Smart Grid Roadmap & Business Case

March 2014

Hawaiian Electric Company, Maui Electric Company, and Hawaiʻi Electric Light Company, (the Hawaiian Electric Companies) submit this document to comply with the Decision and Order issued by the Hawaiʻi Public Utilities Commission on July 26, 2010 in Docket No. 2008-0303.

Table of Contents

Figures

Tables

Executive Summary

Hawaiian Electric Company (Hawaiian Electric), Maui Electric Company (Maui Electric), and Hawaiʻi Electric Light Company (Hawaiʻi Electric Light), (Hawaiian Electric, Maui Electric, and Hawaiʻi Electric Light collectively referred to herein as the Hawaiian Electric Companies) propose to implement smart grid through all three of our operating utilities, on all five islands we serve. 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 overarching goal is to successfully implement a smart grid that brings the greatest benefit to our customers. 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 Hawaiʻi. Our plans reflect our understanding of the complexity of this undertaking.

As the Hawaiʻi Public Utilities Commission (Commission) requested, we have developed a comprehensive roadmap and business case. We based our roadmap and business case on a comprehensive review of other smart grid implementations and on carefully specified fundamental assumptions.

The result is this document: the Hawaiian Electric Companies' *Smart Grid Roadmap and Business Case*. We explain our plan for demonstrating smart grid, the applications available within a smart grid and the benefits they bring, the estimated dollar costs and value of the benefits smart grid brings, and our plan to successfully implement smart grid over time Customers, regulators, and all energy stakeholders can gain a solid understanding of our assessment and our plan for bringing the benefits of smart grid to our customers.

OUR SMART GRID VISION AND ROADMAP

Hawaiʻi faces unique energy challenges. A smart grid can help the Hawaiian Electric Companies better meet those challenges.

The smart grid, at its most fundamental, overlays a communications network on the existing electric grid. A variety of hardware and software applications can be connected to the network to enhance reliability and efficiency while lowering costs. These applications 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 applications can also be added in the future. Together, this network and these applications form the smart grid platform.

We are committed to implementing mature, proven technology. We have studied successful smart grid implementations at other utilities, researched their installed applications, and gained much insight. We are partnering with Silver Spring Networks, an industry leader in smart grid technology, to help us successfully implement a smart grid and install the applications most beneficial to our customers.

Our roadmap is comprised of five main phases. We have already finished the first two—evaluating and developing the initial planning for our smart grid implementation. This year, we will begin moving forward with the remaining three phases (which are an initial demonstration phase, a full implementation phase, and value delivery phase) to implement smart grid across our entire service area.

Our goal is to complete AMI[1] (Advanced Metering Infrastructure, a core smart grid application) implementations by the end of 2018.

ENGAGING OUR CUSTOMERS

We believe a proactive, transparent, and sustained communication effort to educate and engage our customers is critical to successfully implementing and gaining the most benefit from smart grid. This requires building interest from the onset, address questions and concerns, and help customers understand the benefits and how to take advantage of smart grid.

[1] Refer to Appendix A. Definitions (page 123) for a definition of AMI and other terminology.

We have developed a customer engagement plan based on established communication guidelines. We will explain to customers the smart grid and how they can best benefit from the technology. We plan to collaborate and communicate with customers using printed materials, mailings, face-to-face discussions, and online tools.

BENEFITS TO CUSTOMERS

Smart grid provides customers access to accurate, near real-time information about their own energy usage and choices. Through an online Customer Energy Portal (a smart grid application), customers can monitor that usage and make more informed choices on how to lower their energy bills. Customers can also access Prepay, a smart grid payment tool that allows payment for energy before it is used. Both applications have proven to reduce energy usage.

Customers will also benefit from our ability to remotely connect and disconnect power at a customers' home, as well as detect and quickly resolve outages and system disturbances at the neighborhood circuit level. Through Direct Load Control and Dynamic Pricing (two smart grid applications using Demand Response), we can give incentives to customers who adjust their energy usage by encouraging use during times of the day where energy has a lower cost.

Many customers generate renewable energy through distributed generation (especially rooftop solar). Smart grid will not only enable us to provide information that customers can use to optimize the power generated with their solar systems, but could also help us better manage this intermittent distributed generation safely and reliably by providing visibility of their output and enabling control over these systems in the future.

BUSINESS CASE FOR OUR CUSTOMERS

We developed a high-level business case that measured the costs and benefits of our smart grid implementation. We did this by applying a strict four-part methodology, first by defining the scope, second by identifying costs and related benefits, next by collecting utility-specific relevant energy data, and finally by comparing our results with national industry averages.

This is what we found: the value of the benefits that result from our smart grid implementation far outstrips their related costs.

Overall, combining all three operating utilities, smart grid would result in $119–$125 million (present value) in benefits net of costs over the next 20 years.

We will continue to refine our business case over the next several months during the Initial Phase to develop a more refined, mid-level business case. By the end of 2014, we plan to file with the Commission an application for fully implementing smart grid on O'ahu, Maui, Lana'i, Moloka'i, and Hawai'i Island. If approved, we will employ almost a dozen and a half quantifiable metrics during our full implementations to better ensure smart grid is delivering on its expected benefits.

SMART GRID TECHNOLOGY

The backbone of our Telecom System (fully owned by the Hawaiian Electric Companies) acts as an enabler for all of our operational and corporate business applications, including the smart grid applications. The Hawaiian Electric Companies enterprise telecommunications network is commonly referred to as our Wide Area Network (WAN) and Field Area Network (FAN). The smart grid applications 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), which is located beyond the WAN and FAN networks. The foundation of the smart grid platform (the NAN) we intend to implement is a two-way communications network that connects points along the distribution grid to our back-office software. Smart grid applications run on that network providing detailed information about the performance of the distribution grid.

The Advanced Metering Infrastructure (AMI) application supports the installation of smart meters and other smart grid devices in residential and commercial sites. AMI automates many current manual processes, such as meter reading, customer billing, and service connects and disconnects.

