questions. We also invite them to join us at upcoming open houses, call us, and access more information on our website.

Open Houses

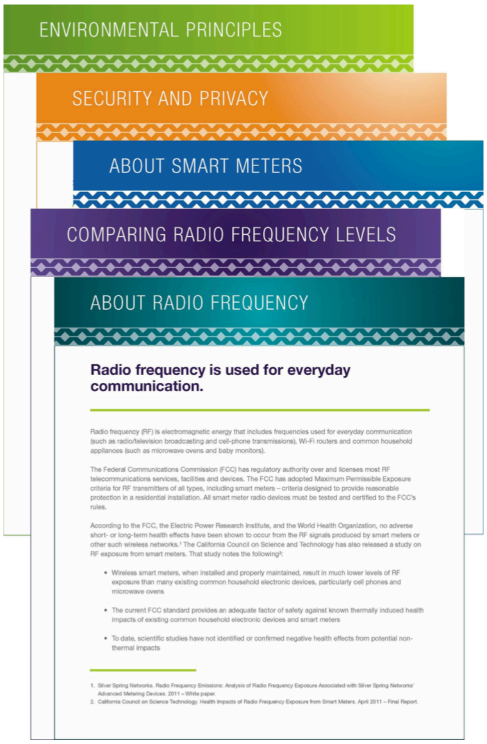
We are holding open houses in each of the communities where smart grid is being implemented. At these open houses, we meet our customers, present detailed information about smart grid, explain the benefits of smart grid, and demonstrate the Customer Energy Portal.

Customer Education

We have created educational materials so that customers can better understand the many components of smart grid and the benefits it enables. These materials adhere to our communication guidelines. They include:

- Brochures
- Question-and-answer handouts
- Website content
- Educational content in our customer newsletters and other company-produced communication vehicles
- Fact sheets
- Customer Energy Portal training materials
- Educational information regarding safety, security, and privacy issues

The content of these materials will be guided by the answers to these questions:



- What is a smart grid?
- Why is smart grid important?
- What's in it for me as a customer of the Hawaiian Electric Companies?
- What is the smart meter installation process and timeline?
- How does access to energy-use information through a customer portal work?
- How will smart grid facilitate improved service and reliability?
- What are the health risks?
- How secure is my information with smart grid?
- Is smart grid safe?

Government Relations and Stakeholder Groups

It is important that elected officials, government agencies, regulatory officials, and key stakeholder groups be informed about the project and updated on its progress. Their understanding of smart grid is critical, especially when addressing questions or concerns that may arise from their respective constituencies.

We briefed these stakeholders about our initial smart grid Demonstration Project, about their specific interests in developing our smart grid, and about any related energy issues. We intend to give them educational and informational materials.

We began these briefings before we embarked on our community outreach efforts, and plan to continue the briefings over the course of implementing our smart grid platform.

Third-Party Engagement

Early on, we engaged other key organizations during the public discussion about smart grid. We are working to foster a healthy public discussion over the role smart grid plays in building a better energy future for Hawai'i. Discussions with third-party organizations are important to helping us achieve the following:

- Building trust and transparency while engaging and educating key stakeholders.
- Helping identify customers' issues and concerns and defining key messages for customer engagement.
- Promoting awareness of smart grid benefits with trusted third-party voices.

- Allowing us to anticipate and better address communication challenges.

How we engaged each organization depended on several factors, including their areas of focus, level of interest, available resources, and operational capabilities.

Media Relations

Smart grid represents a significant change in our electric grid. As such, it has been well covered by the media, garnering much discussion in numerous media forums: newspapers, television, radio, and online. It's imperative, then, that the media have access to accurate, timely, and thorough information about our smart grid implementation and operational plans.

Our job is to enable the media to do theirs. Our media relations program addresses community, local, and regional media through outreach and the availability of relevant materials.

The experienced communication team at Silver Spring Networks is assisting us. Their experience working on previous smart grid implementations has proven valuable when responding to media inquiries, in developing responses to frequently asked questions (FAQs), and in creating other communication materials.

Customer Research

One of our most important jobs is to ensure that customers understand how smart grid modernizes our electric power grid, improves its efficiency and reliability, and creates tangible benefits for them. Their directed comments help us refine our smart grid program as well as improve the effectiveness of our communication.

To support customer participation in smart grid, we have tested various messages and materials with O'ahu residential and commercial customers involved in the Demonstration Project. We identified opportunities and barriers to acceptance, as well as effective ways to communicate the benefits of smart grid. During the entire implementation of smart grid, we are assesses customer behavior, attitudes, and opinions. We are also evaluating the entire process by interviewing our staff and residential and commercial participants to improve the delivery and maintenance of our smart grid effort.

Employee Engagement

Our own employees are a critical audience, as they play a key role in sharing information about the project with their friends and neighbors. We have engaged them in many ways to inform them about issues surrounding smart grid, thus preparing them to answer questions and discuss the project with their communities.

Customer Service Support

Many of our employees and contracted workers, as an integral part of their jobs, interact with customers throughout the day. Not surprisingly, customers who have questions about or who have an interest in our smart grid program direct their questions to our employees and contracted workers they see. We have developed materials and tools about smart grid and trained these employees and contractors to ensure they have the information needed to answer our customers' questions. We also have a process in place so that inquiries can be seamlessly escalated so that these customers receive the answers they seek.

We expect that our commercial customers to continue to contact our Key Accounts and Customer Business Management Services departments for answers and information. These employees also have the educational materials, sample questions and answers, brochures, and other communication tools to help them effectively address customer questions.

In Conclusion

We understand the importance of remaining flexible and adapting to the dynamic needs of our customers, both during the Demonstration Project and, if approved, during full implementation. That is why we have developed many different strategies and methods for communicating with our customers and engaging them in meaningful dialogue throughout the entire smart grid project.

Lessons Learned from Our Customer Outreach

While conducting our customer outreach, we evaluated its effectiveness. We discovered that the steps we took in developing our outreach program—creating a modular and adaptable program—were accurate: engage customers early and often, adjust the messages to fit the specific needs of different communities, focus on smart grid as a customer project, and adhere to our communication guidelines (page 21). We also discovered that customers need additional time to grasp the increased choices and information offered by a smart grid.

We learned how better to employ certain outreach tools when engaging our customers.

Direct Mail is indeed effective communication. We expect to launch a direct mail campaign during full implementation.

Door-to-Door Canvassing, while effective, was labor intensive and demanded a significant number of staff. In addition, it was not conducive in certain neighborhoods due to the terrain, buildings, customers, and access. For instance, canvassing was not effective in gated communities, apartment complexes, and multi-family dwellings.

Open Houses created comfortable environments for customers and their neighbors to meet with us and our trusted third-party organizations.

Stakeholder Meetings afforded us the opportunity to talk, face to face, with like-minded customers, answer their questions, and address their concerns, all in a comfortable environment.

Third-Party Engagement was productive, mainly because these organizations contributed valuable information that we used to refine our messages and improve our customer outreach program.

Customer Research that we conducted was tested with customer focus groups, which proved to be a valuable step in refining our customer outreach program. From these focus groups, we gained insight into our customers' overall awareness of the smart grid technology, identified opportunities for more effective engagement, and recognized certain barriers to acceptance that we can counteract.

Employee Engagement helped us in two ways. First, employees must be informed so they can intelligently answer questions from their friends and neighbors as well as discuss smart grid in their communities. Second, engaging our employees enabled us to evaluate and refine our communication tools, messages, and plans before engaging customers and community groups.

3. Our Smart Grid Roadmap

THE ROLE OF SMART GRID IN HAWAI'I'S ENERGY FUTURE

At the Hawaiian Electric Companies, we are committed to achieving modern and fully integrated electric grids on each of the islands we serve—grids that harness advances in networking and information technology and, as a result, deliver tangible benefits to our customers and the state of Hawai'i.

To accomplish this, we plan to invest in smart grid.

In Hawai'i, we face unique energy challenges. Due to the physical nature of our state—isolated in the middle of the Pacific Ocean, and separated into eight major islands—we are challenged with a relatively high cost of electricity. Our electric power cannot be transmitted among neighboring islands nor obtained from surrounding land as mainland utilities can. This geographic isolation makes balancing supply and demand more difficult because we cannot rely on the other Hawai'i island grids to help address short-term imbalances.

On the other hand, our state's physical location enables us to be a leader in renewable energy. At the end of 2013, 18.2% of our customers' energy needs were met by renewable resources—twice the percentage of just five years ago. We are well on the way to achieving Hawai'i's 2030 Renewable Portfolio Standard (RPS) goal of 40%. Our *Power Supply Improvement Plans* (filed last year) project our surpassing the RPS goal in year 2022.

More than 12% of our customers generate a majority of their electric energy from their rooftop-solar systems. Much of the renewable energy is from variable resources (distributed solar photovoltaics, wind, and run-of-the-river hydroelectric). Taken together, this renewable generation benefits both our customers and the environment.

This accomplishment, however, presents challenges in reliability, safety, and efficiency: solar and wind renewable generation is variable; the amount of distributed solar photovoltaics on the grid is not accurately known nor controlled; and customer-generated solar energy, for the most part, is highly concentrated on some distribution circuits.

A smart grid modernizes our electrical grid enabling a more seamless integration of renewable energy (including distributed generation), increasing reliability and efficiency, helping the environment, and lowering costs—all without compromising safety or the quality of electric service. In addition, the smart grid enables customers to make wiser choices that can guide their energy choices.

Smart Grid Fundamental Design Principles

When designing our smart grid, we pursued a few fundamental design principles to make it easier to enable current and future smart grid solutions. These design principles not only create a solid foundation now for implementing smart grid, but also essentially makes our smart grid "future proof". In other words, we will be able to seamlessly accommodate and integrate current, emerging, and hypothetical smart grid solutions into our smart grid platform, without making any changes to that platform.

The breadth of these fundamental design principles create an incredible value that is ultimately larger than the smart grid platform we intend to implement. It enables us to view our smart grid investment both in the short term and, more importantly, in the long term as a solid asset on which to build an increasingly robust electric grid that keeps pace with the ever evolving shift in our generation portfolio and the need to make smarter, quicker decisions, and to continue delivering increased benefits to our customers.

Here are those design principles.

A Common Communications Network Platform. To better ensure a stable, reliable grid, we are building our smart grid on the foundation of a common communications network platform. With this foundation, smart grid devices can interconnect and communicate with each other as well as with information technology and operational technology solutions in our back office, both now and in the future. This common communications network platform can conceptually be considered larger that our current smart grid implementation, thus being able to readily accept additions in the future. Our smart grid can decentralize and automate the commonplace decisions that are made every day to maintain a stable and reliable grid. Decisions no longer need to be made only from our back offices.

As our grid becomes more complex, the need for immediate, accurate data, the two-way flow of information, and rapid decision-making becomes ever more critical. Peer-to-peer communication and coordination among the smart grid devices scattered throughout the grid (such as voltage regulators, circuit switches, and weather sensors) becomes a necessity for maintaining a stable grid. In this new, smarter grid, decisions made in our back office can be sent into the smart grid to be executed. In addition, devices in the field can share data, make decisions, and quickly effect the necessary changes (such as optimizing circuit loads as generation from variable sources fluctuates), then send that information to the back office where it can be consolidated, stored, and analyzed.

In the end, this one common communications network is simpler to manage.

Broad Device Connectivity and Open Software Interfaces. The common communications network can easily accommodate a wide array of devices. All levels of these smart grid devices, such as in-home smart thermostats (connected through meters via ZigBee or other home area network protocols), load control switches, grid interactive water heaters, and OpenADR virtual end nodes (VENs), can be integrated through a common communications module. Open software interfaces in the back office that support various support services (such as a Demand Response Management System (DRMS) and energy balancing) make for streamlined communication between the back office systems and these devices spread throughout the smart gird.

Open Analytics Platform. An open analytics platform performs two critical functions for our smart grid, now and in the future. First, an open analytics platform makes it possible for grid assets and smart grid devices to communicate with back office systems, where the combined information can be gathered and aggregated. We can then use this information to analyze the system to provide quick and inexpensive insights into grid activity. In addition, we can provide this information to many different outside users for their own analysis. Second, an analytics platform serves as the foundation for future smart grid solutions developed by third parties that can serve to the benefit of our customers.

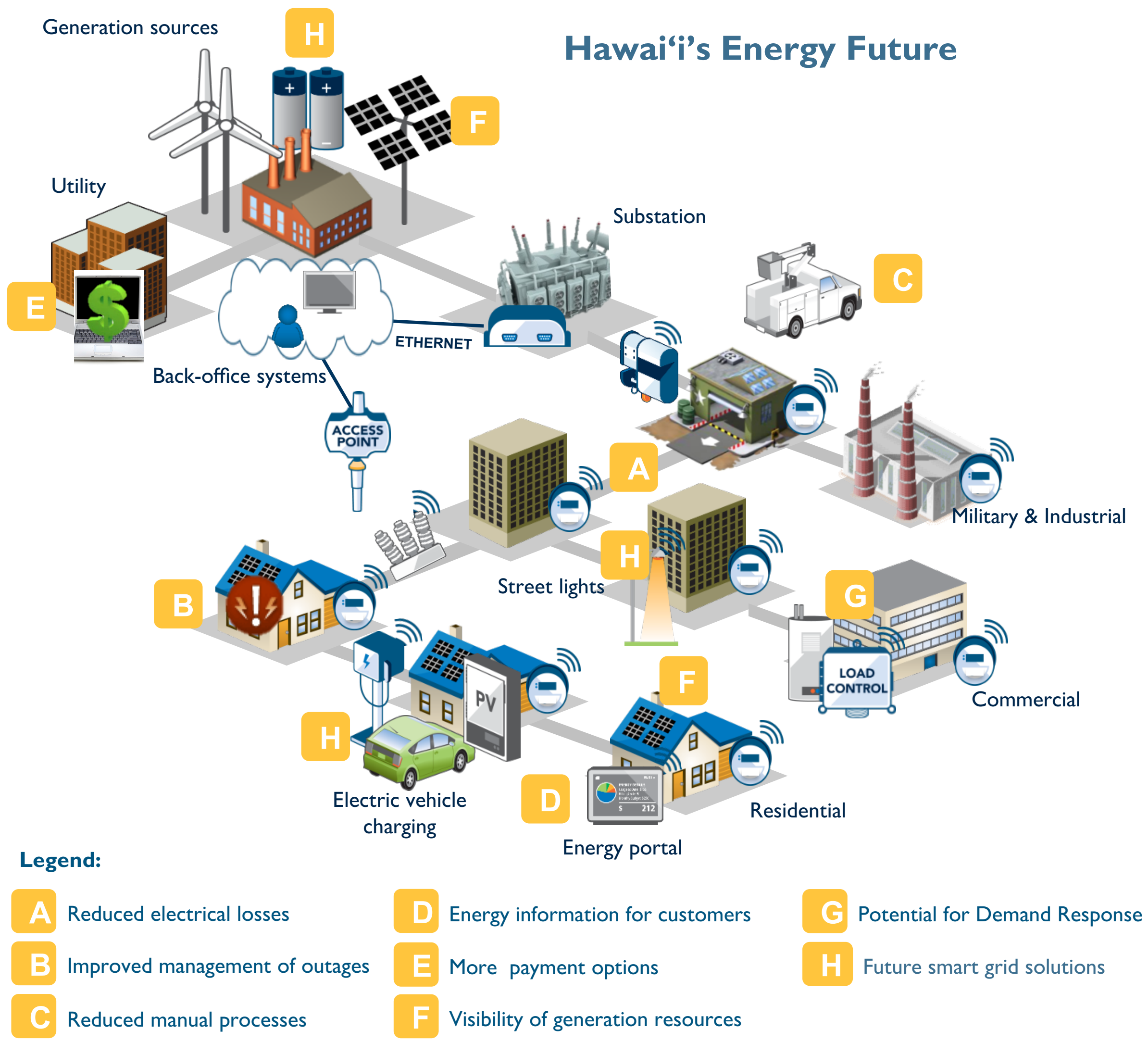


Figure 2: The Role of Smart Grid in Hawai'i's Energy Future

With these design principles in place, a smart, modern, and fully integrated electric grid enables these benefits.

A. **Reduced electrical losses** in distribution circuits can be achieved by optimizing the electricity voltage levels between substations and customers along distribution lines. Optimized voltage levels could enable customers' electrical equipment to operate more efficiently, thus consuming less power. System losses can also be reduced by offsetting the reactive power required by inductive loads (such as large motors) by controlling distribution assets throughout the system. The combination of optimized voltage levels and reduced losses can lower customer distribution costs without requiring customers to change their electricity use and without negatively affecting the quality of power delivered.

B. **Improved management of outages** by automatically detecting outages on distribution circuits beyond those currently detected through the conventional SCADA (existing communications) and EMS (Energy Management Systems), and by precisely determining those customers affected by the outages. Less time locating and diagnosing an outage can lead to reducing the time needed to restore power to customers. After work crews restore power, they can confirm that full power has been restored to all affected customers before leaving the affected area. In addition, information about outages can be more accurately and quickly communicated to the general public and the media. Distribution automation solutions can also automatically reroute power around outage areas, thus minimizing an outage's impact before arriving at the point of failure. Work crews can quickly reconfigure the network to isolate the faulted area and restore service to the non-faulted portions of the network. A common communications network platform enables the centralized and peer-to-peer communication necessary for employing these outage solutions.

C. **Reduced manual processes**, some of which can be completely eliminated, save time. With Advanced Metering Infrastructure (AMI) solutions, we can read electric meters, activate new service, and disconnect existing service from a central location rather dispatching resources to a customer site. Adding communications to distribution grid assets enables remote management of those devices, resulting in reduced truck rolls. These cost savings are then passed along to customers.

D. **Energy information for customers** about their energy usage, in a timely fashion. Customers, then, can make informed decisions about optimizing their energy usage, thus lowering their electricity bills.

E. **More payment options,** including dynamic tariffs, encourage shifts in how energy is used, breaking inefficient patterns. Taken together, the grid can be operated more cost-effectively, lowering customer bills.

F. **Visibility of generation resources** connected to grid distribution circuits. The smart grid enables a more accurate accounting of the two-directional power flowing on these distribution circuits, allowing system operators more accurate modeling and improved visibility of the power production. We also envision a more accurate accounting of system generation and distributed generation, and their interconnections between the distribution grid.

G. **Potential for Demand Response.** The smart grid integrates Demand Response programs, giving grid operators additional resource options when balancing supply and demand. Smart grid solutions make it feasible to consider Demand Response programs for numerous uses: shifting load demand for energy balancing, deferring new electricity to meet peak loads, regulating the frequency of the electrical system when intermittent renewable resources are ramping up, designing and implementing microgrids within distribution circuits, and reducing the requirements for keeping energy in reserve to better operate the electrical grid.

   Each use has specific operational and technical requirements to meet our functional need. The cost-to-benefit of each type of use determines the potential Demand Response value compared to other resource technologies. We plan to incorporate Demand Response programs where the technical capabilities meet the system security requirements and their use results in overall customer savings from reduced operational costs. Customers participating in Demand Response programs could also be compensated or have a direct benefit of reduced costs.

H. **Future smart grid solutions** and services that enable the grid to operate more efficiently. For instance, electric vehicles can be scheduled to charge when energy costs are low or be optimized to better support grid operations. The smart grid can monitor and control larger energy storage systems connected to the distribution system, potentially improving system operation. Also, energy management systems for buildings, facilities, and resorts can use energy more intelligently (including the potential to integrate these systems with the grid). The management of customer assets and grid assets can be integrated to balance energy either from the back office or distributed throughout the power grid, thus unifying grid management. Other solutions can remotely control lighting and electric appliances in homes and businesses. These and many other future solutions are possible because of the smart grid's common communications network platform.

OUR SMART GRID ROADMAP

For several years, the Hawaiian Electric Companies have monitored smart grid technology developments and smart grid programs at other utilities. We recently decided to implement smart grid on the distribution grids of the five islands we serve. To comply with the Commission's Docket No. 2008-0303 in 2008, we have created this robust *Smart Grid Roadmap Update* to guide the five smart grid designs and implementations.

Here is an overview of the roadmap we have travelled, and are still travelling, along our smart grid journey.

Preparing for smart grid. After submitting a smart grid application in 2008, we decided to defer its implementation. Instead, we watched the technology mature until we were certain it was proven, safe, secure, and reliable. In the meantime, we researched and selected a strategic partner in Silver Spring Networks. We made this decision based on their expertise and experience, as well as their network communication platform (called Internet Protocol version 6, or IPv6) and suite of smart grid solutions.

Planning for our smart grid. Working with Silver Spring Networks, we evaluated smart grid implementations from four mainland utilities that were based of the IPv6 platform. We visited their sites, talked with them, and evaluated their smart grids. From this evaluations, we developed a set of best practices to follow in our own smart grid implementation. We implemented a limited-scope Demonstration Project of core smart grid solutions on four circuits on O'ahu. During the project, we reached out to customers to educate and engage them about smart grid, and saw first-hand what benefits smart grid could bring to our customers. From this project, we learned a number of lessons that we employed when designing a smart grid that can deliver the most robust set of benefits to our customers.

Creating a smart grid solution. From our experiences, from our lessons learned, from our best practices, and from the expertise of our strategic partner, we created our smart grid roadmap. Our smart grid platform is based on the stable IPv6 network communications platform, and includes numerous smart grid solutions. Our smart grid application, which we plan to submit to the Commission later this year, details the specifics of our planned smart grid platform.

Implementing our smart grid. While designing our smart grid platform, we simultaneously designed a viable implementation plan. Upon approval of our application, we plan to begin strategically implementing smart grid in 2016, with tiered installations through 2018.

Our ultimate goal is to ensure that smart grid becomes a beneficial reality for Hawai'i's electric power grid and, most importantly, for our customers.

PREPARING FOR SMART GRID

Thoughtfully Implementing Smart Grid

In 2008, Hawaiian Electric filed the Advanced Metering Infrastructure (AMI) Project Application to the Commission to install smart meter technology provided by Sensus (an industry leader in clean technology equipment) on certain circuits on O'ahu. After further evaluation, however, we changed our plans and chose not to be an early adopter.

To better understand the technology, we spent considerable time and effort over the next five years researching and evaluating smart grid options, closely watching industry developments, and analyzing smart grid implementations at four other utilities. We also partnered with Hawai'i Natural Energy Institute (HNEI) on smart grid research projects.

We learned lessons from these similar smart grid implementations, and crafted our roadmap for designing and implementing a smart grid and choosing the smart grid solutions that drive the most benefit for our customers.

Adopting Proven, Safe, Secure, and Reliable Technology

Adopting smart grid technologies when they are more mature enabled us to investigate and address the central concerns surrounding this technology, and to conclude that smart grid technology is safe, secure, and reliable.

One concern raised in relation to other smart grid implementations involves the safety of radio frequencies generated by smart grid devices. Numerous studies have addressed this issue. A study conducted by EPRI— *Radio-Frequency Exposure Levels from Smart Meters: A Case Study of One Model*—found radio frequency exposure levels to be well below limits set by the Federal Communications Commission (FCC). Moreover, these radio frequencies from smart meters are lower than those generated by common devices (such as mobile phones and microwave ovens). The smart grid communications network is safe.

One of the fundamental cyber security considerations is that, to derive additional customer and system benefits, more types of data and more robust data flows are required across the electric grid. These new data types and new data connections, in turn, can tend to blur the traditional bright line distinction between business systems and control systems. For example, residential electric meters are purely an interconnection point and a device for recording electric consumption. In a smart grid environment, the residential meter retains that role, but can also better manage the grid itself, detecting line voltage and systems outages, far more proactively than in the past. In a sense, the implications of smart grid to cyber security can be summarized as follows:

Smart grid capabilities → more data flows → more cyber security controls.

The network infrastructure that delivers data to and from customers employs a variety of technologies to securely communicate sensitive, mission-critical information. The smart grid platform employs a layered defense-in-depth approach to data encryption and network security—including multiple checks, and limits and restrictions to network access. As with other complex data networks, we are not impervious to attack or compromise. As a result, we implement perimeter defense systems and additional security measures intended to make our systems more intrusion tolerant. Being 'intrusion tolerant' assumes some level of cyber intrusion can happen, and thus takes actions to decrease (but not eliminate) the impact of such a compromise. This type of cyber-security system are designed consistent with NERC recommendations (in their document *Reliability Considerations from the Integration of Smart Grid*). The systems are implemented in a way intended to protect the network against cyber-attacks and enhance protection of both customer-specific and system-wide data.

Smart grid technology has proven to have a greater than 99% reliability factor for the availability of back office system and the performance of reading and registering meter readings.

Nonetheless, we expect some customers to still have concerns about smart meters and the use of other smart grid devices. As such, we offered a deferral option during our Demonstration Project; and we offer an opt-out program for customers who prefer not to take part when we are fully implementing smart grid.

Selecting a Strategic Partnership

Early on, we concluded that it would be beneficial and prudent to engage a strategic partner with proven smart grid experience in the electric power industry. We based our choice on several factors: we reviewed potential smart grid solutions, conferred with peer utilities in various stages of their smart grid implementations, experienced first-hand other pilot projects, and interviewed candidate firms.