The Volt/VAR Optimization (VVO) application, by accessing voltage data collected by AMI, enables our operators to safely and more precisely control voltages which results in saved energy, less carbon dioxide emissions, and lower customer bills. VVO increases efficiency.

The Distribution Automation (DA) application allows us to detect and isolate outages and service interruptions almost immediately, enabling restoration crews to quickly restore power. In many cases, we can even reroute power around damaged lines. DA increases reliability.

Smart grid is safe. Many scientific studies have concluded that the radio frequencies generated by smart grid devices are far below that of many household appliances and devices.

Smart grid is secure and private. The smart grid platform layered data encryption and network security protects the network from cyber-attacks, ensuring customer-specific and system-wide data safe from external and internal threats.

ROADMAP FOR SMART GRID IMPLEMENTATION

Over the past five years, we at the Hawaiian Electric Companies have spent a considerable amount of time and effort evaluating and planning the implementation of smart grid and choosing the smart grid applications that drive the most benefit for our customers.

This year, we are rolling out a limited smart grid implementation project (called the Initial Phase) on O'ahu. The Initial Phase involves about 5,200 customers who represent statewide demographics and geography, and includes the implementation of the AMI, Customer Energy Portal, Prepay, Volt/VAR Optimization (VVO), Distribution Automation (DA), and Direct Load Control applications. The Initial Phase is designed to demonstrate these smart grid applications and engage customers.

Full implementation across all five islands will begin in the latter part of 2015 or early 2016, assuming we receive regulatory approval. We have tailored the smart grid implementation, together with its smart grid applications, to best meet the unique needs of our customers on each island. We plan to implement smart grid on each island all at once. Scheduled completion dates range from the end of 2017 through the end of 2018.

Engaging customers in dialogues is crucial to success. Throughout the demonstration project and 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.

1. Introduction

At its very essence, a smart grid modernizes our electrical grid. A smart grid brings five tangible benefits to our customers:

- Increased reliability
- Greater efficiency with expanded customer choices
- Increased renewable energy through integrated distributed generation
- Reduced carbon dioxide emissions
- Lower costs resulting in lower electricity bills

So what exactly is a smart grid? Basically, a smart grid adds an increased level of information and visibility and possibility for greater control on our electrical grid at the distribution level, focusing on how, when, and where electricity is used. This information is gathered through a digital communications network that is added to the existing grid infrastructure—the wires, poles, and substations. Some of this equipment is upgraded to better handle the smart grid while some equipment, including advanced meters, is added to modernize our distribution grid. All these advances increase the "intelligence" of information about activity on the grid, and enhance our ability to respond to current conditions.

What can be done with this information? We at the Hawaiian Electric Companies use it to improve our productivity to better deliver electricity. Customers use it to better manage their usage. Together, increased productivity and management result in lower costs.

That, of course, explains smart grid at a high level. The details presented here reveal a greater understanding and appreciation of the many benefits smart grid brings to delivering, maintaining, and using electricity. In a nutshell, smart grid results in using electricity, well, smarter.

Our goal is to explain smart grid, our plan for implementing smart grid, and how a smart grid platform benefits Hawaiʻi energy stakeholders: the Hawaiʻi Public Utilities Commission (Commission); the Division of Consumer Advocacy, Department of Commerce and Consumer Affairs (Consumer Advocate); the Department of Business, Economic Development, and Tourism; the Hawaiʻi State Legislature, the many state and county policymakers; consumer advocacy groups; environmental organizations; and our customers.

We have a vision—a roadmap—for installing smart grid on all five islands that we serve: Oʻahu, Maui, Lanaʻi, Molokaʻi, and Hawaiʻi Island. This roadmap addresses the benefits that a smart grid brings to all of our customers as well as to the state of Hawaiʻi: financial benefits of lower costs through better productivity and usage, operational benefits of increasing the efficiency and reliability of delivering electricity while reducing outages, and those many intangible benefits from improved worker safety, service quality, economic output, customer satisfaction, and environmental impact.

HOW TO USE THIS ROADMAP

This is a multifaceted document intended for a variety of audiences. It details the many aspects of smart grid: its make-up, its costs, its benefits, and its implementation. Each chapter discusses one of these aspects.

1. Introduction: This chapter that you are currently reading introduces the concept of smart grid at a high level, what it entails, and the benefits it brings.

2. Smart Grid Roadmap: To efficiently arrive at a destination, it's good to have a roadmap. This chapter outlines the many applications available in a smart grid network, and explains our five-phase roadmap: essentially our plan for implementing smart grid on the five Hawaiʻi islands we serve.

3. Engaging Our Customers: You, our customers and stakeholders, benefit the most from smart grid. Here you learn about our communication guidelines, how we plan to proactively address some concerns about smart grid, and engage you in our efforts to implement smart grid.

4. Delivering Benefits to our Customers: This chapter explains in detail five tangible benefits that a smart brings to our customers.

5. Benefits for Customer Groups: This chapter explains the most pertinent benefits to various residential and commercial customers.

6. Business Case: To demonstrate the value of a smart grid, we have developed a high-level business case that shows how the resulting benefits outweigh the estimated costs.

7. Smart Grid Applications: The smart grid we plan to implement consists of several basic applications, while enabling future enhancements. This chapter explains these main smart grid applications deemed to garner the most customer benefit, and summarizes several potential future applications.

8. Smart Grid Implementation Roadmap: Our roadmap consists of five phases, with the two implementation phases: a demonstration phase (which we call the Initial Phase) starting early in 2014, and a full implementation phase beginning in 2016.

9. Strategic Partnership: Rather than go it alone, we partnered with Silver Spring Networks, an industry leader in smart grid technology. We've briefly outlined their capabilities in this chapter.

10. Smart Grid Business Case Assumptions: All successful plans form their foundation on a plethora of useful, meaningful data from which conclusions and expectations can be drawn. This chapter contains myriad tables and figures detailing this data.

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 taken their best practices and lessons learned, and incorporated that knowledge into our roadmap.

2. 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 because electric power cannot be transmitted among neighboring islands nor from surrounding land as U.S. mainland utilities can. This geographic isolation makes balancing supply and demand more difficult because we cannot rely on neighboring utilities to help address short-term imbalances.

Our state's physical location, however, 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 and well on the way to achieving Hawai'i's 2030 Renewable Portfolio Standard (RPS) goal of 40%. More than 10% 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 and there is lack of visibility and control over distributed solar photovoltaics; 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, 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.

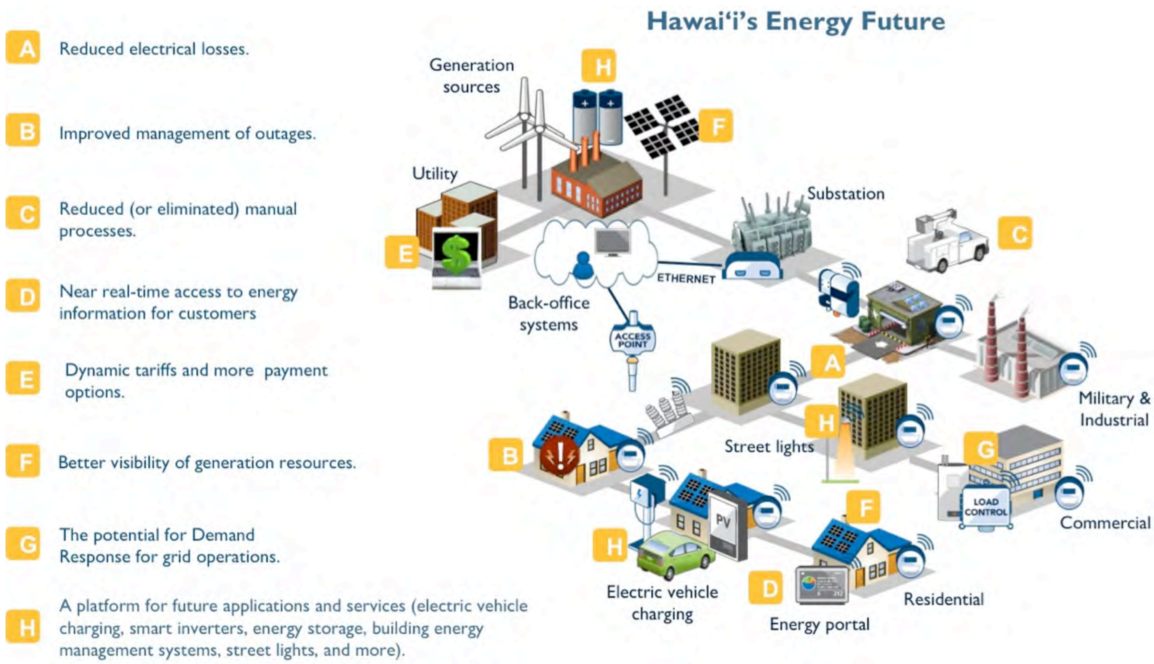


Figure 1: The Role of Smart Grid in Hawai'i's Energy Future

A smart, modern, and fully integrated electric grid enables:

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. Both optimizations can lower customer distribution costs without requiring customers to change their electricity usage 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 precisely determining those customers affected by the outages. Because it takes less time to locate and diagnose an outage, the time needed to restore power to customers can also be reduced. Work crews can confirm that full power has been restored before leaving the affected area. In addition, information about outages can be more accurately and quickly communicated to the general public and the media.

C **Reduced (or eliminated) manual processes,** saving time. With smart grid applications, a utility can read electric meters, activate new service, and disconnect existing service from a central location rather than at a customer site. These cost savings are then passed along to customers.

D **Near-real-time access to energy information for customers** about their energy usage. Customers, then, can make informed decisions about optimizing their energy usage, thus lowering their electricity bills.

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

F **Better 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.

G **The potential for Demand Response for grid operations**. The smart grid allows Demand Response programs, giving grid operators additional resource options when balancing supply and demand. Smart grid technologies make it feasible to consider Demand Response programs for numerous uses:, shifting load demand, 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 a utility's functional need. The cost-to-benefit of each type of use determines the potential Demand Response value compared to other resource technologies. Demand Response programs will be incorporated 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 **A platform for future applications 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). Other applications can remotely control street lighting and electric appliances in homes and businesses. These and many other future applications require the smart grid's foundational communication infrastructure.

THE SMART GRID NETWORK

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 robust, responsive communications network. The smart grid would reside between the residential, commercial, industrial, and military customer locations and the Hawaiian Electric Companies-enterprise telecommunications network for the electrical grid infrastructure commonly referred to as the Company's Wide Area Network (WAN) and the Field Area Network (FAN) (Figure 2).