After much deliberation, we chose Silver Spring Networks as our strategic partner. Silver Spring Networks provides technical expertise, its IPv6 communications network platform, and a suite of smart grid solutions; they also assist us with designing and implementing our community outreach programs.

Together, the Hawaiian Electric Companies and Silver Spring Networks plan to design a unique blend of smart grid solutions for each of the islands served. Each blend of selected solutions brings the most tangible benefit to customers and to the entire state. We base our conclusions on our understanding of the way smart grid technologies can change the specific grid operations to yield greater operational efficiency while improving reliability. We are verifying and carefully analyzing how the technical and operational smart grid capabilities can meet their anticipated uses, and how they impact operating costs.

We expect our strategic partnership with Silver Spring Networks to account for an estimated 10% of our full smart grid implementation. The remaining 90% is comprised chiefly of other third-party items (smart meters, endpoint hardware, installation labor, and other back office software and services), all of which will be procured through a competitive process.

Moving through our roadmap, we might engage other smart grid technology partners of Silver Spring Networks for smart grid solutions that benefit the Hawaiian Electric Companies electric grids, and our customers.

Our Strategic Partner

Silver Spring Networks, an industry leader in smart grid technology, is our strategic advisor, delivering the smart grid platform, and bringing together a team of utility and industry partners to help us implement smart grid, efficiently and intelligently.

Over the past decade, they have successfully installed their smart grid mesh technology to serve over 20 million homes and businesses for more than 30 utilities. They have experience working with more than 75 technology companies and device manufacturers, and command the largest market share for AMI in the country.

Silver Spring Networks offer proven smart grid technology which includes customer engagement software, cloud services, and unified grid-management software tools. Their network tools include a NERC-recommended security system, ensuring that our data network security from both internal and external attacks is at the highest level.

In choosing to work with Silver Spring Networks, we committed to install their smart grid platform, consisting of its IPv6 communications network, head-end software systems, and professional services. Their communications network supports a wide array of third-party solutions.

We believe a strategic partnership with Silver Spring Networks is a prudent business decision, one ensures customer benefits are delivered quickly and efficiently.

PLANNING FOR OUR SMART GRID

Our *2013 Integrated Resource Planning Report* concluded that smart grid technology was mature, would deliver tangible benefits, and should be implemented on our distribution grids. We committed to fully implementing smart grid across all five service islands by the end of 2018.

Learning from Other Utilities

Our own smart grid team immersed themselves in current technology and reviewed core smart grid solutions at several utilities. We wanted to review core smart grid solutions in action, validate the maturity of the technology and its corresponding benefits, and discover any potential implementation problems we might have to overcome. Our smart grid team visited several utilities running Silver Spring Networks' smart grid platform (Figure 3) to find some answers:

- Oklahoma Gas and Electric (OG&E)
- Commonwealth Edison (ComEd)
- Florida Power and Light (FPL)
- Sacramento Municipal Utility District (SMUD)

	OG&E	ComEd (An Exelon Company)	FPL	SMUD
Solutions Implemented	AMI with Outage Management, Customer Energy Portal, Prepay, Direct Load Control	AMI with Outage Management, VVO	AMI, Distribution Automation	AMI with Outage Management, Distribution Automation
Networking / Technology Platform	Silver Spring Networks IPv6	Silver Spring Networks IPv6	Silver Spring Networks IPv6	Silver Spring Networks IPv6
Number of Endpoints Implemented	832,000	203,000	4,600,000	626,000
Year Network / Technology Operational	2009	2009	2008	2009

Figure 3: Smart Grid Implementations Evaluated

Our team gained enough information and understanding to validate that smart grid technology was mature, and that some of the cyber-security requirements that addressed privacy and security concerns were relevant to us. The team also confirmed that these four smart grid implementations not only effectively integrated advanced metering, but also enabled Distribution Automation (DA), Conservation Voltage Reduction (CVR), Outage Management Systems (OMS), Demand Response (DR) programs, and some future solutions (such as remotely managing street lights) to operate on their communications network.These four utilities were all at different stages of their implementation— from planning to full implementation to ongoing maintenance—which served to broaden our exposure and understanding.

OG&E had completed installing nearly 95% of their smart meters, and implemented a critical peak pricing program that helped defer new generation capacity. ComEd was in the early stages of full implementation for AMI.[2] FPL had already completed its AMI implementation, so we were able to see how the AMI system operated and was maintained. SMUD—similar in size to the Hawaiian Electric Companies with approximately 640,000 customers, and which uses a similar SAP Customer Information System (CIS)—was almost finished, having already installed 626,000 endpoints.

Our team gained valuable information from each utility in these areas:

- AMI network implementation, operation, and maintenance.
- IT integration: the cost and scope of integration, the requirements for a meter data management system (MDMS), and details about types of enterprise systems each utility had implemented.
- Staffing requirements during the planning phase, when implementing and maintaining the AMI systems, and for fulfilling IT requirements and maintenance.
- Transition plan for meter reading and field services personnel.
- Planning, implementing, and maintaining several smart grid solutions and their realized benefits.
- Customer engagement planning.

While this research was ongoing, we collaborated with Silver Spring Networks to develop a smart grid roadmap, a Demonstration Project to conduct a limited smart grid pilot, and a high-level business case to fully implement smart grid. Silver Spring Networks discussed how some of their other utility partners engaged customers which enabled us to start developing our own customer engagement plan.

[2] ComEd had already implemented 131,000 smart meters under a pilot program before starting their full implementation program. The Illinois Commerce Commission (ICC) approved ComEd's AMI Plan (case number 12-0298) with minor modifications. The ICC found that the ComEd AMI Plan met with the conditions of the Energy Infrastructure Modernization Act (EIMA) and was cost beneficial.

Here is a summary of the best practices we learned during our visits.

Developing Best Practices

Information Technology (IT) Best Practices

Each visited utility has specific requirements for Information Technology (IT) because each has different back office systems integrated in various ways. For example, each utility has a different Customer Information System (CIS), Outage Management Systems (OMS), and Meter Data Management Systems (MDMS).

The Hawaiian Electric Companies do not currently run an MDMS, nor did we need one for the Demonstration Project because only a small number of the smart meters were being installed. However, with full implementation, an MDMS is necessary to manage and analyze the large volume of interval usage data being collected from the AMI meters. Initially, we intend to install a Silver Spring Networks hosted Software as a Service (SaaS) solution for the MDMS with their UtilityIQ Advanced Metering Manager (AMM) system. During the first year of full implementation, we expect to transition from the AMM to a MDMS hosted by the Hawaiian Electric Companies.

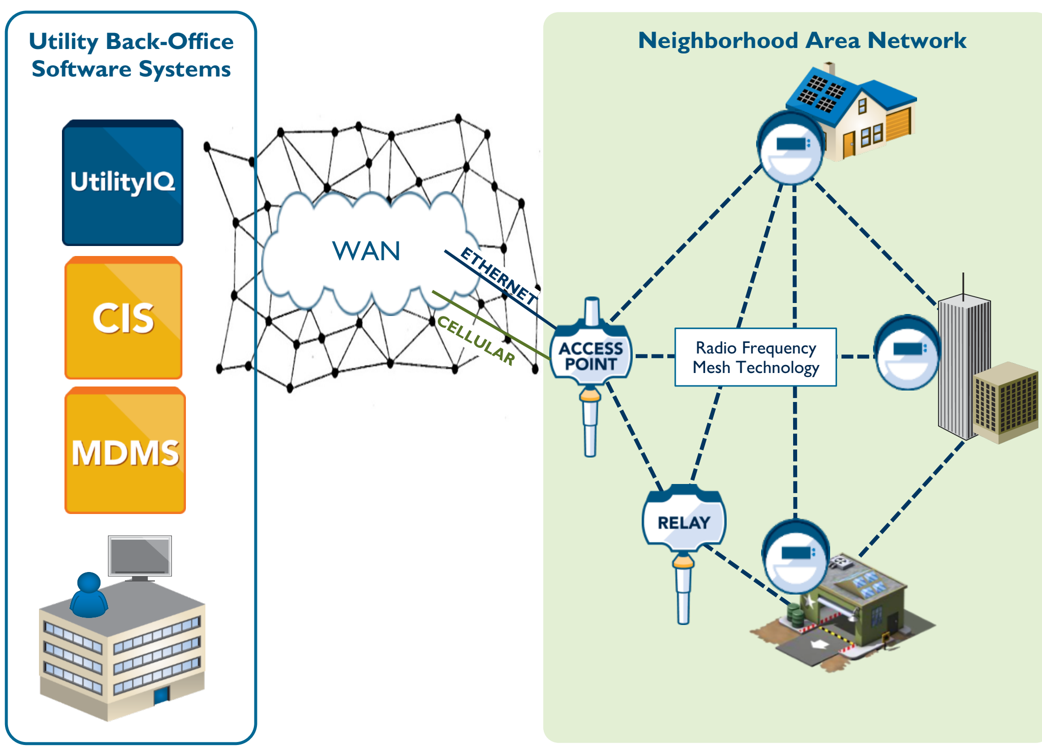


Figure 4: Smart Grid Interconnection with Back Office Software Systems

Figure 4 depicts how the network communications platform connects the radio frequency mesh technology (that in essence collects data from the smart meters) with our back office systems.

Customer Engagement Best Practices

An effective customer engagement plan, successfully put into practice, is of paramount importance before implementing smart grid. Such a program must address the three top customer concerns surrounding smart grid —that is, safety issues related to radio frequency, privacy, and security.

Our customer engagement program for the Demonstration Project is still underway. Our visits to other utilities not only validated the need for planning, but also showed us different ideas on how to respond to customer inquiries.

Oklahoma Gas and Electric (OG&E) has implemented a Silver Spring Networks Web portal (a Customer Energy Portal), which has proven to be an effective tool for their customers. They clearly know how to serve their customers. In 2013, OG&E received a J.D. Power and Associates award for the highest customer satisfaction in the South. Edison Electric Institute awarded their prestigious 2013 Edison Award to the utility for its innovative SmartHours program, engaging customers and delaying the construction of additional fossil-based generation.

We have seen demonstrations of this Customer Energy Portal. Feedback has been very positive as it provides an ideal level of information to customers.

Prepay Best Practices

OG&E runs a small pilot program of roughly 600 customers using a Prepay software system provided by Exceleron. The pilot, however, allowed us to glean only a limited amount of information.

Distribution Automation (DA) Best Practices

ComEd, FPL, and SMUD have all implemented Distributed Automation. This smart grid solutions uses the AMI network to garner information about meters and consumption, and employs Bridges (a Silver Spring Networks product) to provide monitoring and control information to and from distribution switches, reclosers, fault circuit indicators (FCIs), and a host of other Distribution Automation assets.

Demand Response (DR) Best Practices

Demand Response, which includes Direct Load Control (DLC) and Dynamic Pricing, can provide us many opportunities.

OG&E uses a day-ahead critical peak pricing Demand Response program to alert its customers when an event will occur the following day—between peak hours of 2:00 PM and 7:00 PM—when electricity is 44¢ per kilowatt hour (about 10 times the normal rate). The utility urges customers not to use energy during peak periods and gives them incentives to meet energy needs during other times of the day. For instance, customers can raise the temperature setpoint of their centralized air conditioning to conserve energy during these peak-hour periods, thus directly controlling their electricity use and lowering their bill.

We learned how we could implement and market a critical peak pricing program. We still need to evaluate just how many of our customers could actually use such a program.

Creating a Smart Grid Demonstration Project

In early 2014, we began a pilot implementation, a Demonstration Project, of smart grid. This Demonstration Project was based on the best practices garnered from our evaluation of smart grid implementations at other utilities. To reduce risk, we designed the Demonstration Project to mirror our potential full implementation. We conducted this Demonstration Project simultaneously with our Maui pilot project.

The Demonstration project included implementing a suite of smart grid solutions: AMI, a Customer Energy Portal, Prepay, Conservation Voltage Reduction, Distribution Automation (DA) with fault circuit indicators (FCIs), an Outage Management System, and Direct Load Control (DLC) program.

The Demonstration Project included approximately 5,200 customers on six 12 kilovolt (kV) distribution circuits in four different areas of O‘ahu (Figure 5). These neighborhoods circuits are fairly standard, reflecting a general mix of homes, businesses, physical terrain, and diverse cultures across the island. We replaced traditional meters with AMI smart meters for all rate classes on these six circuits. The Demonstration Project circuits represent statewide demographics and geography so that smart grid is demonstrated in a broad array of environments.

Customers who participated in the Demonstration Project were able to access a Customer Energy Portal where they could monitor their energy use and choose to use a Prepay program.

The Demonstration Project served many roles: demonstrate smart grid solutions in the Hawai'i environment, fine-tune the installation process, evaluate upgrades to the grid and substations, engage customers, and gather feedback from customers about the smart grid and smart meters

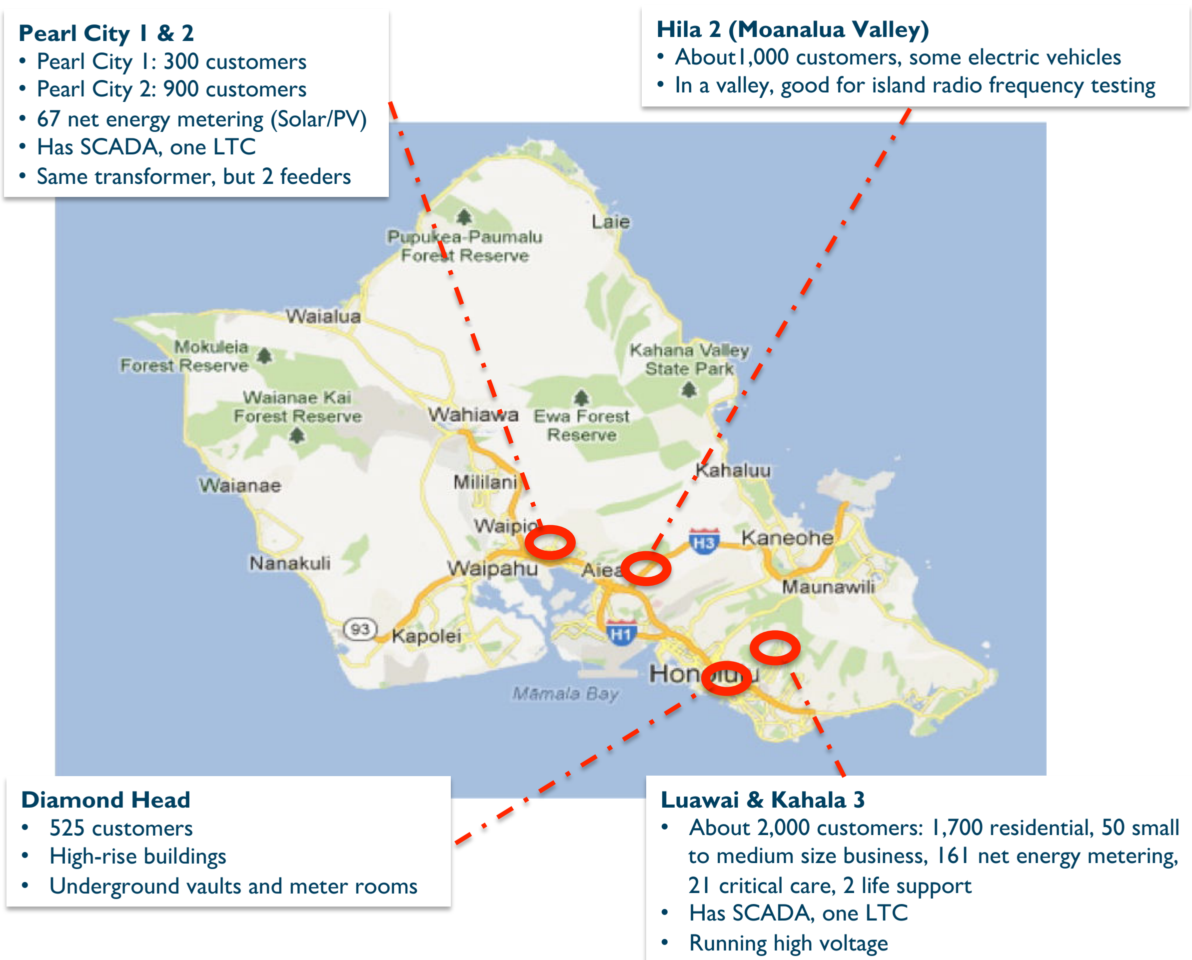
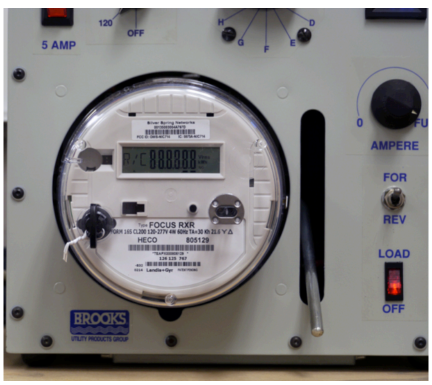


Figure 5: Demonstration Project Overview

In November 2014, we announced a plan to use smart inverters to clear the backlog of customers awaiting approval to connect their rooftop solar systems. Under the plan, the rooftop solar systems must use smart inverters (a smart grid solution) that meet stricter settings for preventing transient overvoltage or rapid voltage spikes that can endanger customers, their appliances, and utility equipment. The smart inverters must also be able to "ride through" unstable frequency and voltage conditions during emergencies on the island-wide electric grid. We also installed Load Tap Changers (LTC) that enable voltage regulation on a circuit by changing voltage in real time.

During the Demonstration Project, we contacted and educated our customers so that they could better understand smart grid, its incumbent benefits, and our implementation plans as well as address any concerns. Our multi-pronged outreach program includes an initial contact letter, door-to-door canvassing, open houses, and a plan for communicating when implementing and operating smart grid.

We have engaged Electric Power Research Institute (EPRI—an industry research organization) to validate Conservation Voltage Reduction (CVR) results from the Demonstration Project and help us develop a systematic approach for a full implementation of CVR. Silver Spring Networks assisted us in developing metrics to monitor the effectiveness of other smart grid solutions.



Now that the Demonstration Project has essentially completed, we are synthesizing the information garnered from the demonstration together with our Maui pilot projects. We are using this information in our application to the Commission for a full implementation of smart grid with solutions tailored individually for the O'ahu, Maui, Lana'i, Moloka'i, and Hawai'i Island grids. We have chosen smart grid solutions based on a refined cost-to-benefits analysis from the Demonstration Project and specific analysis of proposed operation and technical use in reducing operational costs. We expect to implement certain foundational smart grid solutions on all five islands: AMI, Customer Energy Portal, Prepay, CVR, Distribution automation (DA) with fault circuit indicators (FCIs), an Outage Management System, and Demand Response (DR).

Learning Lessons from Our Demonstration Project

We amassed an abundance of lessons from our Demonstration Project, mainly from our implementations of AMI, Customer Facing Solutions, Prepay, and CVR. From these lessons learned, we intend to perform a number of tasks to ensure a smooth road when fully implementing smart grid.

AMI Lessons Learned

Ensure the smart meters have been fully tested and vetted, and successfully operated for several months to eliminate with the installation and the meter configuration templates. Also ensure First Article Testing meters has no issues.

Create a clear communication path between the third-party Work Order Management System (WOMS) integration personnel and our system integration personnel. Clearly state and document the interface development of the interface between our Customer Information System (CIS) and the WOMS.

Select the appropriate method for integrating our CIS and the WOMS: either an Enterprise Service Bus (ESB) or SOAP Messaging Integration. The Flat File Integration method employed in the Demonstration Project, while appropriate for the relatively small amounts of data in that pilot, is inappropriate for a full implementation of smart grid.

Ensure this is sufficient personnel to plan, document, execute, and test the interface between our CIS and the WOMS, and to meet the work deadline in the implementation schedule. Then retain the knowledge from the contractors who developed the interface.

Just to reiterate what we already know: engaging our customers played a big role in the success of the Demonstration Project. Continue that customer outreach to inform our customers of all the safety, security, and privacy issues inherent in smart grid, and hopefully quell some of their concerns.

Develop an automated method for managing, tracking, and installing smart meters and other equipment for full implementation. While the manual method of managing and tracking was sufficient for the limited Demonstration Project, it is not appropriate for the larger scale project.

Establish a clear and transparent method for tracking and accounting for vendor work. for immediately communicating successes and deficiencies, and for creating a means to remedy any deficiencies.

Customer Facing Solution Lessons Learned

Establish a clearly defined scope of the deliverables for the Customer Energy Portal. Develop and maintain a matrix of the roles and responsibilities for all parties involved. Understand and document the functionality and limitations of the Customer Energy Portal before beginning its design and development.

Ensure that account-level data in the Customer Energy Portal can be easily understood by our customers. Customers who become educated about their usage trends tend to make energy-efficiency improvements at their premises.

Make the Customer Energy Portal mobile-friendly, ensuring key content is navigable and visible on these smaller screens. Many customers may normally access the portal from a tablet or smartphone, and want occasional access while away from home to check energy usage.

Employ fully standardized, mature, and proven technologies in securing websites to ensure that the private information of our customers is protected. Include our privacy policies on the portal website to allay customer fears.

Continue to share information throughout the company, especially with the customer call center. The customer call center educates customers and respond to inquiries about smart meters and the Customer Energy Portal, as well as many other issues.

Collect customer comments through focus groups, surveys, and other communication tools to obtain their perspective on the design and function of the Customer Energy Portal. Engaging with the customer helps validate the usefulness of their information.

Establish a centralized issue tracking tool for all phases of the smart grid implementation. Increase awareness and responsiveness to various issues updating their status, assigning responsibilities, and prioritizing issues.

Initial Phase Prepay Demonstration Lessons Learned

We were very interested to assess the results of Prepay from our Demonstration Project mainly because we didn't learn very much about Prepay when we evaluated smart grid implementations at other utilities. As a result, we identified a number lessons about Prepay from a number of different areas that we intend to apply during full implementation.

Developing Prepay with Our Internal Team

Being a relatively new program, Prepay created an impact on many areas of the Company: Regulatory, Legal, Pricing, Billing, Credit, Payment Processing, Contact Center, Field Service, Meter Reading, Education & Consumer Affairs, Corporate Communications, Online Communications, Customer Communication & Research, Accounting, Dispatch, and our back-end processing infrastructure. While the simple number of people involved created some unwieldy moments during our meetings, we found they involvement beneficial to the entire process. For full implementation, we intend to:

- Involve all areas throughout the implementation, and establish clear roles and responsibilities.
- Create work flow charts for all processes (such as Interactive Voice Response routing, enrollment, and de-enrollment processes) to keep departments informed, as well as to identify gaps in the process and then fill them.
- Conduct weekly meetings to inform contributing departments of current developments (for example, when the Consumer Advocate was reviewing our welcome kit).

- Involve CIS staff when developing a blueprint design of Prepay because consultants sometimes do not fully understand the nuances of the design and impact of our current system.

Defining Metrics to Measure Success

To measure the success of Prepay, we intend to:

- Survey customers to gauge their interest in Prepay (as well as other smart grid solutions) before full implementation. This helps up determine customer interest, customer profiles, and customer demographics.
- Clearly define the measurement of success, then inform our internal team. For example, we must identify the number of customers that make Prepay cost-effective, then evaluate their experience based on specific predefined metrics, including outcome-based metrics.

Working with the Prepay Vendor

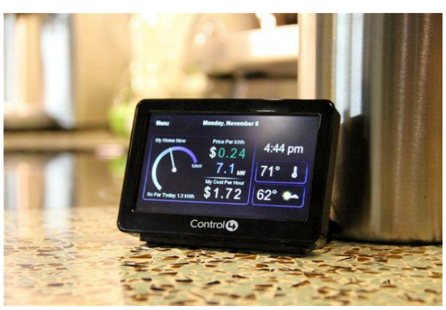
When working with our selected vendor, we intend to:

- Ensure the vendor is onsite for user acceptance testing.
- Engage the vendor early in the implementation process to minimize delays.
- Ensure the vendor is onsite when Prepay goes live.

Creating Back-End Processes

We intend to follow these best practices when creating the back-end processes needed to run Prepay:

- Decide between a batch process or a real-time process for transferring Prepay data between our customers and our back—end processes, determine which processes are best processed as a batch or in real time.
- Develop a clear plan for creating a test and production environment, then ensure this plan is fully carried out before Prepay goes live.



- First design necessary business process, and decide which processes can be manual and which must be automated.

Designing Prepay for Ease of Use

To make Prepay easy to use for customers, we intend to:

- Design a cohesive look and feel to all documents (letter, survey, brochure, and other information) in the Customer Welcome Packet.
- Create an easier process for customer enrollment, including online enrollment.

- Ensure customers can conveniently make their initial payment the same day they enroll in Prepay. (More specifically, reconcile the next-day payment processing glitch with the Western Union transaction fee.)
- Allow all customer deposits currently on hand to cover their minimum starting payment.