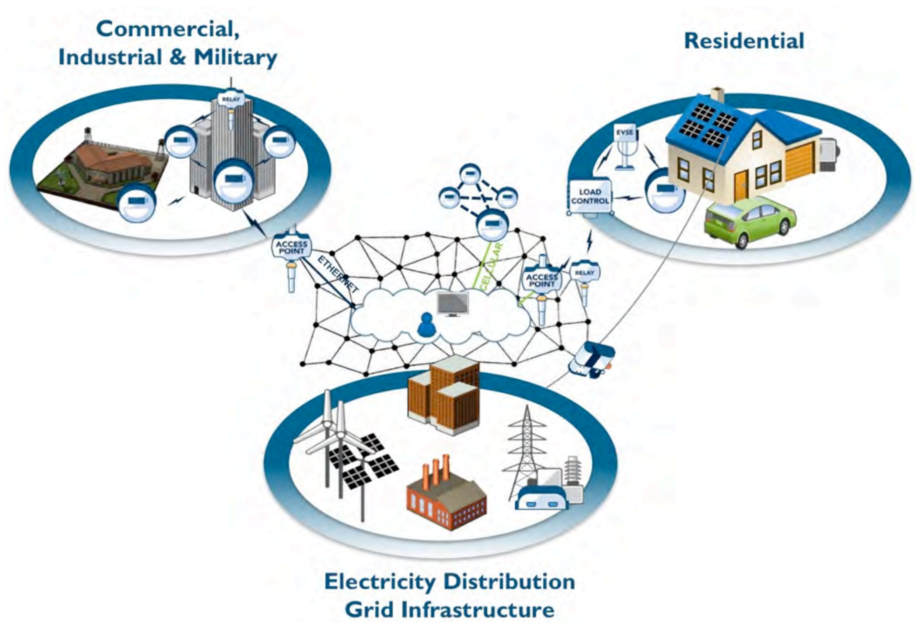


Figure 2: Smart Grid Communications Network

The Hawaiian Electric Companies plan to implement Silver Spring Networks' IPv6 platform over the telecommunications network which will ensure that we can implement standards-based networking throughout our electric distribution grid infrastructure, thus delivering a secure, common platform for a variety of specific smart grid applications. 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 applications that allow utility personnel greater visibility and the possibility for greater control of the grid, particularly at the distribution level. While the Silver Spring's network will be utilized for the 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 NAN applications—both existing and emerging—that we and our customers can phase in over time.

Smart Grid Applications

There are many smart grid applications that can be layered atop this network. After carefully evaluating the available applications, we have chosen several based on the benefits they would produce as part of our full implementation.

Here is a quick explanation of these smart grid applications. (For more detailed information, see "7. Smart Grid Applications" on page 57.)

Advanced Metering Infrastructure (AMI)

Smart meters, installed at homes and businesses, linked up to the networked grid and providing customers with robust, near real time, detailed information about their energy usage, form the basis of AMI. The AMI also allows us to remotely conduct service requests to improve operations and customer service, detect and respond to outages more quickly, and maximize distributed generation on a circuit.

Customer Energy Portal

Through this internet-based portal, customers can access 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.

Prepay

We plan to phase in new service and payment options for customers. Examples of these options include remote service requests (such as remotely activating or deactivating service connections) and a prepay option allowing customers the flexibility to pay for electricity before they use it while avoiding the need for a deposit.

Volt/VAR Optimization (VVO)

VVO stands for Volt/Volt-Ampere Reactive Optimization. Essentially, VVO enables us to optimize—to make the most effective use of—the electric voltages across distribution circuits by accessing very detailed, near real-time data from smart meters and distribution devices, including using remote voltage control. Minimizing voltage loss on the distribution circuits and increasing the efficient operation of customers' electrical appliances lowers operating costs.

Distribution Automation (DA)

Distribution automation links points along the electric grid with our back-office, providing more detailed and specific information on outages and service interruptions. With DA, we can then move quickly to restore power to our customers, and even reroute power around damaged lines, if an alternative path exists.

Direct Load Control (DLC) and Dynamic Pricing

Direct Load Control and Dynamic Pricing 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. As part of these programs, we plan to implement a software-based Demand Response Management System (DRMS) that can aggregate multiple Demand Response programs. 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.

Electric Vehicle Charging

Smart electric charging stations can help coordinate the charging of electric vehicles so that customers can charge these vehicles when power is most readily available, and least expensive, saving customers money while ensuring grid stability.

Smart Grid, Thoughtfully Implemented

The Hawaiian Electric Companies chose not to adopt smart grid early on. Instead, we learned lessons from similar smart grid implementations across the electric power industry, then crafted our roadmap for designing and implementing smart grid based on established best practices. We are also mindful, however, that actual operational and cost benefits must be assessed based on the specific operating, conditions that exist in Hawaiʻi.

To meet these challenges, we formed a strategic partnership with Silver Spring Networks, an industry leader in smart grid technology. Over the last decade, they have proven their mettle in implementing smart grid, and have successfully installed their smart grid mesh technology that currently serves over 17 million homes and businesses for more than 30 utilities. In addition to their robust smart grid program, Silver Spring Networks has the largest market share for AMI in the country.

Together, the Hawaiian Electric Companies and Silver Spring Networks plan to design a unique blend of smart grid applications for each of the islands served: O’ahu, Maui, Lanaʻi, Molokaʻi, and Hawai’i Island. Each blend of selected applications is expected to bring the most tangible benefits to customers of each island, and to the entire state. This must be based on an understanding of the way smart grid technologies could change the specific grid operations that yields lower costs while maintaining or improving reliability. The technical and operational capabilities must be verified to meet the anticipated use, and the impact on operating costs then carefully analyzed.

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 involves the safety of radio frequencies generated by smart grid devices. Numerous studies have addressed this issue, most notably one recent study[2] that 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.

---

[2] *Radio-Frequency Exposure Levels from Smart Meters: A Case Study of One Model* (February 2011), a study conducted by Electric Power Research Institute study (EPRI).

The network infrastructure that delivers data to and from customers employs the same technology used by the United States military to securely communicate sensitive, mission-critical information. The smart grid platform employs a layered approach to data encryption and network security—including multiple checks, and limits and restrictions to network access—which protects the network from cyber-attacks and ensures both customer-specific and system-wide data are secure from external and internal threats.

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 that some of our customers will still have concerns about smart meters and the use of other smart grid devices. As such, we plan to offer a deferral option during the Initial Phase and an opt-out program during full implementation for customers who prefer not to take part in smart grid.

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, and complete the AMI portion of the smart grid by the end of 2018. To comply with the Commission's Decision & Order in 2008,[3] we have created this robust *Smart Grid Roadmap and Business Case* to guide the five smart grid designs and implementations. Our ultimate goal is to ensure that smart grid becomes a beneficial reality for the state's electric grid and, most importantly, our customers.

The Smart Grid Roadmap (briefly outlined in Figure 3) is comprised of five main phases:

1. Evaluation (completed)
2. Planning (completed)
3. Demonstration (The Initial Phase)
4. Full Implementation
5. Value Delivery

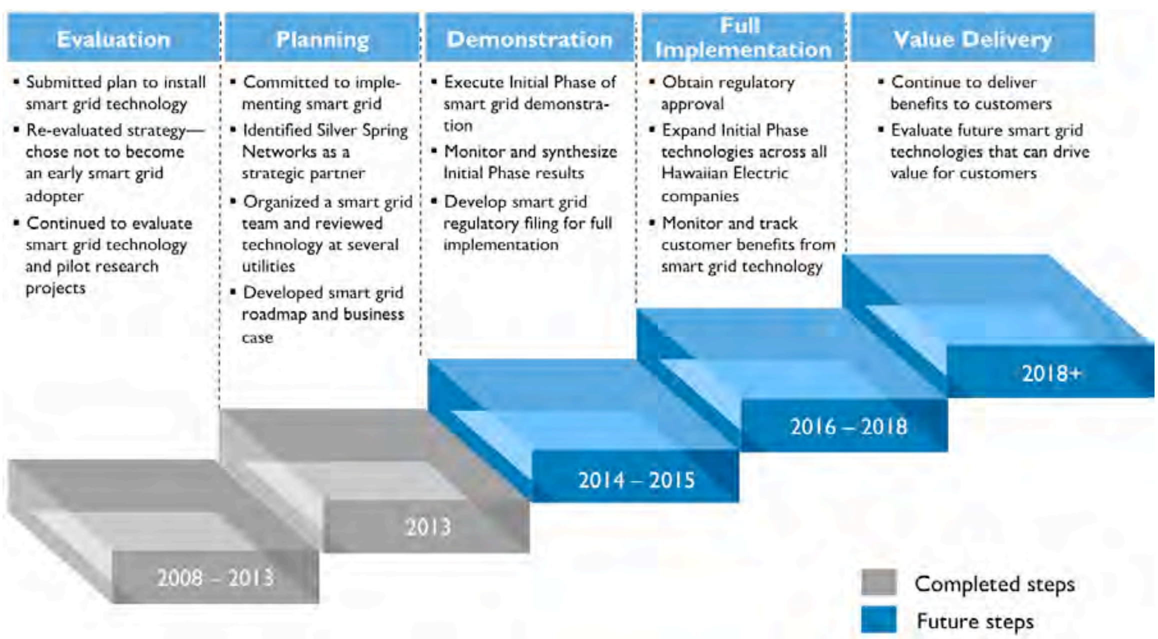


Figure 3: High-Level Smart Grid Roadmap

[3] Docket No. 2008-0303; December 1, 2008.

Phase 1: Evaluation

In 2008, Hawaiian Electric submitted a plan[4] 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 of smart grid technology. To better understand the technology, we spent the next five years researching smart grid options, closely watching industry developments while partnering with Hawai'i Natural Energy Institute (HNEI) on smart grid research projects.

Phase 2: Planning

In 2013 as part of our Integrated Resource Planning (IRP) Report, the Hawaiian Electric Companies concluded that smart grid technology was mature, would deliver tangible benefits, and should be implemented on our distribution grids. We committed to fully implementing AMI across all five service islands by the end of 2018.[5]

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, which included reviewing potential smart grid applications, conferring with peer utilities in various stages of their smart grid implementations, experiencing first-hand other pilot projects, and interviewing candidate firms. After much deliberation, the Hawaiian Electric Companies chose Silver Spring Networks as our strategic partner for the final four phases (Planning, Demonstration, Full Implementation, and Value Delivery) of the Smart Grid Roadmap. Silver Spring Networks will provide technical expertise and its communications network technology, as well as assist with designing and implementing our community outreach programs. While moving through our roadmap, we might engage, as necessary, other smart grid technology partners of Silver Spring Networks for applications that will benefit the Hawaiian Electric Companies electric grids.

4 Docket No. 2008-0303; December 1, 2008.

5 Docket No. 2013-0036; June 28, 2013, Chapter 12.

Our own smart grid team immersed themselves in current technology and reviewed core smart grid applications at several utilities. This review including extended visits to four utilities:

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

During these visits, our smart grid team was exposed to several different stages of the smart grid process, from planning to full implementation to ongoing maintenance. The team gained enough information and understanding to validate that smart grid technology was mature, and that the cyber-security requirements that addressed privacy and security concerns for the utilities visited were fully operational. The team also confirmed that these four smart grid implementations not only effectively integrated advanced metering, but also enabled Distribution Automation (DA), Outage Management, Demand Response programs, and future applications (such as remotely managing street lights) to operate on their communications network.

While this research was ongoing, we collaborated with Silver Spring Networks to develop a Smart Grid Roadmap 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.

Phase 3: Demonstration (The Initial Phase)

In early 2014, Hawaiian Electric plans to begin our first implementation phase, a smart grid demonstration called the Initial Phase. The Initial Phase has many roles, including demonstrating smart grid applications, in the Hawaiʻi environment and engaging customers. We also plan to continue pilot projects on Maui. The Initial Phase will include approximately 5,200 customers on six 12 kilovolt (kV) distribution circuits in four different areas of O'ahu. (These are fairly standard residential circuits.) We plan to replace traditional meters with AMI for all rate classes on these six circuits. Customers who participate in the Initial Phase will be able to access an online Customer Energy Portal where they can monitor their energy use and choose to use a Prepay program.

We have engaged Electric Power Research Institute (EPRI—an industry research organization) to validate results from the Initial Phase, in part to help us develop a systematic approach for implementing Volt/VAR Optimization (VVO) island-wide on O‘ahu. Silver Spring Networks will be helping us during the Initial Phase to develop metrics for monitoring the effectiveness of other smart grid applications.