Planning the Prepay Full Implementation

We intend to follow these best practices when planning to fully implement Prepay:

- Coordinate the installation of smart grid solutions among the affected company departments. For example, in a past installation, two company departments (Key Accounts and Meter Shop) made separate installations to a customer neighborhood, when up-front coordination could have combined this into one installation.
- Test different types of payment options (automatic bill pay, employee paycheck deduction, Western Union transfer, as well as others) against our billing system.
- Define which reports must be automatically generated and sent to a distribution list and which are can be generated on demand.
- Clearly identify the decision makers to ensure they are informed and can respond in a timely manner.

Designing Prepay for Full Implementation

We intend to follow these best practices when designing Prepay:

- Compile and review customer comments received by our Customer Service Representatives to determine key areas about Prepay that must be proactively addressed.
- Review our overall approach to recruiting customers to better assess our experience and to design more recruitment methods.
- Add a separate prepay rate schedule in our billing process if we want to differentiate between Prepay customers and Schedule R customers. Currently both from the same rate schedule.
- Change our Bill Print program to accurately reflect Prepay amounts. Currently, Prepay bills indicate a “Total Amount Due” and “Due Date” for amounts that have already been paid.
- Determine how best to handle minimum charges for Demand Response credits.
- Investigate whether a new rate plan must be developed for Prepay customers (that is calculated differently from Schedule R).
- Include a process for LIHEAP (Low Income Home Energy Assistance Program) customers.

- Print the legend "do not enclose payments" (or something similar) on return envelopes sent to Prepay customers because payments will not be timely processed.
- Create logins before running the user acceptance testing; ensure testers understand their role and attend sessions on time.

Applying our Learned Best Practices during Full Implementation

Finally, we intend to apply these best practices when fully implementing Prepay:

- Enroll employees in the final implementation version of Prepay to fully test the program and fix any problems before enrolling customers.
- Work together with the Commission and the Consumer Advocate when the final implementation version of Prepay to address their concerns and agree on the program's design (such as the rate structure, rules, and customer materials).
- Take notes and track of open action items; ensure responsible parties report on their progress resolving their assigned action items.
- Maintain an internal project fact sheet so that everyone kept up to date with all issues.

Conservation Voltage Reduction (CVR) Lessons Learned

Employ the systematic approach we developed (based on work performed by EPRI) to prioritize the distribution circuits for CVR during full implementation. CVR is most cost effective when dropping voltage on a large load block of load without excessive circuit work needed. Circuit and bus characteristics that make CVR more attractive include:

- High load
- High load density
- Bus voltage regulation
- Short circuits with low voltage drop
- Higher voltage primary circuits
- Balance currents
- Low reactive power
- Short secondaries and services

Implement CVR on existing distribution circuits based on the following priority: (1) circuit peak load, (2) existing substation bus voltage, (3) three-phase line length, and (4) existing SCADA infrastructure. This priority is based on our experience modeling and analyzing CVR during the EPRI *Green Circuits* study, as well as other EPRI projects.

Use smart (AMI) meter voltage data to assess, analyze, and address existing voltage conditions that are ±%5 normal voltage. Per Rule No. 2, Character Service of the tariff specifications that govern the service voltage delivered to our customers, we must deliver voltage within 5% above or below the nominal voltage. Smart meters can identify voltage that exceed ±5% of normal voltage, enabling use to immediately address this issue. Voltages at or below %5 of normal, however, must be addressed before we implement CVR. In other words, the purpose of CVR is to reduce voltage to save energy, thus we cannot apply CVR to those customers whose voltage is already below the tariff limit.

Conducting Additional Smart Grid Pilot Projects

> All this is coming.

CREATING A SMART GRID SOLUTION

In creating our smart grid platform, we combined what we learned from other utilities and what we learned from our Demonstration Project, then used that combined experience and knowledge to design a smart grid platform that is best for us, for Hawai'i, and for our customers. We took a holistic approach to our decision-making, ensuring that all the parts interconnected and worked together.

The Smart Grid Network

We selected Silver Spring Networks not only as an ally for creating a thoughtful smart grid platform, but also for their proven IPv6 communications network and for their smart grid solutions.

The smart grid network has many components. At its most fundamental, the smart grid applies modern networking and information technology onto the existing electricity distribution grid infrastructure to create a more robust, responsive and resilient grid connected and managed through a communications network. The smart grid network resides between the residential, commercial, industrial, and military customer locations and our enterprise-level telecommunications network on the electrical grid infrastructure (Figure 6). This network is commonly referred to as our Wide Area Network (WAN) and our Field Area Network (FAN). Inside the WAN resides smaller geographic networks, referred to as Local Area Networks (LANs) and Neighborhood Area Networks (NANs).

We plan to implement the IPv6 platform over the telecommunications network utilizing a standards-based networking throughout our electric distribution grid infrastructure. This standards-based approach delivers a secure, common platform for a variety of specific smart grid solutions. The smart grid network connects devices across our distribution system, and transports data from those devices to access points connected to the nearest FAN or WAN. This data is carried to back office software programs that allow utility personnel greater visibility and the possibility for greater control of the grid, particularly at the distribution level. While the IPv6 network will transmit smart grid data, we will own the FAN and WAN at our operating utilities.

The network also lays the foundation for a host of other smart grid solutions running in the NAN—both existing and emerging—that we and our customers can phase in over time.

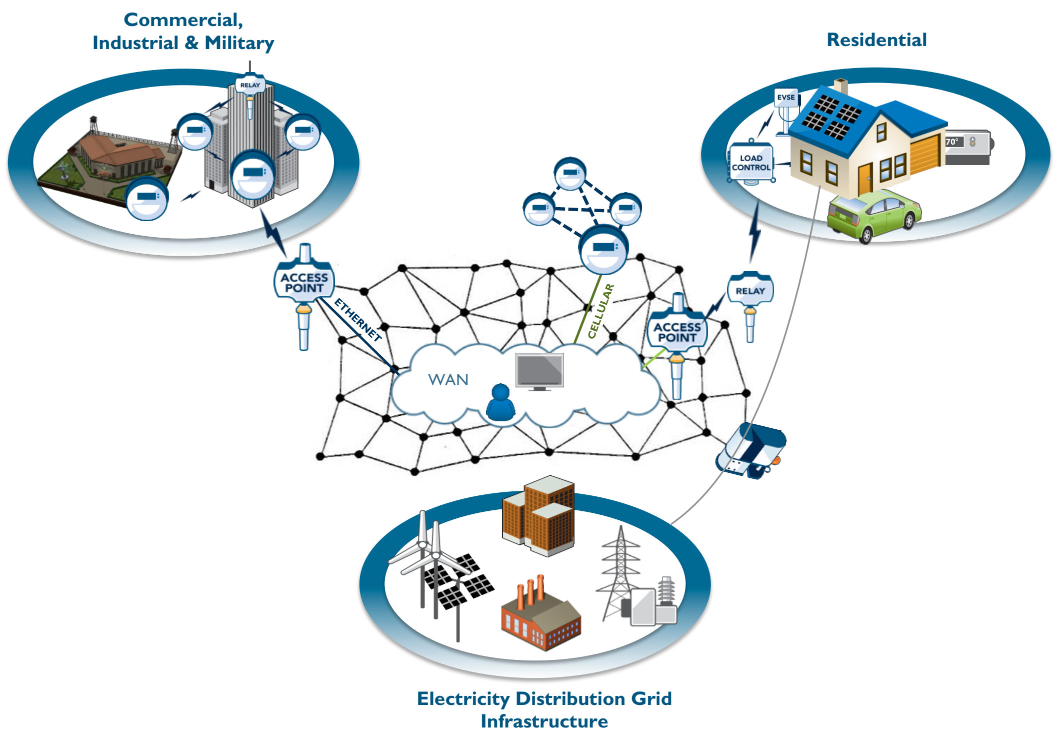


Figure 6: Smart Grid Communications Network

The smart grid solutions and end devices (such as the smart meters), fault circuit indicators (FCIs), SCADA-enabled distribution line transformers and switches, reside in the Neighborhood Area Network (NAN).

Smart Grid Solutions

Many smart grid solutions can be layered atop the communications network. After careful evaluation, we have chosen several based on the tangible benefits they would produce for our customers when fully implemented. These smart grid solutions include:

- **Advanced Metering Infrastructure (AMI)**, including a Meter Data Management System (MDMS), Remote Connects/Disconnects, and Theft Detection.
- **Customer Facing Solutions (CFS)**, including Billing, a Customer Energy Portal, a Prepay option, and standardized Green Button data.
- **Distribution Automation (DA)**, including an Outage Management System (OMS) with Fault Circuit Indicators (FCIs) and Remote Switching.
- **Advanced Distribution Management System (ADMS)**, with Conservation Voltage Reduction (CVR).
- **Energy Management**, including Advanced Analytics and Forecasting, Smart Inverters, and Networked Street Lights.

- **Demand Response (DR)** programs, including Direct Load Control (DLC) and Dynamic Pricing, as well as a Demand Response Management System (DRMS).

For more details on all of these smart grid solutions, please see Chapter 4: Smart Grid Solutions starting on page 57

IMPLEMENTING OUR SMART GRID

Before implementing smart grid, the Commission must approve our smart grid application. We would then fully implement smart grid solutions for the approximately 460,000 customers in the service areas across Hawaiian Electric, Maui Electric, and Hawaiʻi Electric Light. We have tailored the smart grid implementation, together with its smart grid solutions, to best meet the unique needs of our customers on each of the five islands we serve. The implementation schedules are tailored for each operating utility. (For more detail, see Chapter 5: Smart Grid Implementation on page 91.)

To start, we plan to complete installing Advanced Meter Infrastructure (AMI) on the neighbor islands by the end of 2017 and on Oʻahu by the end of 2018. The implementation includes building back office systems, network infrastructure, meter endpoints, and the services necessary to manage the network. Customers who prefer not to have smart meters installed at their home or business can opt-out.

As the AMI is built, we plan to overlay other smart grid solutions (including Customer Energy Portal, Prepay, Outage Management, and Demand Response via Direct Load Control and Dynamic Pricing) taking advantage of AMI's capabilities and integrating them with our back office systems. We anticipate completing the full installation across all three utilities by the end of 2018.

Beginning in 2016 and continuing beyond 2018, we plan to implement Conservation Voltage Reduction (CVR) and Distribution Automation (DA) with fault circuit indicators (FCIs) in parallel with upgrades to the distribution system.

Throughout all five full implementations, we will continue to communicate with our customers so that they understand smart grid and how they can benefit from it, and to address their comments for future refinements.

Delivering Value

The smart grid implementation delivers tangible benefits to our customers, including savings from operating a more efficient and resilient grid and providing customers with information to help them manage their energy consumption.

Benefits resulting from the smart grid implementation will be passed along to our customers. Because the implementation of smart grid devices depend on information technology (IT) and business-related processes, it takes up to a year before benefits are realized (depending on the type of benefit). Together with Silver Spring Networks, we will continually monitor the value of realized benefits using metrics approved by the Commission to ensure an accurate pass-through of savings to customers.

The Silver Spring Networks IPv6 communications network that forms the foundation of our smart grid platform will be able to handle additional smart grid solutions in the future, including emerging solutions that demonstrate great potential for efficiency, reliability, and cost savings.

The Prepay solution requires new tariff and pricing mechanisms. New definitions for Prepay and non-standard (that it, smart) meters must be added to Rule 1 (which governs capacity planning criteria). In addition, a new rule describing non-standard meter service, its corresponding charges, and a potential monthly opt-out charge must be written. (Creating new rules would be simpler than making numerous changes to existing rules and tariffs.) These rules and tariffs must be defined before any benefits can be realized.

As smart grid becomes a reality, we will continue to evaluate implemented and future smart grid solutions to determine how they can favorably impact Hawai'i's energy future and deliver value for our customers.

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4. Smart Grid Solutions

THE SMART GRID PLATFORM

The smart grid platform operates securely using an industry standard Internet Protocol version 6 (IPv6) network that supports smart two-way communication with a variety of smart grid-enabled devices to provide smart grid solutions and services.

Figure 7: Smart Grid Platform

The Hawaiian Electric smart grid environment employs cyber security systems that are used across a variety of industries, including other energy sector companies, banks, and aerospace. These systems are intended to protect connected smart grid devices and solutions, including the back office systems that collect and manage energy-use data and customer information. These cyber-security systems, developed with billions of dollars in industry investment, include a layered defense in depth approach to encryption and authentication measures.

The smart grid IPV6 platform provided by Silver Spring Networks enables the Hawaiian Electric Companies to implement a number of smart grid solutions, both now and in the future. These smart grid solutions, together with future possibilities, are explained in the remainder of this chapter.

SMART GRID SOLUTIONS

The smart grid platform connects hardware devices with smart grid solutions. The Hawaiian Electric Companies have chosen a suite of smart grid solutions for our smart grid implementation, based mainly on the benefits they can deliver.

We plan to implement a core group of smart grid solutions on each of the five islands we serve, customized and scaled to meet the specific needs of each island's grid and its customer base. We intend to implement other smart grid solutions on each island based on the benefits they can deliver. Several of these solutions work together to better realize combined benefits. While these solutions are to be implemented on each of the five islands, the enabling systems that monitor and manage these solutions are centralized within a Network Operations Center (NOC). This minimizes both the cost of hardware implementation and the operational cost for maintaining and operating the solutions. Although the NOC is centralized, the implementation enables local control of the solutions by each of the five islands in order to respond quickly to any issues or situations that require local interaction.

Advanced Metering Infrastructure (AMI)

AMI is a foundational system that saves customers money, allows more solar PV systems to be added, increases customer choices and improves reliability. Through a wide area network and smart meters installed at homes and businesses, Advanced Metering Infrastructure (AMI) provides two-way communications between the Hawaiian Electric Companies, smart meters, customer devices, and distribution automation equipment.

AMI automates many current manual processes, such as meter reading, customer billing, service connects and disconnects, helps detect outages, verifies power restoration, assists in voltage reduction to save energy, and provides customers with detailed information on their energy usage, and the ability to prepay for their electricity. Because of this automation, truck rolls are reduced.

Through the smart grid platform, we can control the smart meters from our offices, which allows us to complete certain service requests (like connecting and disconnecting power to a home) without making a service call. Through a software program called an Outage Management System (OMS), smart meters can help us identify outages and give us a visual representation of the outage's severity, location, and restoration status, which creates patterns that can help us better handle future outages. An OMS lets our system operators track and resolve events by time, type, and duration; and they can use meter data logs to accurately report on and account for these outages and their restoration.

AMI can give customers timely access to a wealth of data on their own energy use, enabling them to better monitor and manage their electricity consumption and offering the opportunity to be true partners with the Hawaiian Electric Companies in increasing energy efficiency and reducing costs. AMI allows us to offer customers various pricing and payment programs such as time-of-use electricity pricing (including specific electric vehicle rates), a Prepay option for billing, and rooftop solar net energy metering (NEM) to better manage their energy usage.

Essentially, the AMI network sends a wealth of data to and from the smart grid devices over the IPv6 platform to a head-end system which relays the data to the proper system where it can be stored and analyzed.

The architectural design of our electric system takes advantage of existing smart grid system design, including the design specified by the National Institute of Standards and Technology (NIST) in the final version of its *Smart Grid Framework (Update 3.0*) published in September 2014. The NIST Smart Grid 3.0 framework defines the plan to transform the nation's aging electric power system into an interoperable smart grid that integrates information and communication technologies with the power-delivery infrastructure.

Our smart grid architecture incorporates most of the NIST logical model which, at the highest level, has seven domains that apply to our smart grid platform (outlined in Table 1; the colors represent the various domains in Figure 9).

Domain	Domain Role/Service	Color Code
Operations	The managers of the movement of electricity.	Blue
Service Providers	Organizations providing services to electrical customers and to utilities. Includes prepay providers, banking services and some demand response providers.	Green
Customers	The end users of electricity. May also generate, store, and manage the use of energy. Traditionally, three customer types are defined, each with its own domain: residential, commercial, and industrial.	Light Orange
Distribution	The distributors of electricity to and from customers. May also store and generate electricity.	Light Brown
Transmission	The carriers of bulk electricity over long distances. May also store and generate electricity.	Maroon
Generation	The generators of electricity. May also store energy for later distribution. At a logical level, Generation includes coal, nuclear, and large-scale hydro generation usually attached to transmission.	Plum
DER	Distributed Energy Resources (DER). At a logical level, DER is associated with customer- and distribution-domain-provided generation and storage, and with service-provider-aggregated energy resources.	Gray

Table 1. NIST Smart Grid Domains

Note: Due to our geographic location, all the Hawaiian island electric grids do not participate in the NIST Market domain; thus, it has been removed.

Figure 8 shows the relationships among the applicable Hawaiian Electric domains. It is simply a high-level overview of the smart grid framework showing the lines of communication and the electric grid interconnections

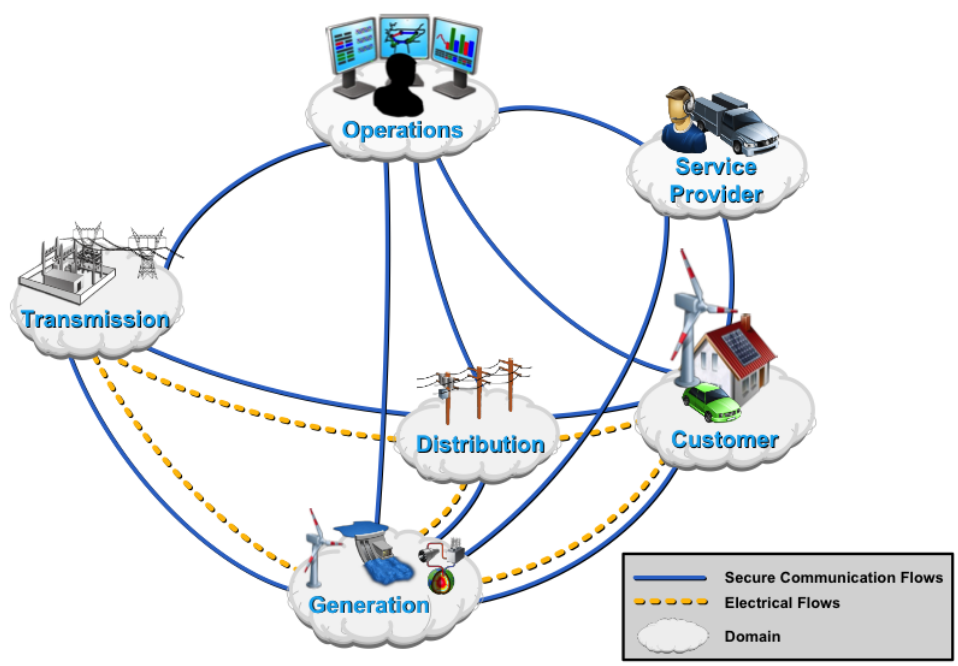

Figure 8: NIST Smart Grid Framework of the Hawaiian Electric Companies

Figure 9 shows the Hawaiian Electric smart grid logical architecture. In the NIST architecture, as in other standard architecture models, the logical model shows the overall system architecture including key systems and system interfaces.

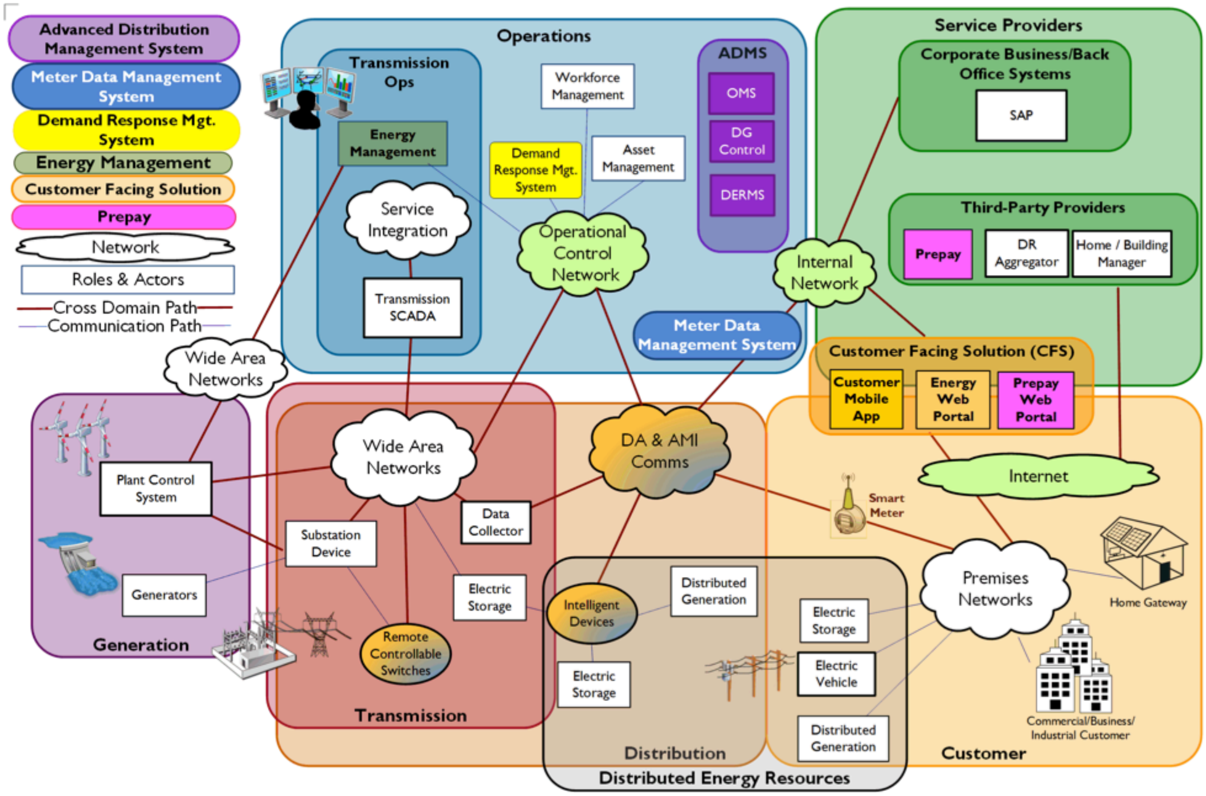

Figure 9: NIST Logical Domain Diagram of the Hawaiian Electric Companies

The Silver Spring Networks mesh network platform connecting the smart meters and other devices has a proven availability of more than 99%. The platform performs efficiently during storms and outages and assists in restoring outages. Full-time staff is necessary to monitor the AMI mesh network on a daily basis, as well as evaluate any network exceptions (such as unread meters or other issues with endpoint devices). The Hawaiian Electric Companies have used Silver Spring Networks' services to monitor this software and communications network during the Demonstration Projects, and continue to rely on these services while planning its smart grid and during full implementation.

AMI includes smart meters, a secure two-way communications network, and back office software databases and systems that store, analyze, and manage smart grid data. This data includes customer information systems (CIS), a Meter Data Management System (MDMS), remote operations, network connectivity, and device upgrades. Lessons learned from visiting utilities with smart grid implementations led us to the conclusion that an MDMS is required to manage and analyze the large volume of interval usage data collected from the smart meters.

AMI uses the secure IPv6 network that employs wireless 900MHz radio frequency mesh technology. This wireless technology consists of: access points; routers enabling devices communicating over the radio frequency mesh network to connect to our IT infrastructure through wired or cellular connections; relays, which are repeater devices that extend the reach of the radio frequency signal; and intelligent endpoints (such as third-party smart meters outfitted with network interface cards from Silver Spring Networks).

All Silver Spring Networks devices contain a one-watt, two-way radio. These devices connect with each other to form a mesh that makes up the Neighborhood Area Network (NAN). Access points and relays will be designed to have multiple paths through the NAN and the utility's WAN to provide high-performance, redundant connections between endpoints and our back office systems and data center. The network interface cards inside smart meters also act as relays (repeaters), further extending the mesh network.

The radio frequency mesh network aggregates smart meter data and transmits it to us either through the utility-owned WAN or cellular connection. The mesh network can also transmit other information (such as remote service connects or disconnects) from us to customers. A back office head-end system (such as UtilityIQ) collects, measures, and analyzes energy consumption, interval and time-of-use data, power quality measures, status logs and other metering data, and manages smart grid devices. Other back office systems manage meter data and integrate that data with customer and billing information.

Meter Data Management System (MDMS)

AMI includes smart meters, a two-way communications network, and back office software systems used to manage customer information systems (CIS), meter data, remote operations, network connectivity, and device upgrades. Smart meters are installed at customer premises and collect detailed information on energy usage. This information is transmitted over the secure mesh communications network through a head-end system to an MDMS.

We have contracted with Silver Spring Networks to provide both the head-end system for meter data collection as well as an Advanced Metering Manager System (AMM) to provide MDMS functionality during implementation. One year after full implementation, we plan to transition to an MDMS managed by the utility staff, shared by Hawaiian Electric, Maui Electric, and Hawai'i Electric Light.

The MDMS can read and record data from multiple channels on the smart meter allowing customer generation and net usage to be recorded. The MDMS processes electric usage data recorded by smart meters (known as the raw interval data), and then validates this meter interval data through a Validation, Estimation and Editing (VEE) process. The VEE process either automatically edits the meter data to find exceptions, or sends notification for a manual review of issues or exceptions. The validated usage data is then available for display to customers to monitor their usage during the billing cycle as well as for billing purposes when the bill date arrives. In addition, our billing system relies on this edited data to produce accurate bills.

The MDMS receives meter data from smart meters that have been registered with and authenticated by the network. The planned MDMS implementation allows reading from the existing Automated Meter Reading (AMR) systems (such as the MVRS system and Turtle System). MDMS support of existing AMR systems also provides meter reading capabilities for any customers who might choose to opt-out and not have a smart meter installed.

The AMI meter monitors and records a variety of information. The smart meters collect interval usage data at 15 minute intervals. For customers participating in Demand Response (DR) program, the meters can collect usage data at 5-minute intervals. The head-end system then relays the usage data to the MDMS for VEE analysis and storage. The Customer Energy Portal displays this data for customers to review their electricity usage. The billing system also accesses this data to to generate a customer bill.

We can review this detailed interval data in aggregate to refine customer usage profiles, which helps us better forecast load and management energy. The MDMS can access five-minute usage data to quantify the performance of DR programs by individual customers as well as in aggregate the data after an event.

Customer Service can issue meter commands to individual customer meters including electric service connect and disconnect requests, load limiting, and on-demand reads, as well as meter pings to support CSRs, pre-payment plans, outage management, and DR programs.

Figure 10 highlights key characteristics of our MDMS implementation.

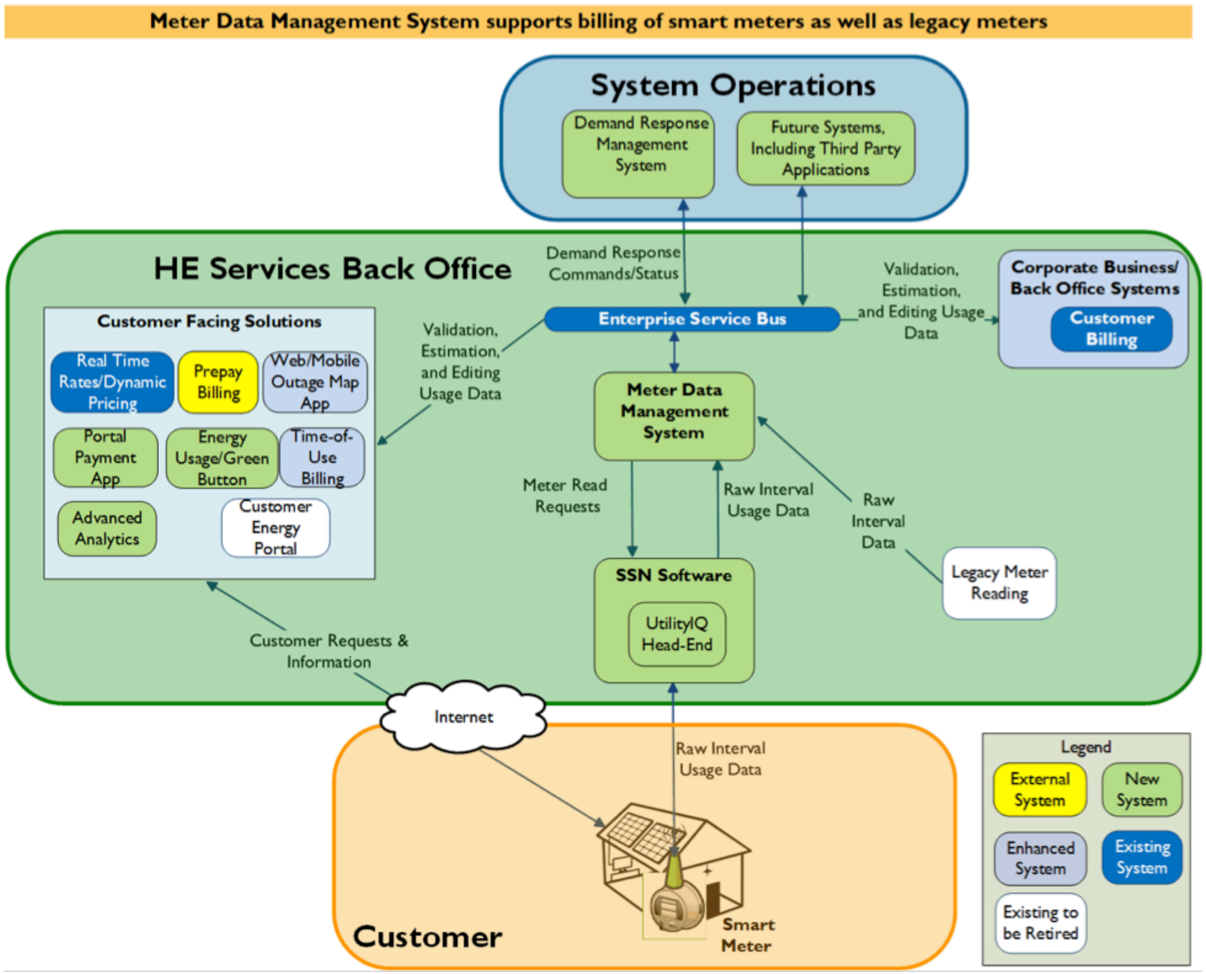

Figure 10: Meter Data Management System (MDMS) Implementation

Connect/Disconnect

AMI systems can remotely connect and disconnect electrical service from a meter. This has a number of benefits. First, it eliminates the need to service the meter in the field, reducing truck rolls and saving time for our field service personnel. This reduces costs, which ultimately saves money for our customers. Second, remote connects and disconnects are faster, especially in response to move-in and move-out requests. Third, remotely disconnecting service for a non-paying account saves our field service personnel from potential altercations with discontented customers.

CSRs send connect and disconnect request using the SAP customer information system over the mesh communications network to the smart meter. Depending on how this smart grid solution is implemented, the MDMS or a head-end system can transmit these connect/disconnect requests, then transmit the request to the mesh communications network.

Remote connect/disconnect requests also help enable the Prepay billing option. Remote connections and disconnections allow CSRs or Prepay to quickly restart service when a payment is received or to stop service when a customer's account reaches zero (and has remained at zero after the regulated number of request that we have sent for replenishing the account have been ignored).

The load control switch in the meter not only enables remote connect/disconnect requests, but also provides load limiting capability. While this capability has not been widely used, it could enable future customer service offerings including a demand subscription service where a customer's demand does not necessarily need a full 200A service. Instead of just shutting off service, load limiting could be used to gradually lower the amount of electricity demand a customer can use for either prepay or bill payment default.

Figure 11 depicts how we plan to implement the remote connect/disconnect smart grid solutions.

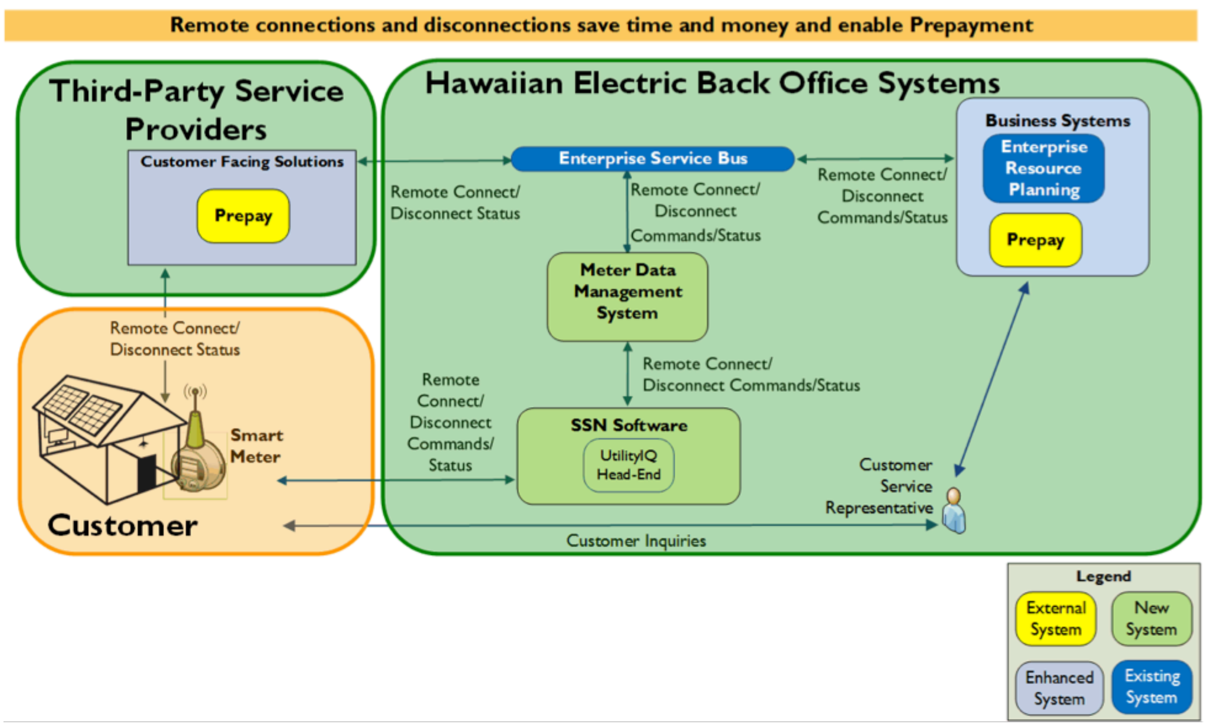

Figure 11: Connect/Disconnect Implementation

Theft Detection

Electricity theft occurs when there is usage on a meter that is not being billed or is offline. All smart meters in the field are registered and authenticated through the AMI. Thus, through data sent to our back office systems from smart meters, company personnel can quickly determine when a non-billable or offline meter registers consumption. We can then remotely turn off service to that meter, and monitor it for future energy theft.

The smart grid data can even send an indication that a meter has been tampered with or otherwise disabled. When this occurs, we must roll a truck to repair the meter in the field, and then monitor that meter to ensure that it remains secure.

Customer Facing Solution (CFS)

Our suite of Customer Facing Solutions enable customers to interact with many online services using a single sign-on. Customers can initiate service, view and pay their bills, and have questions answered via email. In addition, customers can view outage locations and monitor its repair status, prepay for their electricity, view usage to date in between billing periods, and see their estimated bill before their billing date.

Our Customer Facing Solutions are available on computers, tablets, smart phones, and other electronic devices that support web access.

Customer Energy Portal

The Customer Energy Portal shows customers a wealth of data on their actual energy use including features such as a bill estimator and recent energy consumption. All of this helps customers make smart, informed decisions about their own energy use. For instance, a customer can see their energy use over a week-long period and, based on actual data, use that information to budget for their electric bill. The *Advanced Metering Initiatives* study by the American Council for an Energy-Efficient Economy has shown that giving customers access to more robust data on their energy use leads to less energy consumed and, ultimately, to lower bills due to this conservation effect.

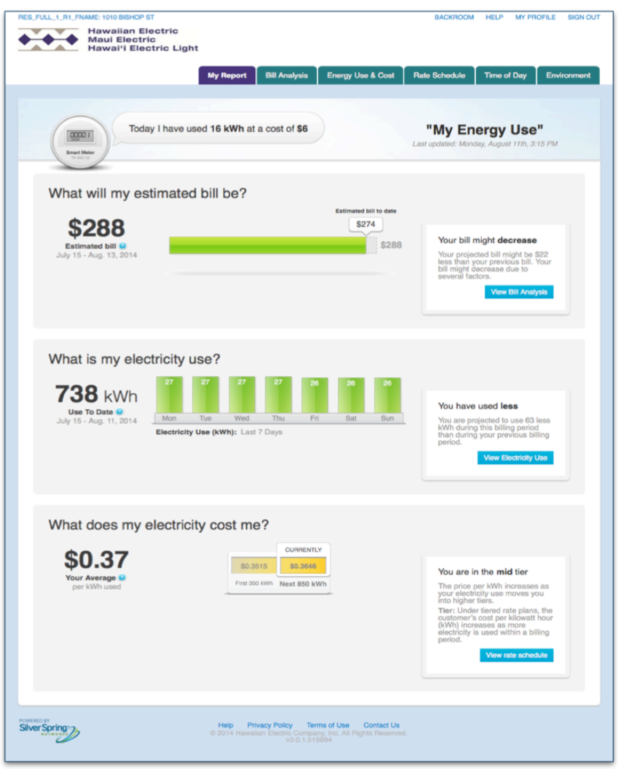

Figure 12: Customer Energy Portal Sample

Our Customer Energy Portal allows customers to view their energy usage, payment and billing information on many devices including smart phones, tablets and personal computers. Data from new and existing systems is available for display including data from the MDMS, Demand Response Management System (DRMS), Advanced Distribution

Management System (ADMS), the SAP Customer Information System (CIS) and data from third-party providers (such as the Prepay solution provider). Regardless of provider, the Customer Energy Portal provides an integrated portal requiring a customer to sign in only once.

The Customer Energy Portal supports a wide range of services and information for customers including support for customer moves, various payment options (including pre-payment plans and time-of-use plans), and assistance for customers with solar PV systems on Net Energy Metering (NEM) tariffs. All Customer Facing Solutions can report on service outages, including notifying users of the outage and allowing them to report on an outage online. The CFS allows customers to enroll in offered programs (such as Demand Response), and supports exporting usage data using the nationwide Green Energy data standard.

The Customer Energy Portal can also report on how often it is used (including the number of visitors), provide details on device hardware and browsers, and list the average time spent on the site. For mobile devices, the Customer Energy Portal allows customers to report an outage using their GPS location, provided the user authorized use of their location. Figure 13 shows our CFS implementation.

Customer Facing Solutions empower our customers to manage their energy usage and costs

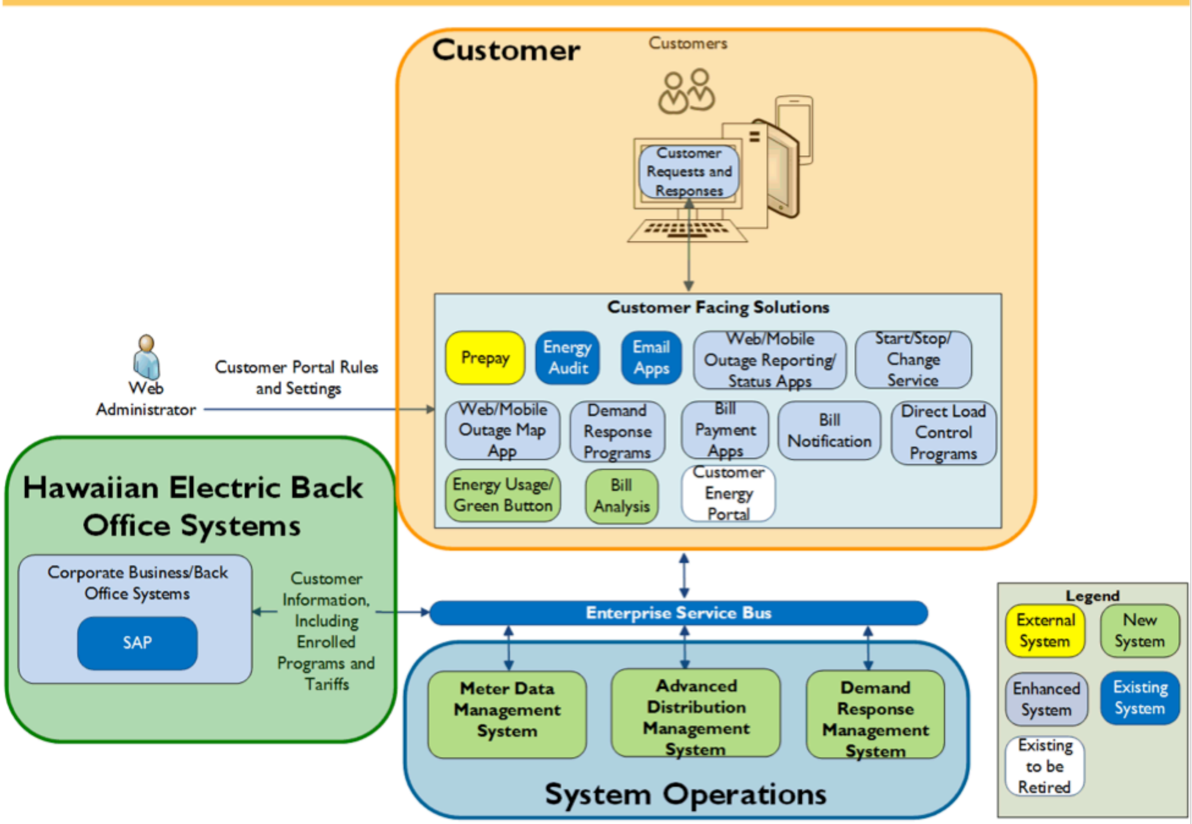

Figure 13: Customer Facing Solution (CFS) Implementation

Billing

Our SAP billing system can retrieve edited interval usage data from the MDMS based on the billing cycle assigned to each customer. The SAP billing system calculates a customer bill based on the applicable tariff, then generate a paper bill for mailing or an automated notification of an eBill. The eBill can be viewed through the CFS.

Originally, billing cycles were based on meter reading cycles; meter reading cycles allowed enough time for a meter reader to read each meter monthly, on a given route. With AMI, smart meters transmit 15-minute interval usage data each hour, obviating the need for a billing date tied to a meter reading schedule. As a result, a customer's billing date can be tied to their historical billing date or to the date of a future move-in and turn-on request. In the future, we might be able to allow our customers to choose their monthly billing date.

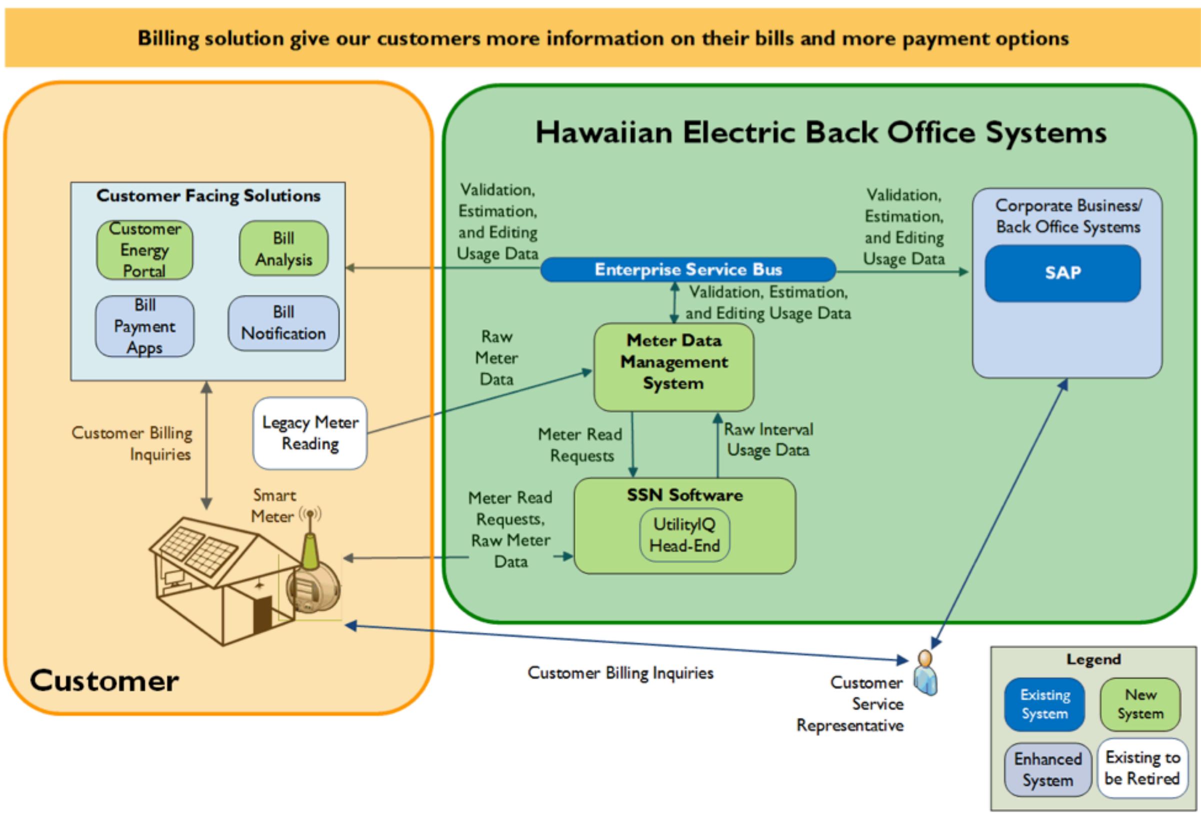

Figure 14: Billing Implementation

Prepay

AMI meters allow us to offer a Prepay program for our customers. Prepay enables customers to pay, either online or over the phone, for electricity before using it rather than receiving a traditional monthly bill where payment is made for usage after the fact.

Customers using Prepay can use the Customer Portal to review detailed electricity usage information and their existing credit balances. Customer can also choose to be notified by phone, text message, or email when they need to replenish a low or zero prepay balance. If a customer ignores repeated requests (following a regulatory process) to replenish a zero balance over a grace period, service can be disconnected remotely. After a payment is made, service can then be quickly reconnected drastically reducing customer wait time.

A Prepay program eliminates the need for collecting customer deposits, and helps customers more easily budget their monthly energy expenses. Case studies presented in a 2011 Chartwell Research report and a 2010 EPRI report on the Salt River Project's Prepayment Program involving 100,000 customers show that customers on Prepay typically use 12–13% less energy than customers receiving traditional bills. While the actual results might vary, the research does suggest that such a program can result in less energy being consumed.

Prepay is integrated with our back office systems and AMI. Prepay uses interval-usage data and remote connect/disconnect requests collected by AMI. Prepay also transmits payment receipts to our back office CIS, and sends out alerts and account balances to customers.

A separate rule and tariff must be defined for Prepay. The terms and conditions and other details for the prepay tariff, including the business process for disconnection of service will receive regulatory review and approval prior to implementation. The rule must define:

- Eligibility requirements for participating in the program, together with the service charge (and to whom it is paid: the utility or the vendor).
- Prepayments as current balances (and not deposits), details for billing and payment (how and when), and amounts and periodicity (how much and how often).
- The grace period before disconnecting power when a balance is zero, and the reconnection charge for restoring service after a payment has been made.
- Disclosure information explaining that the information available through the Prepay is estimated (and how the estimation is calculated) and can be reconciled (with an explanation of the reconciliation process).

Hawaiian Electric issued a Request for Proposal to select a Prepay vendor for our Demonstration Project. Each Prepay vendor handles payment transactions with utilities differently. We worked closely with our selected vendor to define exactly how to handle a Prepay transaction, and to define how best to configure and implement transaction processing.

Figure 15 shows the implementation of the prepay capability for Hawaiian Electric Companies.