When the Initial Phase completes, Hawaiian Electric will synthesize the information garnered from the demonstration together with our Maui pilot projects, then use this information to conclude our application to the Commission for a full implementation of smart grid applications tailored individually for O‘ahu, Maui, Lana‘i, Moloka‘i, and Hawai‘i Island. The chosen applications will be based on the refined cost-to-benefits analysis by the Initial Phase demonstration and specific analysis of proposed operation and technical use in reducing operational costs. We expect certain foundational smart grid applications to be implemented on all five islands: AMI, Customer Energy Portal, Prepay, VVO, Distribution Automation (DA) with fault circuit indicators (FCIs), Outage Management, and Direct Load Control (DLC).

During the Initial Phase, we will reach out to and educate our customers so that they can 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 installing and operating smart grid.

Phase 4: Full Implementation

Before implementing smart grid, the Commission must approve our application, which we are basing our planning efforts on happening at the start of 2016. We would then fully implement smart grid applications for the approximately 460,000 customers in the service areas across Hawaiian Electric, Maui Electric, and Hawai‘i Electric Light. The implementation schedules are tailored for each operating utility. (For more detail, see “8. Smart Grid Implementation Roadmap” on page 75.)

To start, we plan to complete installing Advanced Meter Infrastructure (AMI) on the neighbor islands by the end of 2017 and on O‘ahu 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 of the installation.

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

Beginning in 2016 and continuing beyond 2018, we plan to implement Volt/VAR Optimization (VVO) and Distribution Automation (DA) with fault circuit indicators (FCIs) in parallel with upgrades to the distribution system.

Phase 5: Value Delivery

The smart grid implementation delivers tangible benefits to our customers, including savings from operating a more efficient grid and energy consumption reductions, all of which help, over time, to lower customer bills.

Overall, combining all three operating utilities, the Hawaiian Electric Companies estimate that smart grid would result in $119–$125 million[6] in benefits net of costs over the next 20 years. This results in a 1.4 benefit-to-cost ratio—in other words, a 40% return in benefits over related costs. (See "6. Business Case" on page 47 for more details.)

Reduced operating costs 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 applications in the future, including emerging applications that demonstrate great potential for efficiency, reliability, and cost savings.

[6] Dollars are based on a 20-year present value. In other words, all amounts are in today's dollars.

Four examples of these future applications are: (1) Advanced Analytics that provide detailed, real-time energy information to help customers understand how energy is being used within their homes or businesses; (2) Automated Circuit Sectionalization that helps restore power faster and more efficiently; (3) Smart Inverters and networked energy storage to better manage renewable generation; and (4) Microgrids to deliver energy to critical or remote customers. (See "Future Smart Grid Applications" on page 72 for more information on these and other future applications.)

The Prepay application 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.

We will evaluate these and other smart grid applications to determine how they can favorably impact Hawai'i's energy future and deliver value for our customers.

3. Engaging Our Customers

The Hawaiian Electric Companies believe in a proactive, transparent, and sustained communication effort to educate and engage our customers is critical to successfully rolling out the Initial Phase, the initial step in our smart grid plans. Our efforts to engage our customers underscore our commitment to continually improve customer service, modernize the grid, and integrate renewable energy.

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

Through a multi-pronged approach for the duration of our smart grid roadmap, we intend to build interest from the onset, address questions and concerns, and engage customers in understanding the benefits of smart grid. Our communication 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 seeks to engage our customers with information tailored to their specific needs and questions. Working with trusted third-party groups, we plan to engage customers in direct conversations wherever they are—at home, in their neighborhoods, and online.

That said, customers may not be able or want to engage with us during the first phase of our communication efforts while we implement the initial phase of our plan. Customers may also choose not to participate in the initial phase of our smart grid program. At that point, we will advise them that they can defer participation now at no charge. We will also let these customers know that some utilities have received approval from regulators to charge a fee to customers who chose to opt out, and that such a path remains an option in the future.

We have developed a customer engagement plan based on established communication guidelines to proactively address customer concerns and engage them in various ways. While this plan was developed specifically for the initial implementation phase, these same principles would apply during full implementation. We will use this initial phase of our engagement plan to assess our efforts and refine them if necessary. We will then use this updated plan during full implementation, based on timing, rollout schedule, and customer questions and interests at that time.

COMMUNICATION GUIDELINES

Our efforts to engage our customers—indeed, all our stakeholders—will be guided by these 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 and transparently to all inquiries.
- Flexible: Expect and accommodate continual process and communication improvements.

Educating Customers about Smart Grid

Our engagement efforts will 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.
- Modernizing the grid to help integrate higher amounts of renewable energy and reduce Hawai'i's dependence on oil.

Studying Other Smart Grid Implementations

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

We have reviewed the following utility implementations and accompanying engagement programs:

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

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

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 applications 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 applications. Finally, we learned that early engagement consistently resulted in higher rates of customer acceptance.

PROACTIVELY ADDRESSING CUSTOMER CONCERNS

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

- The safety of smart meters and radio frequency emissions
- Security of the communications 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 actually 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 security applications. We will incorporate future enhancements as they become available.

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

- We will not sell, rent, or license your personal information.
- We treat customer information as confidential, consistent with legal and regulatory requirements.
- We will 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 do not track online behavior at an individual's level. We only track aggregated statistics to improve our products and services.
- We only use customer data for customer service, billing, planning, and grid management. We limit our data gathering to the usage data recorded by the meter, unless you have given us permission to measure 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

The following sections describe the tactics and activities in each category.

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'll do so early and often. Through these personal discussions, we hope to better understand customers' concerns and respond to them directly.

We will give them information to allow them to make informed decisions. Our information, tailored for both residential and commercial customers, will explain 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 will 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

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

Open Houses

We intend to hold open houses in each of the communities where smart grid will be implemented. At these open houses, we will meet our customers, present detailed information about smart grid, explain the benefits of smart grid, and host demonstrations of the CustomerIQ (Customer Energy Portal) Web portal.