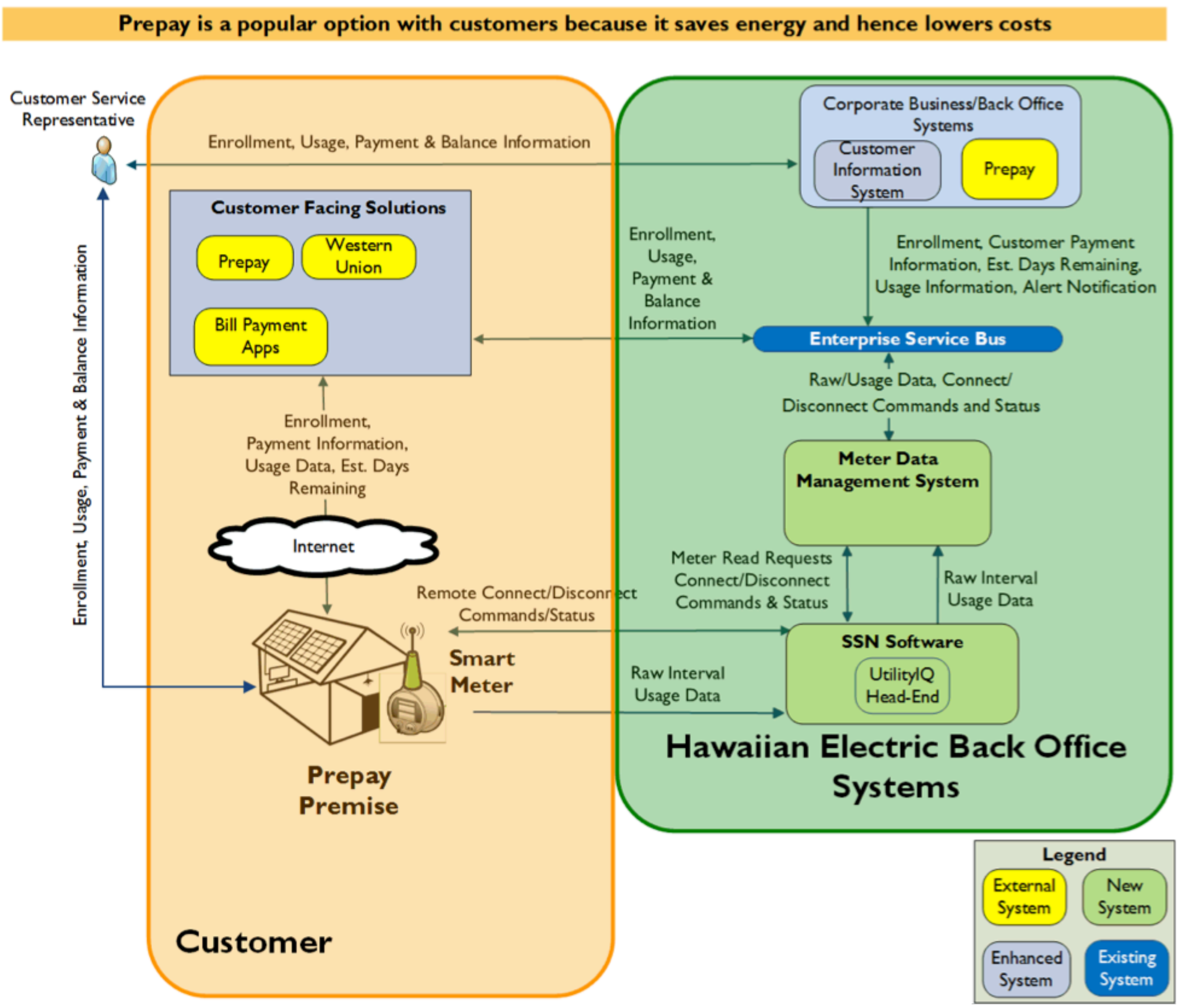

Figure 15: Prepay Implementation

Standardized Green Button Data

The Customer Energy Portal allows customers with smart meters to view their energy usage over several time periods including energy used today, energy used during the current and previous billing periods, and energy used for the last week. Energy usage is available on an hourly basis and for 15-minute time periods. Customers can also see the environmental impact of their usage. The nationally standardized "Green Button" format governs how energy usage is displayed on the Portal.

Under the Energy Independence and Security Act (EISA) of 2007[3], the National Institute of Standards and Technology (NIST) was assigned "primary responsibility to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems…" To carry out its EISA-assigned responsibilities, NIST developed a process through an industry collaborative Smart Grid Interoperability Panel (SGIP). Together, they identified and reviewed standards for inclusion in a Catalog of Standards that are nationally recognized to meet interoperability criteria.

Three North American Energy Standards Board (NAESB) standards in the NIST/SGIP Catalog of Standards are relevant to customer and authorized TPS AMI Data Access:

REQ-18/WEQ-19. Retail Customer Energy Usage Information Communication Model Business Practices: This standard defines an information model of semantics for how customer energy usage information is defined and exchanged. The actual exchange standards are likely to be derived from this seed standard.

REQ-21. Energy Services Provider Interface Model Business Practices: ESPI builds on the NAESB Energy Usage Information Model and, subject to the Governing Documents and any requirements of the Applicable Regulatory Authority, helps enable retail customers to share energy usage information with third parties who have acquired the right to act in this role.

REQ-22. Third Party Access to Smart Meter-based Information Model Business Practices: "Establishes voluntary Model Business Practices for Third Party access to Smart Meter-based information." These business practices are intended only to serve as flexible guidelines rather than requirements, with the onus on regulatory authorities or similar bodies to establish the actual requirements. These "Model Business Practices" are expected to help "adopters [of these guidelines] to make informed decisions that appropriately balance beneficial uses of the Smart Meter-based information with privacy concerns."

The NAESB REQ-21 ESPI standard is the technical basis for "Green Button" which is a standardized interface to provide consumers access to their energy usage information in a downloadable, easy-to-read format. Customer Energy Portal access to AMI meter data for both customers and authorized parties (such as Hawaiʻi Energy) can be based on these ESPI standards.

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[3] *Energy Independence and Security Act of 2007, SEC. 1305. Smart Grid Interoperability Framework*; On Hundred Tenth Congress of the United States of America: pages HR 6-296–297.

To exemplify the traction of ESPI and Green Button, a December 5, 2013, Presidential Memorandum on Federal Leadership on Energy Management augments Executive Order 13514 by directing agencies to update their building-performance and energy-management practices and by encouraging the use of the consensus-based, industry-standard Green Button data access system (Green Button) and the Environmental Protection Agency's (EPA) Energy Star Portfolio Manager.

Distribution Automation (DA)

Distribution Automation links points along the electric grid with our back office, providing more detailed and specific information about the distribution grid such as outages, service interruptions, power quality issues, and impacts from distributed generation. With DA, we can move quickly to restore power to our customers, and even reroute power around damaged lines if an alternative path exists. Also, we can better understand the impact of distributed generation and the condition of distribution assets with virtually immediate feedback so as to better control and improve the operation of distributed generation on the grid.

We continue to evaluate DA, including reviewing latency (the delay between signal and response) and security requirements.

Outage Management System (OMS)

During an outage, a smart meter can send a "last gasp" indication which can then be imported into an Outage Management System to predict the most probable areas causing the outage. The "last gasp" information, however, requires filtering before being imported into the OMS. (OG&E, ComEd, and SMUD all have custom programs to filter "last gasp" messages which we can model.)

During our Demonstration Project, we monitored the OMS to see how well it performed with "last gasp" outage notifications. For full implementation, we are developing the requirements for an OMS as a component of Distribution Automation (DA) so that it is compatible with the mesh communications network, the MDMS, and the ADMS. The OMS uses a topology of both the geographic and logical network of devices and analyzes the most likely network component and location for an outage. While the OMS might not pinpoint the outage source (such as a car accident that downs a power line), the information developed from the analysis will narrow down the likely cause for the outage.

AMI Meters send the "last gasp" meter outage notification through the head-end system. The MDMS may or may not be a repository for storing alerts and messages associated with each specific meter; this detail will be determined after we acquire our MDMS. The meter outage notification can be relayed by the MDMS or transmitted directly to the

OMS module of the ADMS. The OMS data can also provide DA input to trigger automated circuit bank switching which can minimize the impact of an outage by rerouting power for some customers through circuits and relays that are not affected by the outage.

Figure 16 depicts our implementation of an Outage Management System.

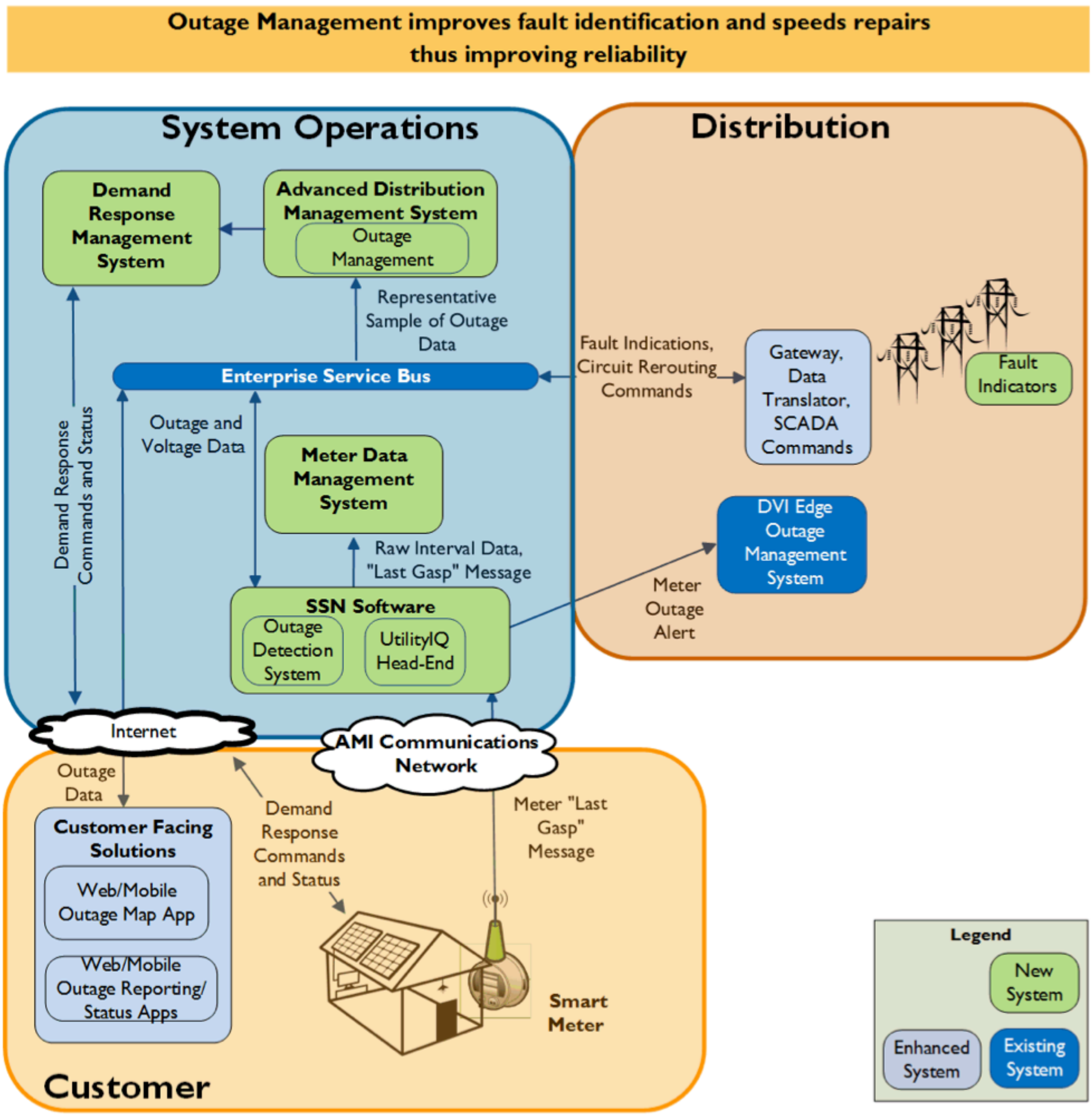

Figure 16: Outage Management System (OMS) Implementation

Fault Circuit Indicators (FCIs) and Remote Switching

Smart grid technology can help us minimize outage times by automating both their detection and, in some cases, its resolution, which increases reliability. Our current manual process is time-consuming. Restoration crews spend critical time patrolling a circuit to locate a fault before it can begin to be resolved.

Smart grid implements devices called fault circuit indicators (FCIs), which allow us to almost immediately isolate where on a circuit an outage has occurred, enabling restoration crews to effectively restore power. In addition, remote switching allows us to route electricity around outage points so fewer customers are affected by an outage. As a result, power is restored more quickly and operational cost savings are passed on to customers.

Advanced Distribution Management System (ADMS)

The Hawaiian Electric Companies' highest priority is to operate a safe, reliable electric grid. Smart grid can help us improve grid operations.

Advanced features of the smart grid and AMI include optimizing the network to address issues with feeder loading, grid reliability and power quality including voltage fluctuations. Remote sensing using both distribution system assets and AMI meters can improve customer power quality and reduce distribution costs to the utility. AMI meter can record average voltage but, more importantly, report voltage variations from a power quality perspective. Voltage quality alerts sent by the AMI meter can provide input to trigger feeder capacitor bank switching, and transformer voltage tap switching and feeder switching decisions to help mitigate the issue.

While Distribution Automation tends to focus on real-time monitoring and control, the offline analysis of historical data can help determine system optimization options and develop approaches for longer-term remediation in areas with chronic power quality issues. Of course, the AMI network includes more devices than just the smart meters and distribution system devices. These devices include Intelligent Electronic Device (IED) and remote terminal unit (RTU) that interface with sensors, and fault circuit indicators (FCIs) and SCADA (supervisory control and data acquisition) to provide telemetry data and control of the distribution grid. By using these system capabilities, system operators can optimize operational processes (such as capacitor bank control) with almost immediate feedback on whether the adjustment had the desired effect.

The ADMS can use data collected from the AMI to refine the load model by improving the visibility of the generation mix on the distribution circuits (such as knowing the amount of generation offset by distributed generation). This knowledge helps make more informed decisions when responding to unplanned outages, and when optimizing the generation mix on distribution networks (such as minimizing energy loss and balancing load). Using this constant flow of system information, the ADMS can make more informed decisions, such as preventing additional outages from an overload in areas adjacent to an outage. Ultimately, we would have a a better understanding of the impact of actions to control the grid.

We plan to install an Advanced Distribution Management System (ADMS) that takes advantage of the AMI and smart meter systems, and that makes it easier to integrate new renewable energy systems—especially solar PV systems. The ADMS also enables an Outage Management System (OMS) and Conservation Voltage Reduction (CVR).

Figure 17 shows our planned ADMS implementation.

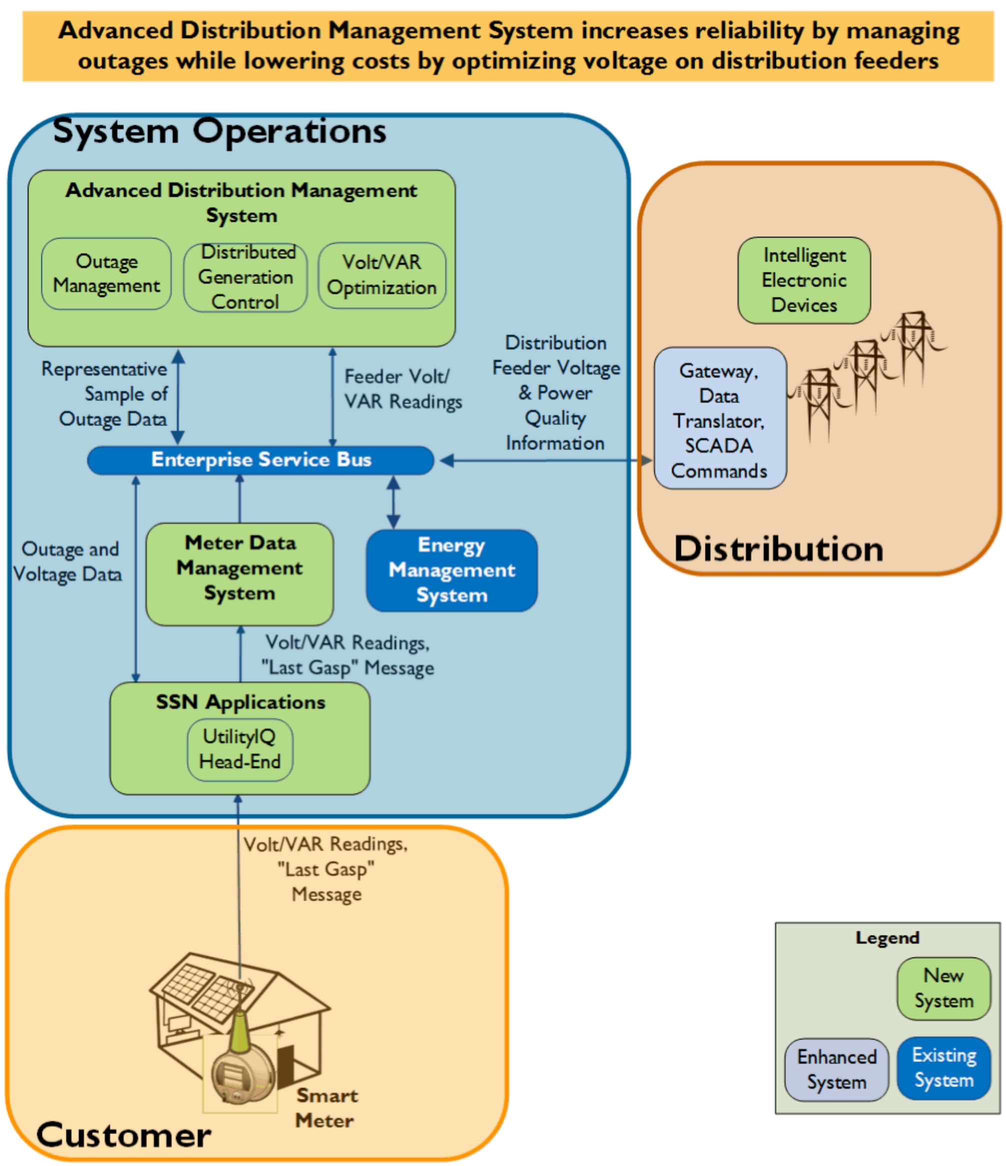

Figure 17: Advanced Distribution Management System (ADMS) Implementation

Conservation Voltage Reduction (CVR)

Conservation Voltage Reduction accurately monitors voltages at customer premises and on locations on the distribution feeder and optimizes voltage thus saving energy.

Tariff specifications govern how distribution voltages at customer endpoints are set and managed. Under normal conditions, voltages must remain within ANSI standard C84.1-2011 limits, defined as Range A. For 120-volt service, the service range is defined as 114-126V and the utilization range is defined as 110-126V. To keep within these specifications, voltages are typically set at the upper end which leads to wasted energy, higher energy bills, and unnecessary carbon dioxide emissions. By collecting real-time voltage data through AMI, CVR allows these values to be optimized (and flattened) closer to the lower limit of the tariff specifications (Figure 18), resulting in saved energy, lower energy bills, and less carbon dioxide emissions, all without requiring changes in customer behavior.

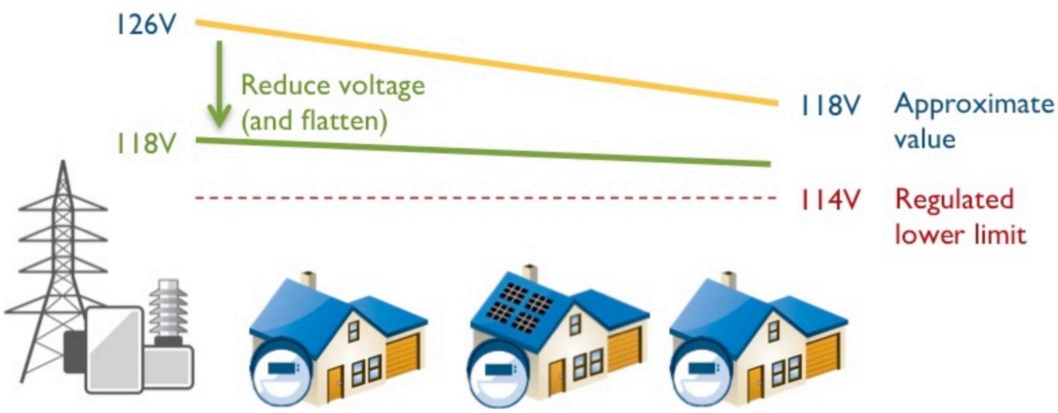

Figure 18: Conservation Voltage Reduction (CVR) Impact on Tariff Specifications

Conservation Voltage Reduction (CVR) improves efficiency by reducing the average voltage on distribution feeders. More specifically, CVR enables us to optimize the electric voltage across distribution circuits by monitoring near real-time data from smart meters and distribution devices and controlling the system's voltage level to reduce energy consumption. The distribution system's voltage is controlled at multiple points, including the substation and at locations along the circuit where capacitor banks and voltage regulators are installed. The energy savings result in reduced energy bills for customers and a reduction in the peak demand for Hawaiian Electric Companies.

CVR improves energy efficiency but unlike many energy efficiency programs, it must be implemented by utilities and not by third parties which is the case for many energy efficiency programs.

Smart grid systems, especially the AMI and smart meters, enable CVR by providing voltage readings at many locations throughout the distribution system. CVR also makes use of smart grid equipment, including Intelligent Electronic Devices (IEDs), transformers, voltage regulators, capacitors, and reclosers to measure and adjust feeder voltages.

CVR has the potential to improve power quality, lower line losses, and reduce peak demand. Our approach (1) uses AMI to collect customer voltage readings which are then (2) analyzed by the CVR solution to (3) determine voltage setpoint recommendations for substation controllers (such as load tap changers) and control operations for distribution feeder devices (such as capacitor banks) to (4) implement optimal voltage settings for the circuit. CVR can monitor and track improvements to validate energy savings. With our planned integrated smart grid platform, we can achieve a variety of objectives including reducing peak demand, reducing line losses, and conserving energy.

Figure 19 shows how we plan to implementation CVR.

Conservation Voltage Reduction reduces energy use and saves customers money

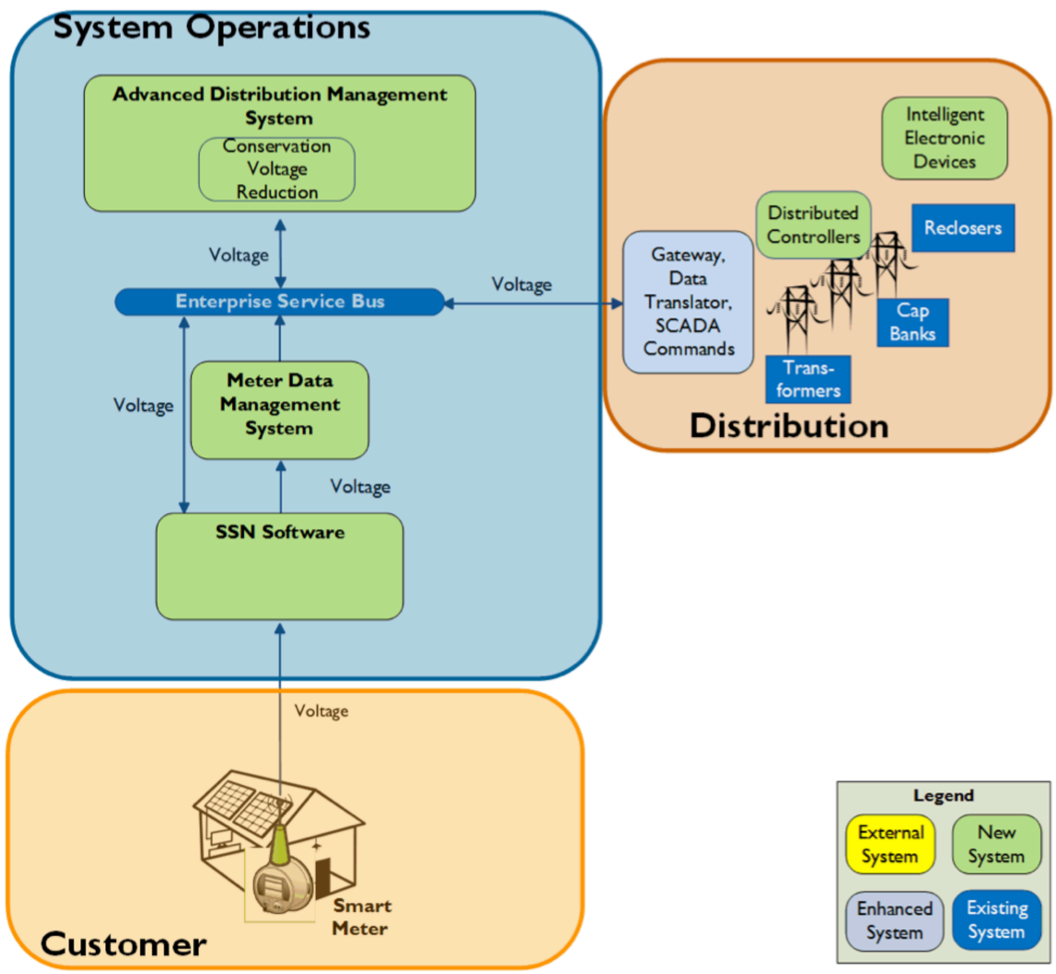

Figure 19: Conservation Voltage Reduction (CVR) Implementation

Energy Management

The fundamental challenge for an electric utility is to constantly balance electricity supply and demand. The difference between forecasted electricity demand and actual demand means that generation has to be modified to match the actual demand. These modifications can be through capacity and ancillary services including contingency reserve, regulating reserve, non-spinning reserves, and non-Automatic Generation Control ramping. Essentially, excess generation capacity must be available in order to increase or decrease the amount of generated power on the electric grid to continuously balance supply and demand.

Currently, we analyze historical load data to develop a load forecast for future electricity demand (MW) and usage (MWh) so that we can maintain a supply portfolio to meet the current and future electricity needs for customers. This historical load data, unfortunately, is limited, which in turns limits our ability to create accurate forecasts. As a result, we maintain enough generation resources to meet the anticipated electricity demand from consumers at any given time. In addition, we also maintain a reserve margin of generation capacity to use when actual demand exceeds forecast demand. Maintaining this reserve generation capacity, however, is expensive.

Improved energy analytics that translate to more accurate forecasting can directly lead to smaller amounts of reserve generation capacity, resulting in cost savings. Through AMI connected devices (such as smart meters and SCADA systems), these improved energy analytics are possible.

Advanced Analytics and Forecasting

As the grid integrates more devices (such as rooftop solar and energy storage), the Hawaiian Electric Companies together with our customers need more detailed, immediate information to use energy more efficiently, while having a minimal impact on the overall system. Advanced analytics can do just that. Advanced analytics help separate information from many different energy sources to provide us with more insight on how their energy is being used within homes and businesses. Advanced analytics, combined with better forecasting, can be used to balance energy production with energy demand.

For years, customer electricity demand has been fairly predictable. However, the relationship between supply and demand is becoming more dynamic. Distributed energy resources (including customer-owned photovoltaic solar generation) are causing net demand to vary based on actual usage combined with the output from distributed generation. Greater amounts of utility-scale renewable generation (such as wind) results in a more variable supply portfolio, thus making it more difficult to match the more dynamic demand forecast. Weather, while always a factor in developing load forecasts, has had an increasing impact. Certain weather conditions greatly impact generation from customer-owned solar system, as well as renewable generation from wind.

Advanced Analytics and Forecasting solutions can perform a more complex analysis of conditions using data collected from Distributed Automation and AMI meters to more accurately predict and forecast demand. This data is also stored in a database to use in the future.

Figure 20 shows our implementation of Advanced Analytics and Forecasting.

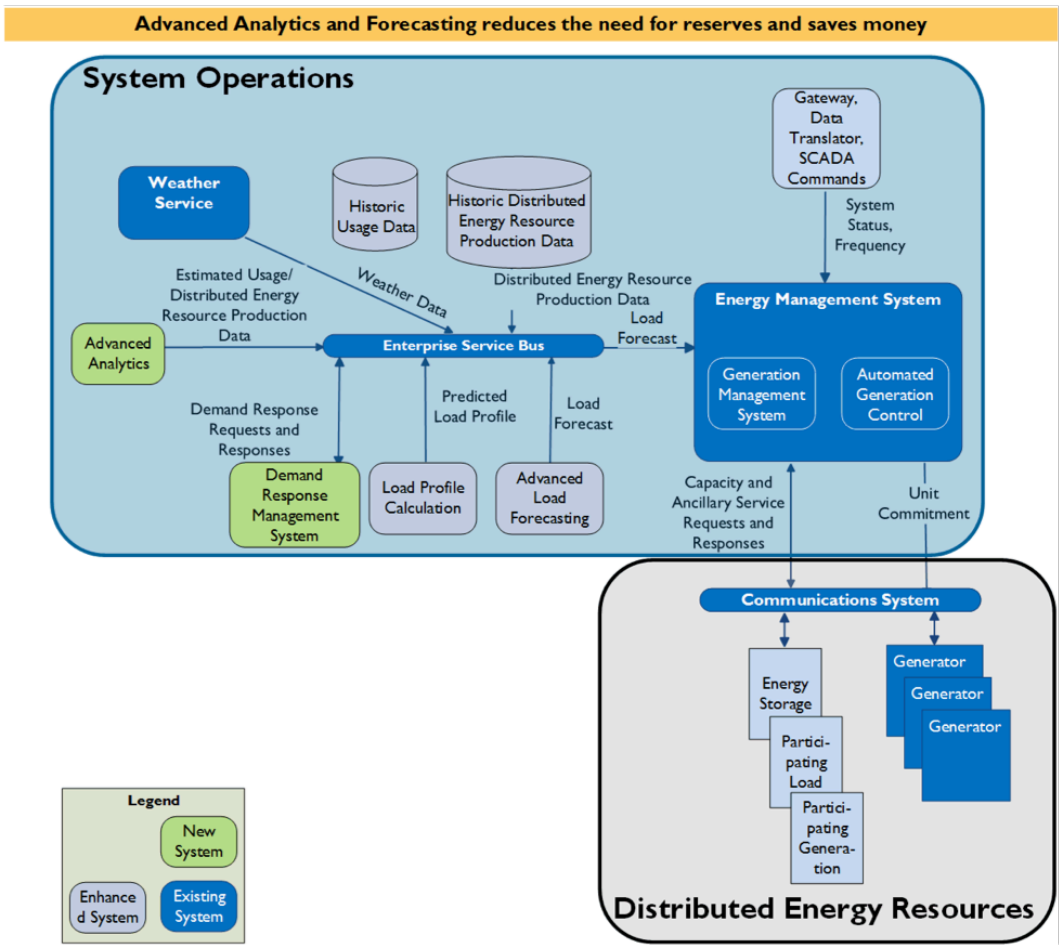

Figure 20: Advanced Analytics and Forecasting Implementation

Smart Inverters

Distributed Energy Resource (DER) systems, including renewable wind, solar photovoltaic (PV), and energy storage systems, are increasing exponentially. By the end of 2013, our generation mix included roughly 250 MW of PV capacity (primarily rooftop

PV systems) and 100 MW of wind capacity.[4] In other part of the country, DER systems use inverters that are compliant with the IEEE 1547 standard. That standard requires grid--connected DER devices to disconnect from the grid at specific prescribed points during system events including under and over frequency.[5]

The Hawaiian Electric Companies have DER penetration levels that already affect the reliability of the local bulk power system.[6] For example, in April 2013, loss of Hawaiian Electric's largest generator (AES) resulted in system frequency dipping down to 58.35Hz, initiating three blocks of under-frequency load shed. Exacerbating the event was the loss of roughly 60 MW of rooftop PV generation that tripped at 59.3Hz following the IEEE 1547 under-frequency trip setting.[7] On the 1547-complaint inverters, the DER frequency trip settings have been adjusted to the maximum duration and lowest frequency settings available.[8]

Newer smart inverters allow for more leeway in the frequency and voltage settings. Future smart inverters will have communications capabilities which will allow us to issue commands in real time to help stabilize our electric grids. In order to control distribution feeders with high penetrations of DER, inverters could support advanced "smart" capabilities such as those specified by California's Smart Inverter Working Group (SIWG).

The most basic smart inverters include the ability to "ride-through" wider ranges of voltage and frequency fluctuations, to actively counteract voltage changes, and to "soft-reconnect" to avoid sharp spikes when large numbers of DER systems reconnect to the distribution system.[9] These capabilities help make it possible for is to incorporate more renewable energy systems, especially distributed generation systems. Basic smart grid capabilities can be implemented through inverter settings; more advanced capabilities are implemented using real-time commands to inverters.

Smart inverters can potentially allow us to stabilize the grid by remotely regulating a photovoltaic system's voltage or watt output based on local voltage conditions. Readings from a smart inverter paired with a home's primary meter can potentially detect when a photovoltaic system is back-feeding into the grid.

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4 *Hawaiian Electric Company State of the System Summary for the ESS RFP*; Hawaiian Electric Company Transmission Planning: page 3, paragraph 2.

5 *Advanced Inverter Technologies Report*; CPUC: page 2.

6 *Performance of Variable Resources During and After System Disturbance*; NERC: page 10, third-to-last sentence.

7 *op. cit.*, Hawaiian Electric Company Transmission Planning: page 4, paragraph 2.

8 *op. cit.*, NERC: page 10, second-to-last sentence.

9 *Recommendations for Updating the Technical Requirements for Inverters in Distributed Energy Resources.* CPUC: page 15.

In the future, smart inverters could be used to send curtailment commands to limit such back-feed. A collaboration between the United States Department of Energy, the Hawaiʻi Natural Energy Institute, Maui Electric Company, Potomac Electric Power Company, Oklahoma Gas & Electric, Silver Spring Networks, and other technology providers is currently researching this technology to better understand its capabilities and limitations.

Figure 21 shows our implementation of smart inverters.

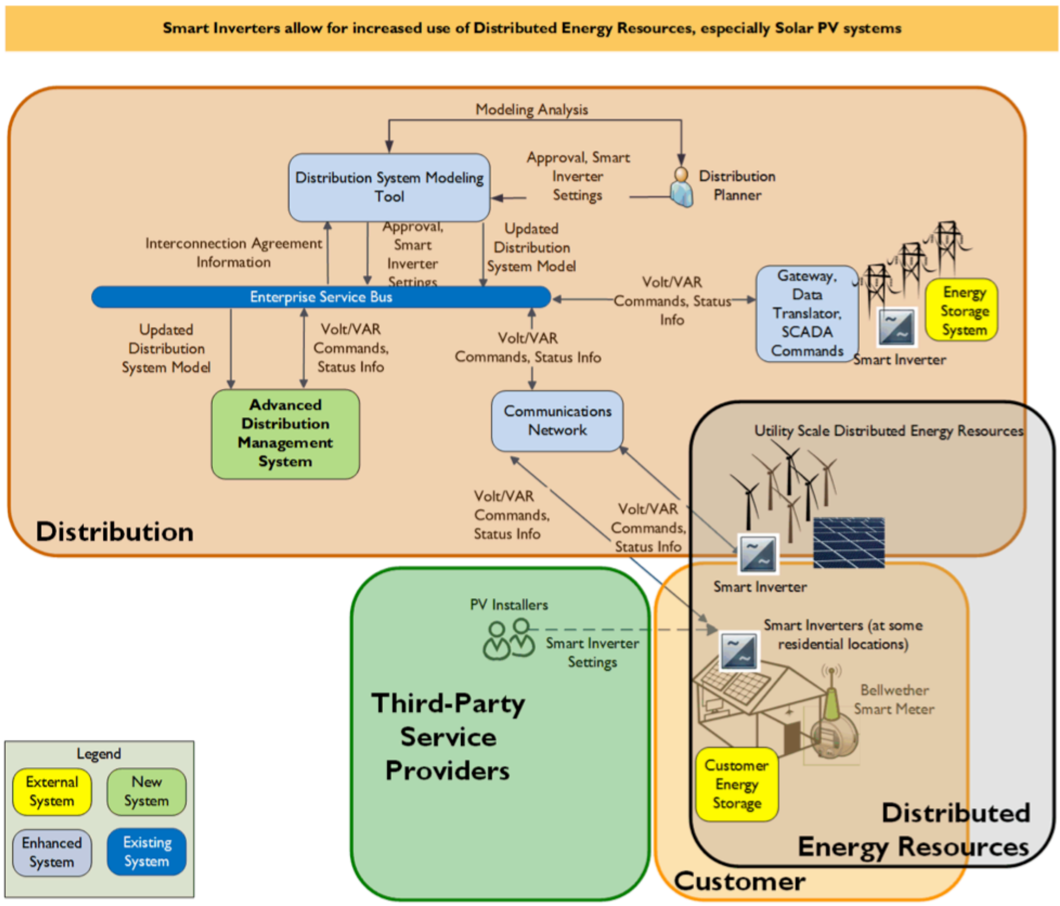

Figure 21: Smart Inverter Implementation

Networked Street Lights

Through the smart grid infrastructure, Hawaiʻi can begin networking community electrical devices (such as street lights) to run more intelligently and efficiently. For instance, networking street lights replaced with networked high-efficiency LEDs can reduce energy consumption, cut maintenance costs, and identify outages more quickly. These networked street lights can also be controlled remotely to help with public safety.

Demand Response (DR)

Demand Response programs provide customers with technology and financial incentives to change their energy use, helping the grid operate more efficiently and making the best use of Hawai'i's increasing portfolio of wind and distributed solar generation.

Hawaii's island grids are unique in that they have seen higher levels of rooftop solar photovoltaics (PV) than mainland utilities, mainly because solar PV relative is economically competitive with cost of electricity. This means that customers play a critical role in supplying energy; they also need to play an equally critical role in managing energy demand to help maintain energy balance for overall grid reliability.

The Hawaiian Electric Companies filed an *Integrated Demand Response Portfolio Plan* (IDRPP) on July 28, 2014. The IDRPP proposes a portfolio of demand response programs with different objectives and targeted categories. The IDRPP included programs for residential, small business, commercial, and industrial customers and addressed such issues as direct load control, water pumping facilities, on-site generators, and other load shifting options. These DR programs can reduce the cost of electricity, offer options for customers to manage electricity use and enable higher levels of renewable energy without compromising service reliability.

As a result of this Demand Response strategy, the smart grid business case includes the use of DR to provide ancillary services. Our strategy targets commercial and industrial customers for reducing the cost of electricity and enabling greater penetration of photovoltaics. This strategy, however, must include the following:

- Standardize DR solutions for all customer and grid devices necessary to manage the grid in the future, enabling peer-to-peer communication and reducing implementation ongoing management costs.
- Segment DR assets into "standard mesh" assets and "low-latency" assets that have higher performance requirements and likely need to connect back into the distribution operations infrastructure.
- Standardize on the device types, manufacturer, and model in customer facilities, to better enable an integrated platform that is directly controlled.
- Integrate aggregators with standard interfaces on the utility side to reduce overall IT costs.

The AMI system can enable and facilitate these proposed DR programs in several ways. AMI can provide the means to dispatch DR resources through enrolled and registered DR-enabled devices. AMI meters, through five-minute usage intervals, can provide the means for quantifying the performance of DR participants, estimated in terms of load (kW) and energy (kWh). The AMI network can be used to estimate the amount of available DR capacity available at any given time.

Through the Customer Energy Portal, customers can enroll in DR programs, provide DR event or CPP alerts, and receive information about the performance in DR programs.

Figure 22 shows our implementation of Demand Response through smart grid.

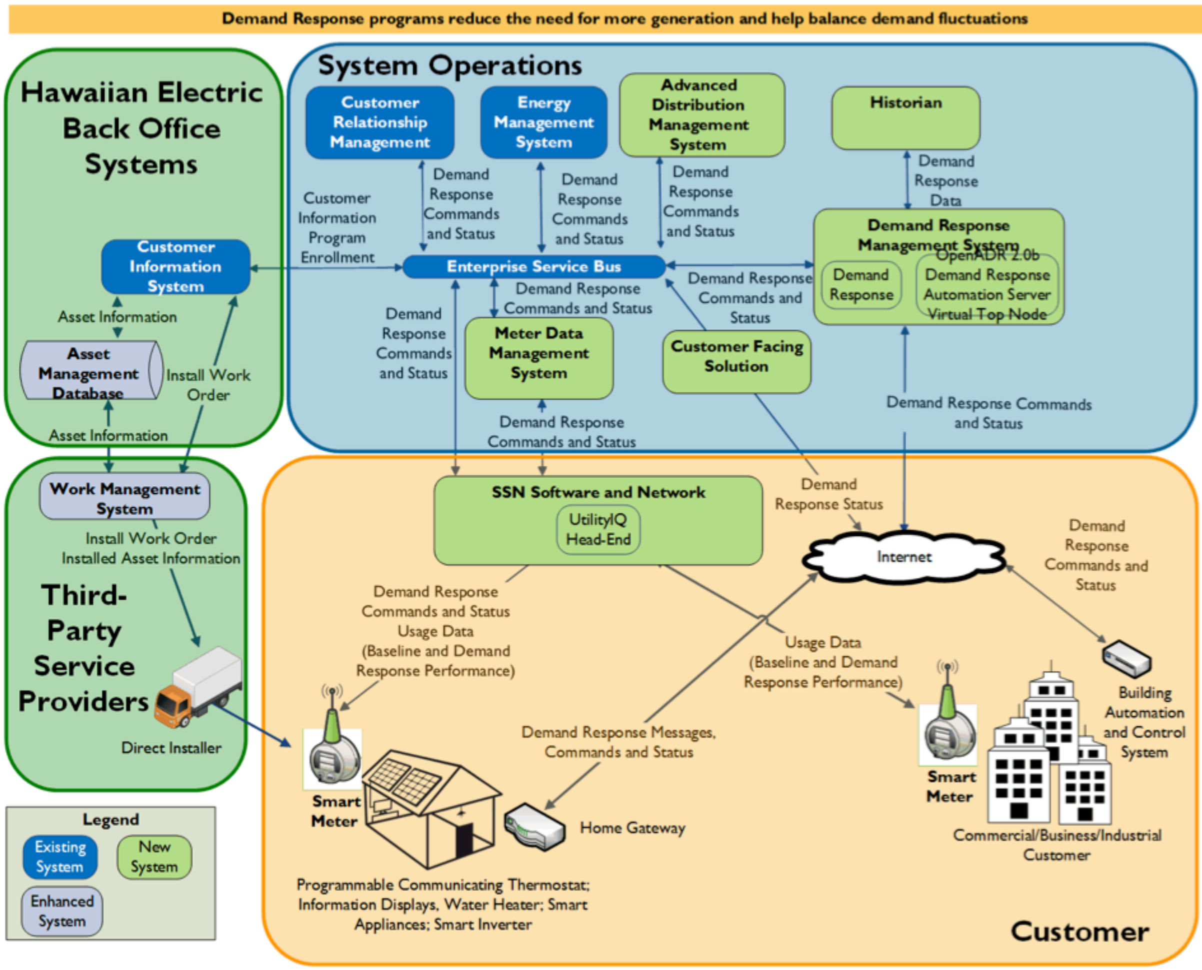

Figure 22: Demand Response (DR) Implementation

Direct Load Control (DLC)

Direct Load Control is a Demand Response program. Customers who voluntarily join a DLC program allow us to temporarily reduce (curtail) their energy use when electricity demand is high, or when reducing demand helps improve grid stability. Energy is curtailed by remotely turning off or cycling specific customer devices (such as water heaters, air-conditioners, and non-essential equipment). To encourage participation, we send incentive payments to customers who join.

The underlying technology of DLC manipulates the controls on customer appliances (such as load control switches for hot water heaters and programmable communicating thermostats for air conditioners). When a Demand Response event start, the smart grid network spreads the signal to these customer appliance controls. A load control switch cycles power on and off, whereas a programmable communicating thermostat sets the temperature higher or lower, both reducing energy consumption.

Figure 23 shows the Direct Load Control implementation for Hawaiian Electric Companies.

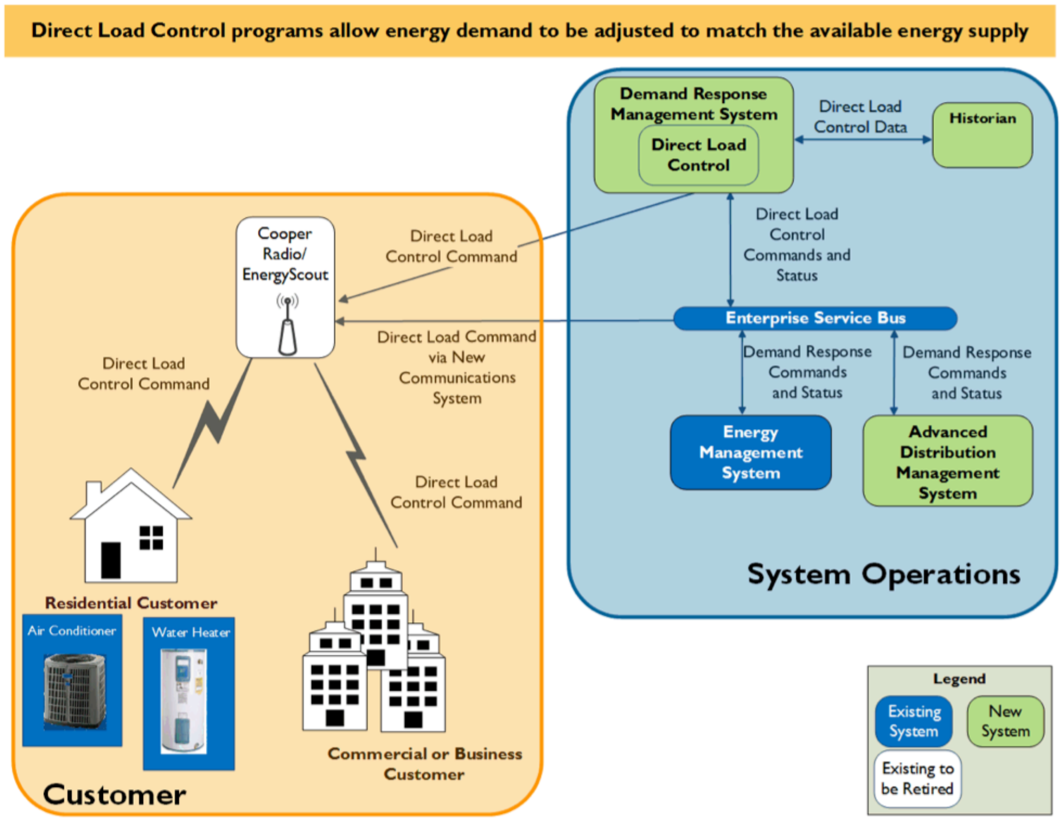

Figure 23: Direct Load Control (DLC) Implementation

Dynamic Pricing

We intend to establish variable pricing programs, such as Dynamic Pricing and Critical Peak Pricing, based on the AMI. These programs require the AMI-collected interval usage data to calculate the bill charges based on usage and pricing from different times of day.

Demand Response Management System (DRMS)

A Demand Response Management System (DRMS) aggregates all participating customers so that system operation benefits the most. This allows Demand Response to be viewed as a single asset, forecasting both load and load shed potential while providing actionable measurement and verification analytics during and after Demand Response events—all of which optimizes the overall benefits for the electric grid, the utility, and our customers. The DRMS helps manage all of our Demand Response programs (both residential and commercial Direct Load Control programs) because each program might have different operating constraints and projected load reduction capabilities.

The DRMS provides three main benefits: (1) real-time resource forecasting which shows how much energy will be reduced (shed) during a specific Demand Response event before having to dispatch the event; (2) analytics both during and after an event to better assess how the system performed and how many customers participated; and (3) built in decision-making tools to optimize events across all customers as well as residential and commercial programs.

Analytics prevalent in modern DRMSs expose details about the number of customers who participate in and opt-out of Demand Response programs. This insight, in turn, helps us better understand our customers' behaviors enabling us to design programs tailored to their usage patterns. A high-functioning DRMS coupled with a well-planned Demand Response program will help us balance our Demand Response needs while still satisfying our customers.

Summary of Smart Grid Solutions in Our Smart Grid Application

The inherent beauty of a smart grid platform is the seamless interoperability of the smart grid solutions coupled with the breadth of the mesh communications network—all to better enable us to monitor, manage, and optimize the flow of energy on the grid, and to better ensure the reliability and stability of the grid.

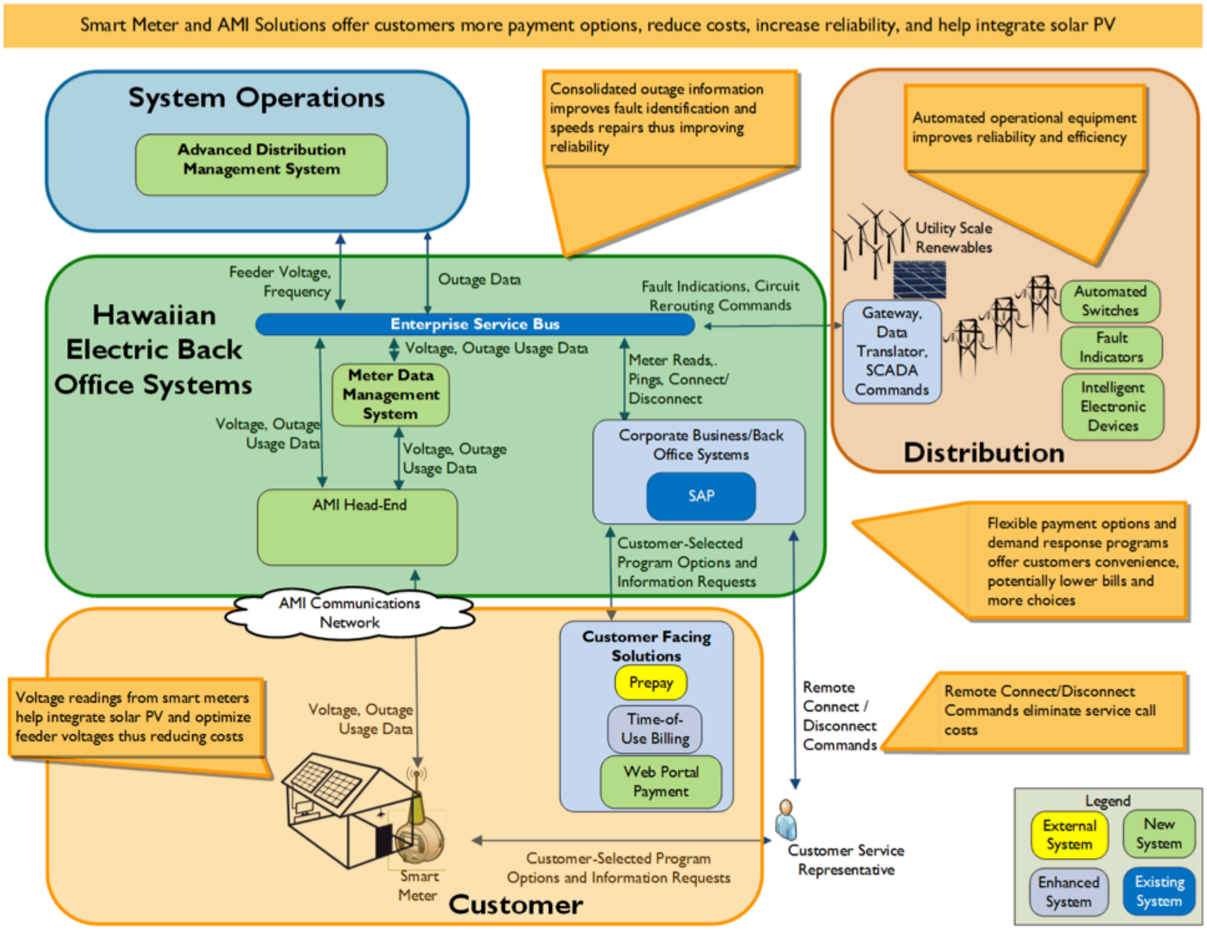

Figure 24: Advanced Metering Infrastructure (AMI) Enables Many Smart Grid Solutions

FUTURE SMART GRID SOLUTIONS

Smart grid development continuously evolves. The smart grid platform is designed to be extensible and can be adapted, upgraded and expanded for future solutions and continuing to take advantage of the convergence of information and energy systems.