Customer Education

The Hawaiian Electric Companies are creating educational materials so that customers can better understand the many components of smart grid and the benefits it enables. These materials will adhere to our communication guidelines. They include:

- Brochures
- Question-and-answer documents
- Website content
- Educational content in our customer newsletters and other company-produced communication vehicles
- Fact sheets
- CustomerIQ Web 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 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?
- Is smart grid safe?

Government Relations

It is important that elected officials, government agencies, and regulatory officials 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 will brief these government stakeholders about the initial phase implementation plans, about their specific interests in smart grid development, and about any related energy issues. We will give them informational materials that educate and inform.

We plan to begin these briefings before embarking on our community outreach efforts and continue the briefings over the course of the project.

Third-Party Engagement

We intend to engage, early on, other key organizations during the public discussion about smart grid. From this, we hope 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 engage with each organization depends 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, we expect it to be well covered in new 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 will assist us. Their experience working on previous smart grid implementations will be 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, improving its efficiency and reliability, and what the benefits are for them. Their directed comments will 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. We want to identify opportunities and barriers to acceptance, as well as effective ways to communicate the benefits of a smart grid program. Before and after implementing smart grid, we will assess customer behavior, attitudes, and opinions. We will also evaluate 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 will engage 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 may direct their questions to our employees and contracted workers they see. We will develop materials and tools about smart grid and train these employees and contractors to ensure they have the information needed to answer our customers' questions. We will also have a process in place so that inquiries can be seamlessly escalated providing these customers the answers they seek.

We expect that our commercial customers will contact our Key Accounts and Customer Business Management Services departments for answers and information. These employees will 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 how important it is to remain flexible and to adapt to the dynamic needs of our customers, both in the initial phase 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.

4. Delivering Benefits to Our Customers

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

- Increased reliability
- Greater efficiency with expanded customer choices
- Increased renewable energy through integrated distributed generation
- Reduced carbon dioxide emissions
- Lower costs that can result in lower electricity bills

INCREASED RELIABILITY

The Hawaiian Electric Companies' smart grid improves the reliability of our service by quickly resolving outages and routine service interruptions.

Advanced metering infrastructure (AMI) provides us with more timely and accurate information about distribution system outages. Currently, we rely on customers to report service interruptions. By integrating smart meters with our Outage Management System, outages can be identified more quickly.

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. Using AMI, 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 applications improve reliability.

A December 2012 report from the US Department of Energy[7] showed up to a 43% improvement in the System Average Interruption Duration Index (SAIDI) on distribution feeders where these type of applications had been implemented.

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

GREATER EFFICIENCY WITH EXPANDED CUSTOMER CHOICES

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

The Prepay smart grid application 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. Coupling Prepay with our back-office processes means we can extend payment hours for our customers. In addition, we will be able to more quickly reconnect customers whose service was shut off when their bill wasn't paid.

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 applications also helped SMUD reconnect customers more quickly, typically within twenty minutes after payment. The Distribution Automation (DA) application (planned for the full implementation of our smart grid program) increased same-day

---

[7] *Reliability Improvements from the Application of Distribution Automation Technologies – Initial Results* (December 2012) by Department of Energy.

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 usage during periods when electricity is better used to operate the system. Appliances (such as air conditioners and hot water heaters) can then 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 new 165 megawatt peaking generation plants. As of August 2013, OG&E had enrolled 76,000 customers in the program—about 10% of its customer base—with the goal of increasing that number to 120,000 participants in 2014. The program resulted in an average annual savings of $191 per customer in 2012 while reducing system-wide peak by 67 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. We will calculate the potential savings through use of Demand Response by reducing peak demand, deferring capacity and reducing operational costs to determine the cost to benefit and value of Demand Response before implementing smart grid. We anticipate realizing this benefit for those systems that have high-cost peaking generation or the need for additional capacity.

INCREASED RENEWABLE ENERGY THROUGH INTEGRATED DISTRIBUTED GENERATION

The total percent of energy from renewable sources across the consolidated Hawaiian Electric Companies systems was 13.9% in 2012 and 18.2% in 2013. Customer-sited rooftop solar connected to distribution circuits contributed significantly to these totals, and was the major reason for renewable energy growth from 2012 to 2013. We expect 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 applications, in particular AMI, will 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.

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.

Smart grid applications provide our system operators more accurate, near real-time information about customer-sited demand and generation throughout our service territories. Real-time visibility of the amount of variable generation distribution circuits will also help system operators observe the contribution of distributed solar to the total system generation, which can be useful in allocating reserves to balance the system generation. Visibility of distributed solar production can be used to improve solar power forecasting tools by providing actual production feedback which is used 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.

Taken together, we expect these operational improvements to increase the reliability and use of renewable energy.

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 among distribution circuits to alleviate overloaded circuits.

REDUCED CARBON DIOXIDE EMISSIONS

The smart grid increases energy conservation and more optimal energy use 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 in managing the system with renewable energy production from resources connected at the distribution level. Both factors contribute to less reliance on non-renewable energy resources.

In Hawai'i, that means less power 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[8] metric tons in carbon dioxide (CO_2) emissions. Based on the experiences of smart grid implementations at other utilities nationwide, we can expect 1–3% reductions 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.

8 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.

LOWER COSTS THAT CAN RESULT IN 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 lower energy bills as a result of several smart grid innovations. For example, the smart grid will enable enhanced versions of Volt/VAR Optimization (VVO) on distribution feeders. The average distribution feeder voltage must be maintained within tariff specifications; VVO could bring those voltages closer to optimal levels.

VVO, while not unique to smart grid implementations, is enhanced with smart grid. Appliances run more efficiently, reducing the waste heat produced by excess voltage and 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.