Volt/VAR Optimization (VVO)

VVO stands for Volt/Volt-Ampere Reactive Optimization. Essentially, VVO enables us to make the most effective use of the electric voltages across distribution circuits by accessing very immediate, detailed data from smart meters and distribution devices, including remote control of voltage regulating devices on distributed generation.

Our operators can use this information to safely and more precisely control voltages and minimize their loss, which also leads to the efficient operation of customers' electrical appliances. This can result in saved energy, lower operating costs, less carbon dioxide emissions, and lower customer bills.

Electric Vehicle Charging

Electric vehicles can help Hawaiʻi further reduce its dependence on expensive fossil fuels and lower greenhouse gas emissions. The Hawaiian Electric Companies are a committed partner in these green energy efforts.

Smart meters on electric vehicle charging stations will not only allow us to offer customers special rates on electric vehicle charging and but also quantify how much fuel is saved and carbon dioxide emissions are reduced. Smart grid technology (such as a DRMS) can help coordinate the charging and discharging cycles of electric vehicles with the hours most beneficial to grid operations or with the times when the cost of electricity is most economical. This means customers can charge these vehicles when power is most readily available, and least expensive, saving customers money while ensuring grid stability.

In addition, electric vehicles and smart charging stations could schedule their charging to coincide with those times when generation from wind turbines tend to be the most productive.

These smart grid solutions provide another set of tools to aid the state in its commitment to promoting electric vehicles.

Energy Storage

Energy storage bridges the gap between energy supply and demand to better manage the stability and efficiency of the grid. Many different types of energy storage solutions are being developed. Community Energy Storage (CES) sited at customer or community locations, when connected to the smart grid platform through a communication link, ensures its optimal coordination with other generation sources so that frequency and voltage can be regulated. Similar to electric vehicle charging, a DRMS can utilize CES as a resource to charge during periods of excess generation and discharge when demand exceeds the available supply. This can be a local issue, with distribution capacity limiting the amount of electricity delivered.

Microgrids for Critical Customers

A microgrid is an energy system consisting of co-located power generation and load that operates as part of the power grid but can be separated (or islanded) from the power grid to operate independently. For example, a microgrid can maintain energy supply when the main power grid has an outage, can take advantage of lower-cost energy, can electrify rural areas, and can help balance distributed generation sources with centralized sources.

The military has investigated microgrids for their base operations as a security measure to ensure continued power during intentional or accidental power outages. The SPIDERS (Smart Power Infrastructure Demonstration for Energy Reliability and Security) demonstration is being implemented at both Hickam Air Force Base and Camp Smith in O'ahu.

As microgrids become more prevalent, smart grid technology can help control distribution and storage devices to better balance power and loads within the microgrid.

Automated Circuit Sectionalization

Automated circuit sectionalization, quickly and productively, manages outages by automating the opening and closing of switches on a circuit. Before fully automating our electrical system with this solution, however, The Hawaiian Electric Companies are first implementing circuit sectionalization with switches that we control remotely. This step enables workers to become more comfortable and fully trained with manual circuit sectionalization before moving to a fully automated system.

Phasor Measurement Units

Phasor measurement units track changes in power quality and voltage at substations, feeders, and line control points to manage variable distributed generation sources (such as some renewables). As this technology becomes more mature and proven in large-scale field implementations, the Hawaiian Electric Companies plan to explore options for implementing the technology.

In June 2014, we received a $500,000 grant from the Department of Energy (DOE) to incorporate synchrophasor data into our transmission and distribution modeling and system-wide data analysis efforts. The project will evaluate new visualization techniques that use synchrophasor data to inform grid modernization activities.[10]

Other Smart Grid Solutions

The Hawaiian Electric Companies endeavor to best serve the needs of our customers while being mindful of our costs. As such, we are choosing *not* to invest in all potential smart grid solutions, specifically transformer monitoring and printed energy reports.

Transformer Maintenance Monitoring

Transformer maintenance monitoring does just that: it monitors transformers and helps understand when a transformer will need maintenance, especially during high-loading situations. The Hawaiian Electric Companies do not currently overload transformers excessively, so accelerated degradation is not a major problem. Instead, we use an asset management program to conduct routine maintenance checks, mitigating the need for additional monitoring.

Printed Energy Reports

Printed energy reports would provide customers more information on their energy usage. In lieu of these printed reports, the Hawaiian Electric Companies will be implementing a greener alternative: a Customer Energy Portal available online for customers.

Decentralized Neighborhood Controllers

Decentralized, neighborhood controllers monitor and control a localized network, keeping a watch on "choke" points in the distribution network (for instance, points where an overload of distributed generation might cause protection, safety, or loading issues).

The neighborhood controllers interact with AMI meters, smart inverters, and other sensors and controllers to create a locally optimized neighborhood. These controllers also can inform higher level automation points (such as a substation or control center) of their

[10] DOE Awards Electric Grid Grants. Recharge; July 13, 2014.

decisions. This enables these higher level automation points to assess information from many neighborhood controllers to optimize a wider area of the grid. As the complexity of our grid grows, these types of decision can help us better manage the electric grid.

Line Monitoring

By leveraging the critical locations presented by distribution transformers, line monitor sensors extract actionable information from within the heart of the power grid.

Line monitors help us better manage distributed generation. Line monitors collect information from distribution transformers located at critical spots throughout the electric grid. This information offers insight into grid performance, power quality, preventive maintenance opportunities, distributed generation impacts, loss reduction opportunities, and outage restoration enhancements. When combined with substation and smart meter data, we can:

- Determine if distributed PV generation is causing safety, reliability, or power quality issues.
- Ensure that distributed generation circuit voltages are within tariff and applicable standards.
- Understand the condition of circuits with high PV penetration to determine boundaries and thresholds, and to better integrate distributed generation in the future.

Demand Response (DR) Ancillary Services

Increasing amounts of renewable energy cannot provide the same level of ancillary services as firm generation. Demand Response, however, can begin to fill that gap. DR can contribute to grid service requirements, including capacity, accelerated energy delivery, and several ancillary services: regulating reserve, contingency reserve, non-spinning reserve, and non-AGC ramping. Our smart grid platform supports the critical performance requirements of DR for ancillary services, while enabling broad device connectivity and maintaining open software interfaces. In addition, using a common network platform can reduce stranded assets, and foster standard data interfaces for aggregators.

Data Analytics Platform

Data Analytics examines the large set of data collected by our smart grid platform to uncover hidden patterns, unknown correlations, trends, customer preferences, and other useful information. We can then use this information to respond to these new discoveries, ultimately providing another level of improving our business operations and optimizing the grid.

5. Smart Grid Implementation

The roadmap for implementing smart grid across the Hawaiian Electric Companies consists of two main stages:

Demonstration Project, where we demonstrated a suite of smart grid solutions on a limited number of circuits that represent statewide demographics and geography, and engaged our customers in a dialogue about smart grid benefits.

Full Implementation, where we completely install smart grid all at once with a suite of solutions, individualized for each island we serve, that provide the most customer benefit.

This roadmap lays out the timeline for implementing the smart grid solutions, as well as the regulatory, customer-engagement, and back office integration activities required for each operating utility so that smart grid becomes a reality.

In developing this roadmap, we have been guided by three key design principles:

1. Implement a complete smart grid by focusing on a suite of solutions that can deliver customer benefits as quickly as possible.
2. Engage early and often with customers, ensuring they understand the benefits of smart grid technology, and maximizing their participation in programs that can deliver them tangible benefits.
3. Use the Demonstration Project to reduce risk during full implementation and reinforce the smart grid business case.

SMART GRID IMPLEMENTATION OVERVIEW

Figure 25 depicts our past and future activities for implementing a smart grid platform.

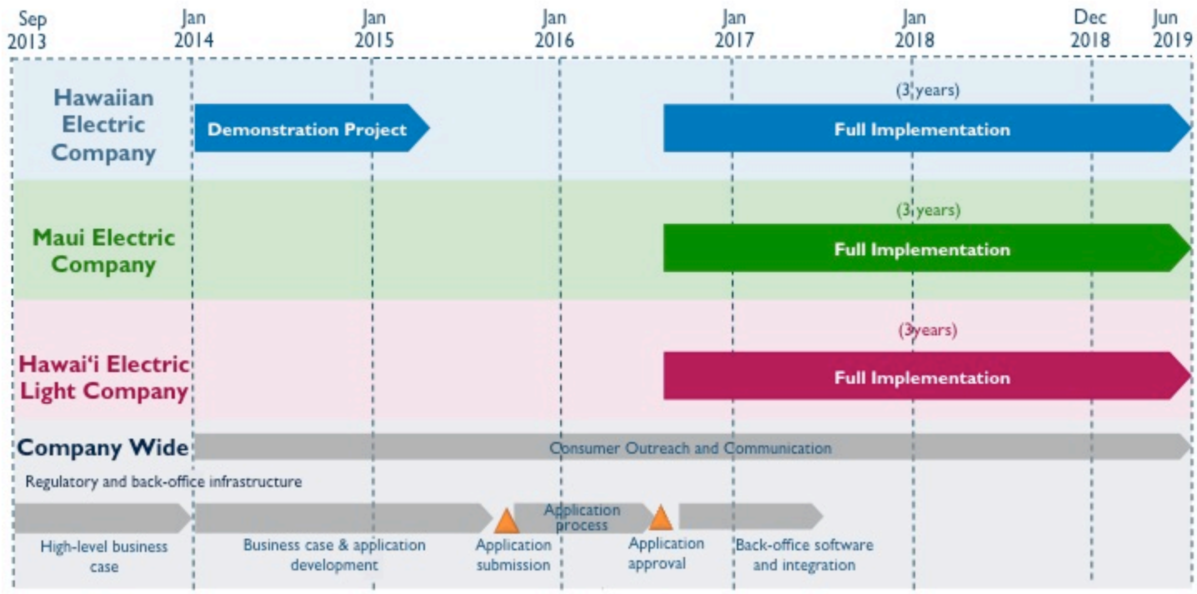

Figure 25: Smart Grid Implementation Overview

The Demonstration Project

During our Demonstration Project, we implemented a smart grid program on O'ahu with two primary objectives:

- Demonstrate the technology.
- Engage customers.

We've designed the Demonstration Project to mirror as much as possible, the many critical smart grid capabilities that needed to be tested on our grids. We chose not to demonstrate a few capabilities because they had already been proven successful at several other utilities.

During the Demonstration Project, we began engaging our customers to educate them on smart grid and how it can benefit them.

Table 2 lists the smart grid solutions tested during the Demonstration Project, and the solutions to be included in our full implementation.

Technology Capability	Demonstration Project	Full Implementation
Automated Meter Reading	Yes	Yes
Billing from Automated Reads	No	Yes
Remote Connect/Disconnect	Partial	Yes
Theft Detection	Yes	Yes
Outage Management System	Partial	Yes
Customer Energy Portal	Yes	Yes
Prepay	Yes	Yes
Conservation Voltage Reduction (CVR)	Yes	Yes
Distribution Automation (DA), including Fault Circuit Indicators (FCIs) and Remote Switching	Yes	Yes
Direct Load Control (two-way load control switch)	Yes	Yes
Dynamic Pricing	No	Yes

Table 2: Smart Grid Capabilities for the Initial Phase and Full implementation

During the Demonstration Project, we began creating our smart grid application encompassing our three operating utilities across five islands. The purpose of filing the application is to seek approval for the full smart grid implementation. The application will detail costs and benefits of the smart grid and will be tailored to each operating utility.

Our Demonstration Project (which ended last year) included smart meters, Prepay, and portions of the AMI and Customer Energy Portal. By September 2014, we had installed 5,200 smart meters on O‘ahu. Customers in Moanalua Valley and portions of Pearl City, Kaimuki, Diamond Head, Kahala, and Waikiki were able to access their own personalized Web portal and use that information to help better manage their electric bills.

Up to 250 customers with smart meters could also enroll in the Prepay program.

Full Implementation

During our full implementation, we will build the foundational infrastructure and install the devices necessary for a smart grid, including back office systems, smart grid NAN infrastructure, utility FAN and WAN infrastructure (separate from the smart grid project), sensor endpoints, and services to manage the network. We will then install the smart grid solutions that can have the most positive impact on our customers: AMI, the Customer Facing Solutions of a Customer Energy Portal and Prepay; Distribution Automation including an Outage Management System (OMS), FCIs, and Remote Switching; an ADMS with Conservation Voltage Reduction (CVR), and the Direct Load Control (DLC) and Dynamic Pricing Demand Response programs.

Because we are tailoring the smart grid to meet the unique needs of our customers on each island, the implementation timeline differs for each operating utility. We expect to complete full implementation for Maui Electric and Hawaiʻi Electric Light in 2017, and for Hawaiian Electric in 2018. Customers realizing benefits early on is crucial to the overall success of our smart grid platform. We expect that customers who realize that smart grid innovations can contribute to lower bills will be more motivated to participate in the full range of smart grid solutions. To that end, communication will be key. We are engaging our customers from the outset, making sure they understand the benefits available from a smart grid, and explaining how they can best maximize those benefits.

Before we can start, our smart grid application, this *Smart Grid Roadmap Update*, and our specific implementation timelines must be approved by the Commission.

SMART GRID IMPLEMENTATION BY OPERATING UTILITY

Hawaiian Electric: O‘ahu Demonstration Project

Hawaiian Electric serves the highest concentration of customers on Hawai‘i's most densely populated island. The biggest challenge faced by our customers on O‘ahu is high electricity bills. Thus, our focus is on introducing smart grid solutions that can contribute the most to lowering monthly energy costs.

During our Demonstration Project, we demonstrated smart grid features and created positive customer experiences to help encourage acceptance during and after a full implementation.

Figure 26 shows the timeline to plan and implement, demonstrate and measure, and sustain the implementation of these solutions.

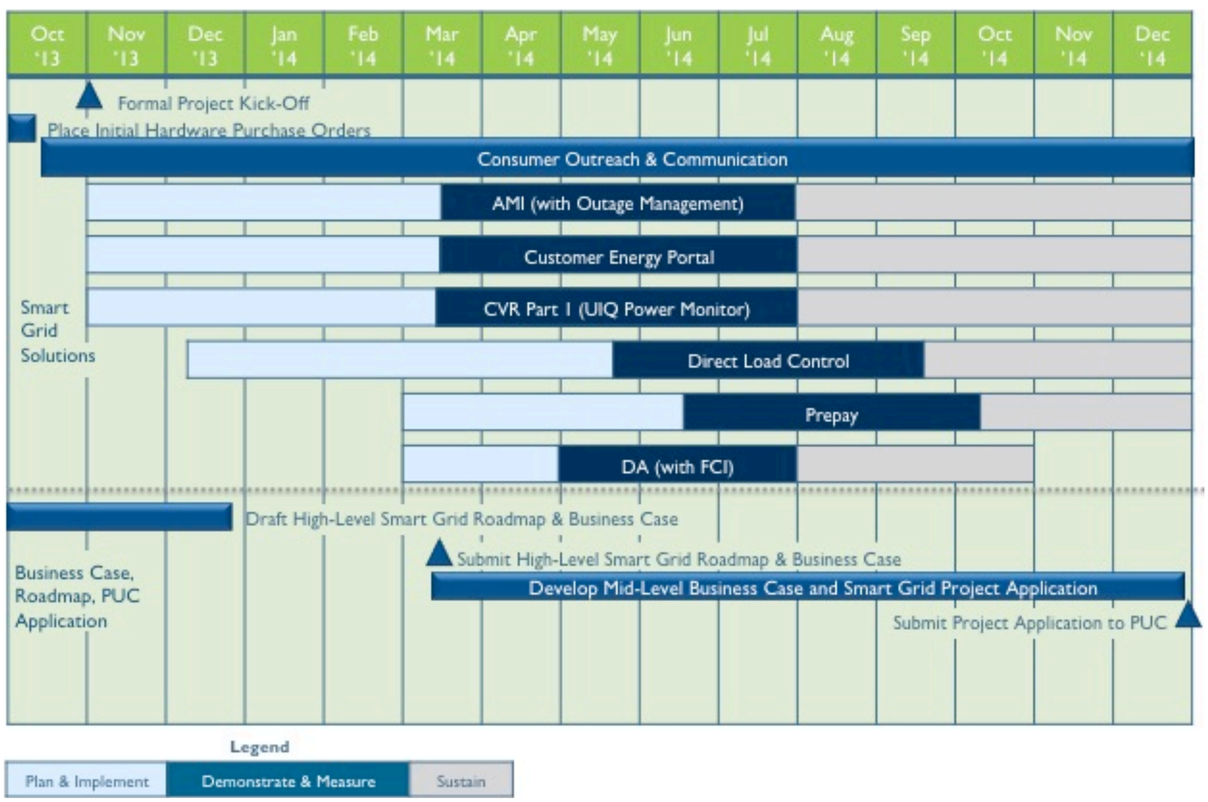

Figure 26: Hawaiian Electric (O‘ahu) Demonstration Project Plan

Hawaiian Electric: O'ahu Full Implementation

Hawaiian Electric plans to build the necessary infrastructure to implement its smart grid platform on O'ahu, including back office systems and utility WAN network infrastructure (through a project separate from the smart grid). We plan to expand AMI to all our customers so they can better manage their monthly energy usage through the Customer Energy Portal and by enrolling in expanded Prepay programs. Hawaiian Electric also plans to complete a full rollout of Conservation Voltage Reduction (CVR), Distribution Automation (DA) with fault circuit indicators (FCIs) and an Outage Management System to better manage outages, plus the Direct Load Control (DLC) and Dynamic Pricing programs.

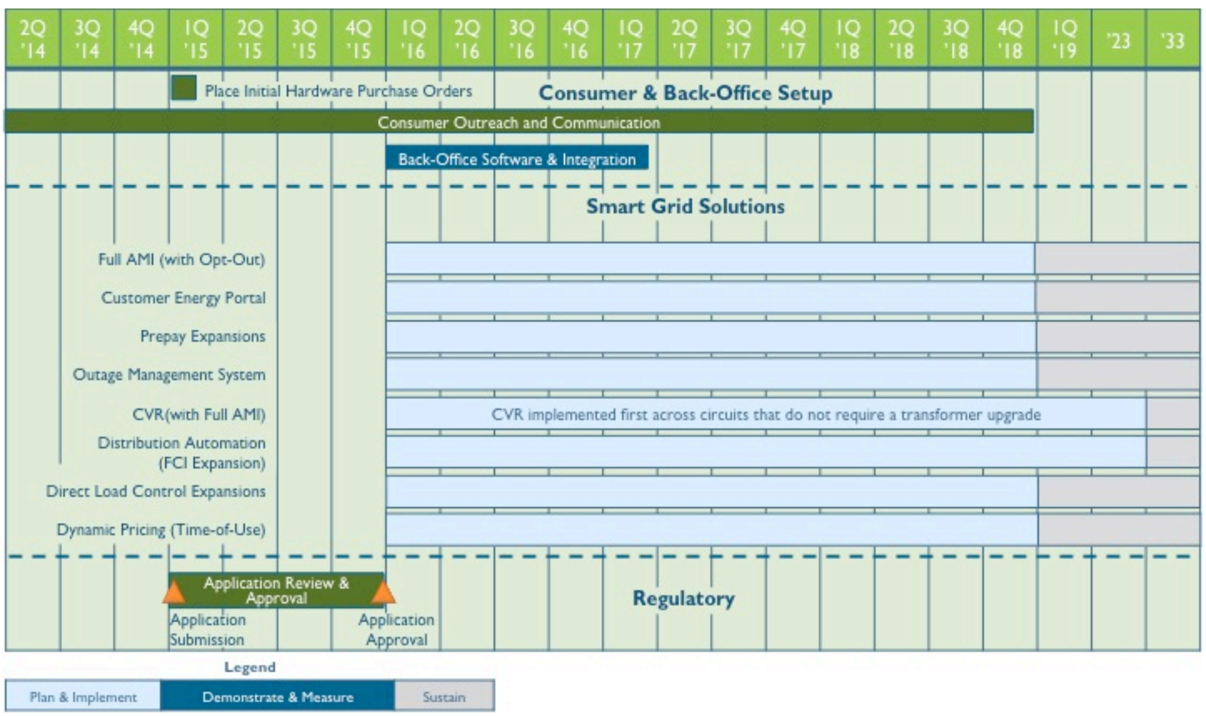

Figure 27: Hawaiian Electric (O'ahu) Full Implementation Plan

Maui Electric: Maui Full Implementation

Over the last few years, Maui Electric has brought online more than 72 megawatts of wind power from three large-scale wind farms. They also plan to decommission oil-fired generation units by 2019. Maui Electric is building on Hawaiian Electric's experience in O'ahu by rolling out several customer-focused smart grid solutions for Maui customers beginning in 2016.

Maui Electric plans to implement AMI by 2017, including a build-out of a utility WAN network infrastructure (through a project separate from the smart grid). Maui Electric then plans to begin running a Customer Energy Portal, Conversation Voltage Reduction (CVR) on a limited bases, plus the first phase of Distribution Automation with fault circuit indicators (FCIs) to better manage outages, the Direct Load Control (DLC) program, and networked street lights all across the island of Maui. The next year, they plan to implement Prepay, a full implementation of CVR, and the Dynamic Pricing program.

After 2018, Maui Electric plans to roll out the second phase of its Distribution Automation plan while continuing to sustain existing implementations.

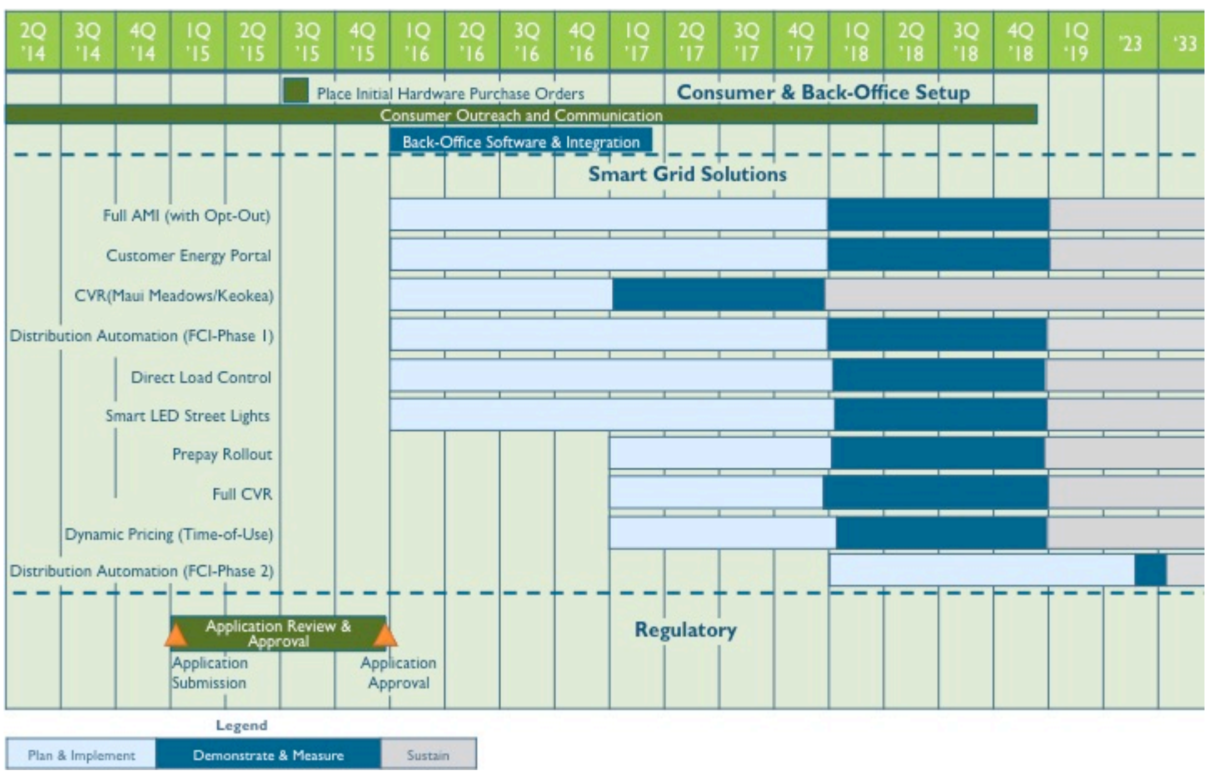

Figure 28: Maui Electric (Maui) Full Implementation Plan

Maui Electric: Lana‘i and Moloka‘i Full Implementation

On Lana‘i and Moloka‘i, Maui Electric plans to initially implement full AMI by 2017, including a build-out of a utility WAN network infrastructure (through a project separate from the smart grid), a Customer Energy Portal, and a Prepay option. Once completed, the rollout continues with the implementation of CVR and Distribution Automation with fault circuit indicators (FCIs) to better manage outages, plus a Direct Load Control program (if DLC is applicable to customers on these two islands).

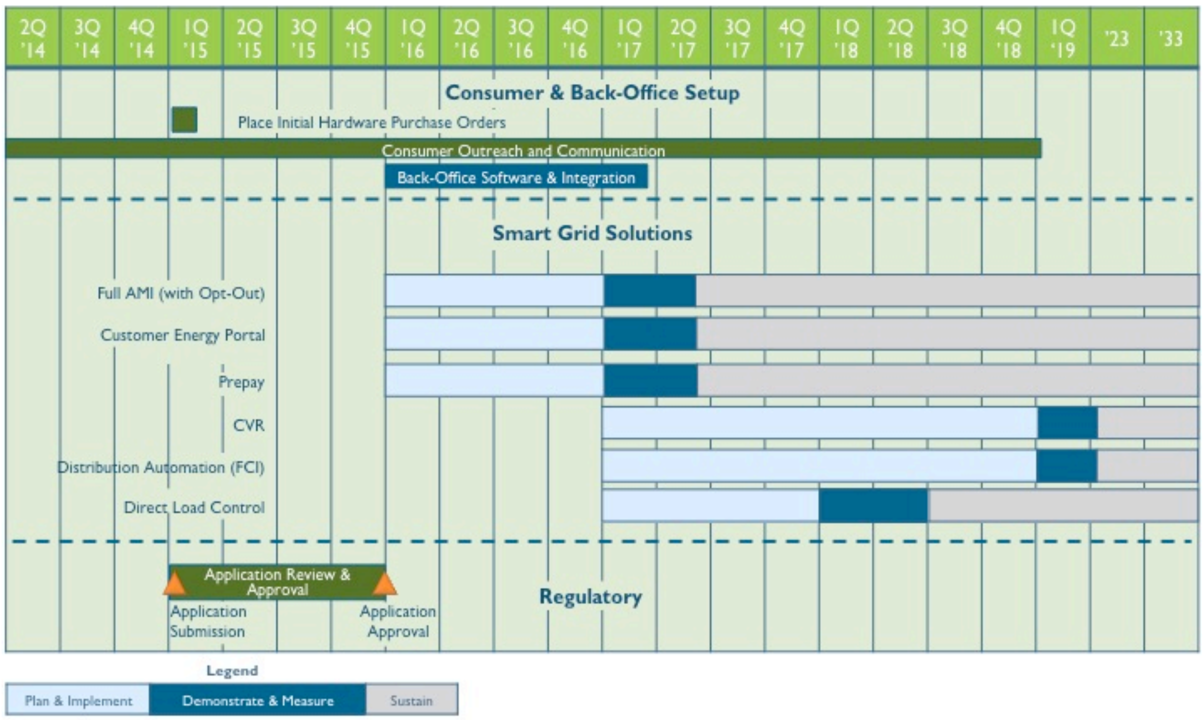

Figure 29: Maui Electric (Lana‘i and Moloka‘i) Full Implementation Plan

Hawai'i Electric Light: Hawai'i Island Full Implementation

Hawai'i Electric Light expects its full smart grid implementation to largely follow the approaches used on O'ahu and Maui.

Initially, Hawai'i Electric Light plans to implement AMI by 2017, including a build-out of a utility WAN network infrastructure (through a project separate from the smart grid), while introducing CVR to deliver immediate benefits to its customers together with the first phase of Distribution Automation with fault circuit indicators (FCIs) to better manage outages, and the Direct Load Control (DLC) program. The utility then plans to implement a Customer Energy Portal, Prepay, full CVR, and the Dynamic Pricing program.

After 2018, Hawai'i Electric Light plans to roll out the second phase of its Distribution Automation plan with FCIs while continuing to sustain existing implementations.

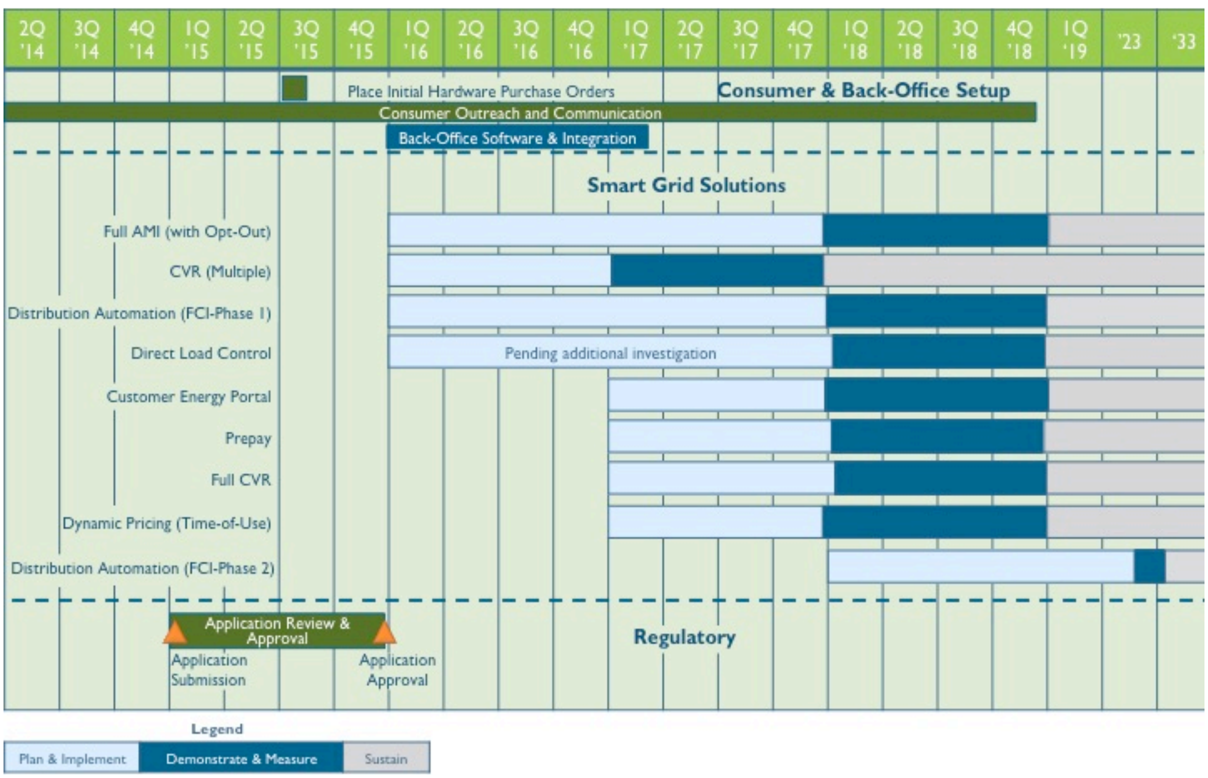

Figure 30: Hawai'i Electric Light (Hawai'i Island) Full Implementation Plan

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Appendices

A. DEFINITIONS

To aid understanding, this appendix contains definitions for many of the terms and acronyms used throughout this document.

Advanced Distribution Management System (ADMS): The software platform that supports the full suite of distribution management and optimization. An ADMS includes functions that automate outage restoration and optimize the performance of the distribution grid. ADMS functions being developed for electric utilities include fault location, isolation and restoration; volt/volt-ampere reactive optimization; conservation through voltage reduction; peak demand management; and support for microgrids and electric vehicles.

Advanced Metering Infrastructure (AMI): The hardware and software, together with the telecommunications services, that enables automated meter reading and other capabilities. AMI integrates advanced metering data from the meter all the way through to back office systems.

Automated Meter Reading (AMR): A form of advanced metering that uses communications devices to send data from the meter to the utility, including simple energy consumption data to outage detection and over-the-air meter programming.

Back Office: The internal business operations of an company that are not accessible or visible to the general public.

Conservation Voltage Regulation (CVR): A technique for improving the efficiency of the electrical grid by optimizing voltage on the feeder lines that run from substations to homes and businesses.

Critical Peak Pricing (CPP): A hybrid of time-of-use and real-time pricing. Utilities charge fixed time-of-use rates for preset periods but might charge higher rates during extreme supply conditions. Customers are notified in advance of the price change, allowing them time to reduce energy usage.

Customer Energy Portal: An online solution where customers can monitor their usage and make more informed choices on how to lower their energy bills.

Customer Information System (CIS): A suite of software programs that stores a plethora of information about utility customers. The CIS system also stores meter and customer-generation data.

Demand Response (DR): A program that enables customers to voluntarily curtail their energy usage when demand is high or during periods when their continued use might jeopardize the stability of the electrical system. Fully automated demand response can be initiated at a home or building by an external signal, which initiates pre-programmed shedding strategies. Facility staff at each site pre-program the control systems to receive the signals. The utility can provide payments as an incentive to participate in Demand Response programs.

Demand Response Management System (DRMS): An solution that optimizes Demand Response programs offered by a utility, enabling the DR programs to be viewed as a single asset. This solution allows a utility the ability to optimize load shedding customers while managing peak load by precisely estimating the potential available load shed in time. The solution also accurately measures and verifies load shed events.

Demonstration Project: Hawaiian Electric's plan to replace traditional meters with AMI meters for approximately 5,200 customers on six 12 kilovolt (kV) distribution circuits in four different areas of O'ahu. These neighborhoods from these six circuits reflect the general mix of homes, businesses, physical terrain, and diverse cultures across the island. This Demonstration Phase allowed Hawaiian Electric to fine-tune the installation process, evaluate upgrades to the grid and substations, and gather feedback from customers about the smart grid and smart meters to assist in the full implementation of smart grid.

Direct Load Control (DLC): A Demand Response program that enables a system operator to interrupt a customer's load during the period of annual peak load. DLC is enabled by a utility-installed device that remotely controls equipment such as a central air conditioner or a water heater. During periods of heavy use of electricity, a system operator can send a signal through this device to turn off or cycle off and on the appliance for a set period of time.

Distributed Generation: A system that involves small amounts of generation or pieces of generation equipment applied to a utility's distribution system for the purpose of meeting local peak loads, sometimes displacing the need to build additional infrastructure. Distributed generation can take many forms, but predominately it wind or rooftop photovoltaics systems.

Distribution Automation (DA): An solution that quickly detects and isolates outages and service interruptions, thus enabling restoration crews to efficiently restore power. DA intelligently controls and monitors the electrical power grid down to the distribution and substation level.

Dynamic Pricing: A Demand Response program that provides pricing signals to encourage customers to use energy during times of the day where energy has a lower cost.

Electric Power Research Institute (EPRI): An industry association that conducts research, development, and demonstration related to electric generation, delivery, and use for the public's benefit. This independent, nonprofit organization brings together scientists and engineers as well as experts from academia and the industry to help address challenges in electricity.

Electric Vehicle (EV): A battery-powered automotive vehicle.

Energy Management System (EMS): A system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation and transmission systems.

Event: An action that occurs on any device in the network, including device configuration changes, schedules, and errors. Events can be associated both with the device and with a communications protocol. All events have a severity level: informational, warning, or error.

Fault Circuit Indicator (FCI): A device placed in the field that provides either a local or remote indication of a fault (or problem) on an electrical circuit.

Field Area Network (FAN): The field communications network that connects substations, Neighborhood Area Networks (NANs), and other field devices to each other and to the core communications backbone (WAN gateway). The FAN can also serve as the link between the NAN and the core communications backbone (WAN) when a direct link from the NAN to WAN is not available.

Home Area Network (HAN): A data communications system contained within a home or small to medium business that communicates with other HAN devices.

IPv6 (Internet Protocol version 6): The latest revision of the Internet Protocol communications component that identifies and locates computers and devices on networks and routes traffic across the Internet. IPv6 was developed by the Internet Engineering Task Force (IETF) to deal with the long-anticipated problem of IPv4 address exhaustion.

Last Gasp: An asynchronous message from an electricity meter that indicates the meter has lost power. Last gasps can result when the loss-of-power PIN becomes active, when zero crossing events are missed, or when a transition from utility power to battery power occurs. There is no guarantee that a last gasp will be received by any other failed device in the network.

Load Shedding: The process of deliberately removing preselected customer demand from a power system in response to an abnormal condition to maintain the integrity of the system and minimize overall customer outages.

Local Area Network (LAN): Computers and other devices that share a common link within a geographic area.

Mesh Communications Network: A LAN of continuously connected meter end nodes, access points, and relays that connect to and communicate with adjacent nodes. In a mesh network, devices collaborate to propagate the data in the network.

Meter Data Management System (MDMS): A system that performs long-term data storage and management for the large quantity of data delivered by smart metering systems. The MDMS imports the meter data, then validates and processes it so it can be used for billing and analysis.

Neighborhood Area Network (NAN): The Companies' last-mile, outdoor access network that connects smart meters and distribution automation devices to each other and to an access point device. These NAN access points communicate to the Field Area Network (FAN) or to the Wide Area Network (WAN) gateways through a cellular or Ethernet connection.

Net Energy Metering (NEM): An agreement that all residential and commercial utility customers must execute to request approval to interconnect their eligible, independently-owned and operated renewable energy generation system generating up to 100 kW to the Companies' electrical grid (according to Hawaii state law, Hawaii Revised Statutes (HRS) Section 269-101–269-111). The executed agreement allows the NEM customer to connect their renewable generator to the utility grid, allowing it to export surplus electricity into the grid, and to receive credits at full retail value which can be used to offset electricity purchases over a 12-month period. NEM customers are billed for net energy purchased determined by subtracting the excess energy exported to the utility grid from the total energy supplied by the utility. Here is the formula: Energy Supplied by the Utility (kWh) minus Excess Energy exported to the Utility (kWh) equals Net Energy Billed to the Customer (kWh).

Outage Detection System (ODS): A program that manages outage-related messages from electricity meters, including "last gasp" and power restore messages. Unlike an Outage Management System, an ODS does not include a work order management system.

Outage Management System (OMS): A computer-aided system that allows an electric utility to receive customer calls or indications from the SCADA system to manage and restore electrical outages. An OMS system is generally integrated with a work order management system.

Prepay: An smart grid solution where electricity customers are able to pay for their usage on a daily basis (as compared to the traditional method of a monthly billing). Prepay allows a customer to have electricity service without placing an initial deposit.

Renewable Portfolio Standard (RPS) for Hawai'i: A goal established for the Hawaiian Electric Companies to attain 40% of all electricity sales using renewable energy resources by the end of 2030.

SCADA (Supervisory Control and Data Acquisition): This computer-controlled system remotely monitors and manages electrical equipment (such as substation electric circuit breakers, substation transformers, and electrical switches).

System Average Interruption Duration Index (SAIDI): The average outage duration for each customer served on an electrical system. SAIDI equals the sum of all customer interruptions durations divided by the total number of customers served.

Time-of-Use (TOU): An electric utility billing rate where the rate varies by period of time during the day when the energy is actually consumed. The rate is usually based on expected average cost: lower cost during periods of low demand and higher during periods of peak demand.

UtilityIQ: A software suite from Silver Spring Networks that includes utility software programming for smart grid initiatives as well as network administration software for configuring, upgrading, and managing a smart grid network. For instance, UtilityIQ Advanced Meter Manager, the base platform upon which other UtilityIQ products and components depend, reads utility usage data from smart meters using configurable, automated metering schedules. UtilityIQ Demand Optimizer creates and manages utility Demand Response programs, forecasts load and load shedding potential, and provides actionable analytics, after an event, about load shed and customer participation.

Volt/VAR Optimization (VVO): An smart grid solution that uses voltage data collected by AMI at customer sites. VVO enables Hawaiian Electric Company operators to safely and more precisely control voltages, resulting in saved energy, less carbon dioxide emissions, and lower customer bills. VVO minimizes voltage loss on the distribution circuits and increase the efficient operation of customer appliances.

Wide Area Network (WAN): A WAN is the core communications backbone of the utility's enterprise communications system. The WAN connects key facilities (such as substations, power plants, and corporate offices) to each other and to the FANs and NANs. The FAN and NAN networks transport data to the WAN, where the enterprise back office systems (such as Customer Information Systems, Energy Management Systems, and Geographic Information Systems) reside. The WAN is a dispersed telecommunications network (in contrast to a LAN or NAN which are localized networks) and often includes public networks.

B. SMART GRID REFERENCES

Hawaiian Electric Reference Documents

Make all the punctuation consistent.

2013 Integrated Resource Planning Report. Docket No. 2012-0036; June 28, 2013
http://dms.puc.hawaii.gov/dms/OpenDocServlet?RT=&document_id=91+3+ICM4+LSDB15+PC_DocketReport59+26+A1001001A13G01B54746G5196418+A13G01B54746G519641+14+1960
IRP Appendices A–I:
http://dms.puc.hawaii.gov/dms/OpenDocServlet?RT=&document_id=91+3+ICM4+LSDB15+PC_DocketReport59+26+A1001001A13G01B61746B2601118+A13G01B61746B260111+14+1960
IRP Appendices J–N:
http://dms.puc.hawaii.gov/dms/OpenDocServlet?RT=&document_id=91+3+ICM4+LSDB15+PC_DocketReport59+26+A1001001A13G01B64445C0576718+A13G01B64445C057671+14+1960
IRP Appendices O–Q:
http://dms.puc.hawaii.gov/dms/OpenDocServlet?RT=&document_id=91+3+ICM4+LSDB15+PC_DocketReport59+26+A1001001A13G01B70951F7830518+A13G01B70951F783051+14+1960

Advanced Metering Infrastructure (AMI) Project Application. Docket No. 2008-0303; December 1, 2008
http://dms.puc.hawaii.gov/dms/OpenDocServlet?RT=&document_id=91+3+ICM4+LSDB15+PC_DocketReport59+26+A1001001A08L04B61247I3996218+A08L04B61247I399621+14+1960

Distributed Generation Interconnection Plan (DGIP). Docket No. 2011-0206; August 26, 2014
http://files.hawaii.gov/puc/4_Book 1 %28transmittal ltr_DGIP_Attachments A-1 to A-5%29.pdf

Enterprise Information Systems Roadmap. Docket No. 2014-0170; June 13, 2014; referenced in the *Hawaiian Electric Companies Enterprise Resource Planning-Enterprise Asset Management System Implementation Project Application*; July 23, 2014
http://dms.puc.hawaii.gov/dms/OpenDocServlet?RT=&document_id=91+3+ICM4+LSDB15+PC_DocketReport59+26+A1001001A14G24B12704G1684118+A14G24B41643F763201+14+1960

Hawaiian Electric Company State of the System Summary for the ESS RFP. Hawaiian Electric Company Transmission Planning; April 23, 2014
http://www.hawaiianelectric.com/vcmcontent/StaticFiles/pdf/ESS_Attachment_G_Hawaiian_Electric_State_of_the_System.pdf

Hawaiian Electric Power Supply Improvement Plan (PSIP). Docket No. 2011-0206; August 26, 2014
http://1.usa.gov/1C3ZBAb

Integrated Demand Response Portfolio Plan (IDRPP). Docket No. 2007-0341; July 28, 2014
http://puc.hawaii.gov/wp-content/uploads/2014/08/HECO-Companies-Integrated-Demand-Response-Portfolio-Plan-07-28-14.pdf

Smart Grid Roadmap & Business Case. Docket No. 2008-0303; March 17, 2014
http://1.usa.gov/1ymcGDt

Relevant External Publications

Advanced Inverter Technologies Report. California Public Utilities Commission (CPUC), Grid Planning and Reliability Energy Division; January 18, 2013
http://www.cpuc.ca.gov/NR/rdonlyres/6B8A077D-ABA8-449B-8DD4-CA5E3428D459/0/CPUCAdvancedInverterReport2013FINAL.pdf

Advanced Metering Initiatives and Residential Feedback Programs: A Meta-Review for Households Electricity—Saving Opportunities. American Council for an Energy Efficient Economy (ACEEE); by Karen Ehrhardt-Martinez, Kat A. Donnelly, and John A. "Skip" Laitner; June 26, 2010
http://www.aceee.org/research-report/e105

Case Study: Salt River Project—The Persistence of Consumer Choice. U.S. Department of Energy (DOE) and the Federal Energy Regulatory Commission (FERC); by Judith Schwartz. Chartwell Research, prepared for the National Forum on the National Action Plan on Demand Response: Program Design and Implementation Working Group; June 2011
http://emp.lbl.gov/sites/all/files/napdr-srp-case-study.pdf

DOE Awards Electric Grid Grants. Recharge; July 13, 2014
http://www.rechargenews.com/wind/article1365776.ece

Energy Independence and Security Act of 2007, SEC. 1305. Smart Grid Interoperability Framework. One Hundred Tenth Congress of the United States of America; January 4, 2007
http://www.gpo.gov/fdsys/pkg/BILLS-110hr6enr/pdf/BILLS-110hr6enr.pdf

Green Circuits: Distribution Efficiency Case Studies. Electric Power Research Institute (EPRI); 1023518; October 14, 2011
http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=000000000001023518

NIST Framework and Roadmap for Smart Grid Interoperability Standards, Update 3.0. National Institute of Standards and Technology, United States Department of Commerce; September 2014
http://www.nist.gov/smartgrid/upload/NIST-SP-1108r3.pdf

North American Energy Standards Board (NAESB) Energy Services Provider Interface (ESPI) standards
http://www.naesb.org/ESPI_standards.asp

Paying Upfront: A Review of Salt River Project's M-Power Prepaid Program. Electric Power Research Institute (EPRI); October 2010
http://www.srpnet.com/environment/earthwise/pdfx/spp/EPRI_MPower.pdf

Performance of Distributed Energy Resources During and After System Disturbance: 2013 Special Reliability Assessment. North American Electric Reliability Corporation (NERC); June 2013
http://www.nerc.com/comm/PC/Integration of Variable Generation Task Force II/IVGTF17_PC_FinalDraft_December_clean.pdf

Presidential Memorandum—Federal Leadership on Energy Management. The White House Office of the Press Secretary; December 5, 2013
http://www.whitehouse.gov/the-press-office/2013/12/05/presidential-memorandum-federal-leadership-energy-management

Radio-Frequency Exposure Levels from Smart Meters: A Case Study of One Model. Electric Power Research Institute (EPRI); February 2011
https://www.nvenergy.com/NVEnergize/documents/EPRI_1022270_caseStudy.pdf

Recommendations for Updating the Technical Requirements for Inverters in Distributed Energy Resources. California Public Utilities Commission; January 2014 (filed February 7, 2014)
http://www.energy.ca.gov/electricity_analysis/rule21/documents/recommendations_and_test_plan_documents/Recommendations_for_updating_Technical_Requirements_for_Inverters_in_DER_2014-02-07-CPUC.pdf

Reliability Considerations from the Integration of Smart Grid. North American Electric Reliability Corporation (NERC) Smart Grid Task Force; December 2010
http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/SGTF_Report_Final.pdf

Reliability Improvements from the Application of Distribution Automation Technologies – Initial Results. United States Department of Energy; December 2012
http://energy.gov/sites/prod/files/DistributionReliabilityReport_Dec2012Final.pdf

REQ-18/WEQ-19. Retail Customer Energy Usage Information Communication Model Business Practices. North American Energy Standards Board (NAESB); August 30, 2013
http://www.naesb.org/member_login_check.asp?doc=retail_bk18_083013.pdf (login required)

REQ-21. Energy Services Provider Interface Model Business Practices. North American Energy Standards Board (NAESB); August 30, 2013
http://www.naesb.org/member_login_check.asp?doc=retail_bk21_083013.pdf (login required)

REQ-22. Third Party Access to Smart Meter-based Information Model Business Practices. North American Energy Standards Board (NAESB); August 30, 2013
http://www.naesb.org/member_login_check.asp?doc=retail_bk22_083013.pdf (login required)

Smart Grid Interoperability Panel (SGIP) National Institute of Standards and Technology (NIST) Catalog of Standards
http://www.sgip.org/Catalog-Standards-Search

SPIDERS: Smart Power Infrastructure Demonstration for Energy Reliability and Security. Sandia National Laboratories; February 23, 2012
http://energy.sandia.gov/wp/wp-content/gallery/uploads/SPIDERS_Fact_Sheet_2012-1431P.pdf

Volt/VAR Optimization Improves Grid Efficiency. National Electric Manufacturers Association (NEMA); August 23, 2103
https://www.nema.org/Policy/Energy/Smartgrid/Documents/VoltVAR-Optimazation-Improves Grid-Efficiency.pdf