For example, at Dominion Power in Virginia and North Carolina, VVO 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). EPRI, who we've contracted for the Initial Phase, will verify the potential savings through VVO before full implementation. VVO will not be implemented at the transmission level, and could yield superior value than smart-grid VVO for much less investment (particularly on Hawai'i Island).

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.

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 470,000 annual field operations that would have previously required an on-site visit from a technician.

Savings Due to Better Management of Energy Use by Customers

Smart grid applications will enable customers to access their energy usage. Through an online Customer Energy Portal, customers can see detailed information about their electricity use and then make informed decisions to change their behaviors and lower their electricity bills.

According to a recent study[9] from the American Council for an Energy Efficient Economy, customers who receive this kind of daily or weekly feedback reduce their energy use between four percent (4%) and eight percent (8%), resulting in a direct reduction in their electricity bill.

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

5. Benefits for Customer Groups

Hawaiian Electric, Maui Electric, and Hawaiʻi Electric Light, together serve approximately 460,000 customers on Oʻahu, Maui, Lanaʻi, Molokaʻi, and Hawaiʻi Island. These customers fall into two basic groups: residential and commercial.

Most are residential customers in single-family homes or multi-unit dwellings, while the balance are primarily business (including hotels and resorts), light-industrial, and military customers. The Hawaiian Electric Companies' smart grid vision is being developed to provide tangible benefits to customers across all of these groups. While many customers will experience benefits from smart grid, here are some of the most pertinent examples for select customer groups.

RESIDENTIAL CUSTOMERS

Fixed-Income Customers

On average, residential customers could see lower monthly bills due to smart grid applications like AMI and Volt/VAR Optimization (VVO). Customers on fixed or limited monthly budgets could also benefit from increased payment options through the Prepay and Dynamic Pricing programs. Prepay allows customers to pay up front for their energy use, then through the Customer Energy Portal, monitor how they use electricity, enabling them to change behaviors and lower their next bill.

Busy Families

Busy families and working professionals can also use the Customer Energy Portal to monitor and manage their energy consumption. They can access information about their energy usage at any time rather than waiting for a monthly bill. Through the portal, customers can review near-real-time energy usage and estimate their electricity bills, and then can choose to be more economical with their energy use. The smart grid provides busy people with more customer service options, such as our ability to quickly connect or disconnect power to help with customer move-ins and move-outs.

High-Usage Customers

Customers who use a significant amount of electricity can take advantage of detailed, near-real-time data to better manage their monthly energy usage and reduce consumption. Smart grid applications enables the potential for Demand Response programs where customers can voluntarily shift energy usage during high-demand hours to lower-demand times in exchange for incentive payments, providing this can result in an overall reduction in customer costs.

Customers with Distributed Generation Systems

Currently, customers with distributed generation systems (such as roof-top solar systems) compare the bottom lines on their monthly bills to estimate their kilowatt-hours usage. Smart grid applications will give customers more detailed, accurate, and real-time information about the performance of their rooftop-solar systems—information that enables these customers to make more informed choices about their energy use and maximize the value of their net energy metering (NEM) credits.

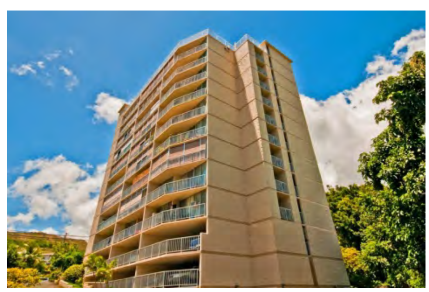
COMMERCIAL CUSTOMERS

Small Business Owners

Small business owners can use the more robust energy-use data available from the smart grid to make informed choices about their energy usage and drive down their monthly bills. For example in Norman, Oklahoma, Native Roots Market used smart grid applications to analyze its energy usage in the summer months. They quickly realized significant savings by making some simple changes: pre-cooling the store in the early morning hours and stocking their frozen-food section during low-energy demand hours. As a result, they saved about $2,000 that summer.

While Hawai'i doesn't experience the dramatically high temperatures of an Oklahoma summer, our electricity rates are three times higher. Smart grid applications will provide Hawai'i businesses similar opportunities to analyze their energy-use practices and make changes based on verifiable data. Small businesses can also benefit from Demand Response and conservation programs that are available through the smart grid.

Owners of Multi-Family Properties, Hotels, and Resorts



Tourism drives a large segment of Hawai'i's economy. Vacation property owners must be mindful of the effects high energy bills have on their relative competitiveness, especially from high-usage items like air conditioning.

The Customer Energy Portal will allow these property owners to easily monitor electricity usage across one or more units. Through smart grid, owners can connect their air-conditioning systems to Direct Load Control programs, which will help them manage energy costs in high-demand situations. Multi-family property landlords, in particular, can benefit from our ability to remotely connect and disconnect properties, creating more efficient move-ins and move-outs.

Manufacturing Facilities and Food-Processing Plants

Small industrial customers can experience business losses due to power interruptions. Smart grid will enable us to quickly locate, isolate, and resolve power interruptions and outages, helping industrial customers get back online more quickly. Small industrial customers can use detailed energy information to adjust their usage, helping them lower energy costs and improving their bottom line.

Military Customers

Military customers account for approximately 15% of the Hawaiian Electric Companies' consumption. These customers highly value power reliability and security, both of which are enhanced by smart grid. The ability to reduce outage restoration times is particularly important for military outposts. Military customers are also exploring using microgrid technology to generate their own power, independently or in cooperation with the Hawaiian Electric Companies. The Silver Spring Networks' smart grid network can help integrate a military microgrid with our electric grid, and support automated control.

6. Business Case

The Hawaiian Electric Companies plan to deliver cost-effective smart grid applications to ensure that the benefits customers receive outweigh their implementation costs. With that in mind, we have developed a high-level smart grid business case, which estimates the costs and benefits of a full implementation.

During the Initial Phase on O'ahu in 2014, we will begin building a more detailed mid-level business case to submit to the Commission together with an application for full implementation.

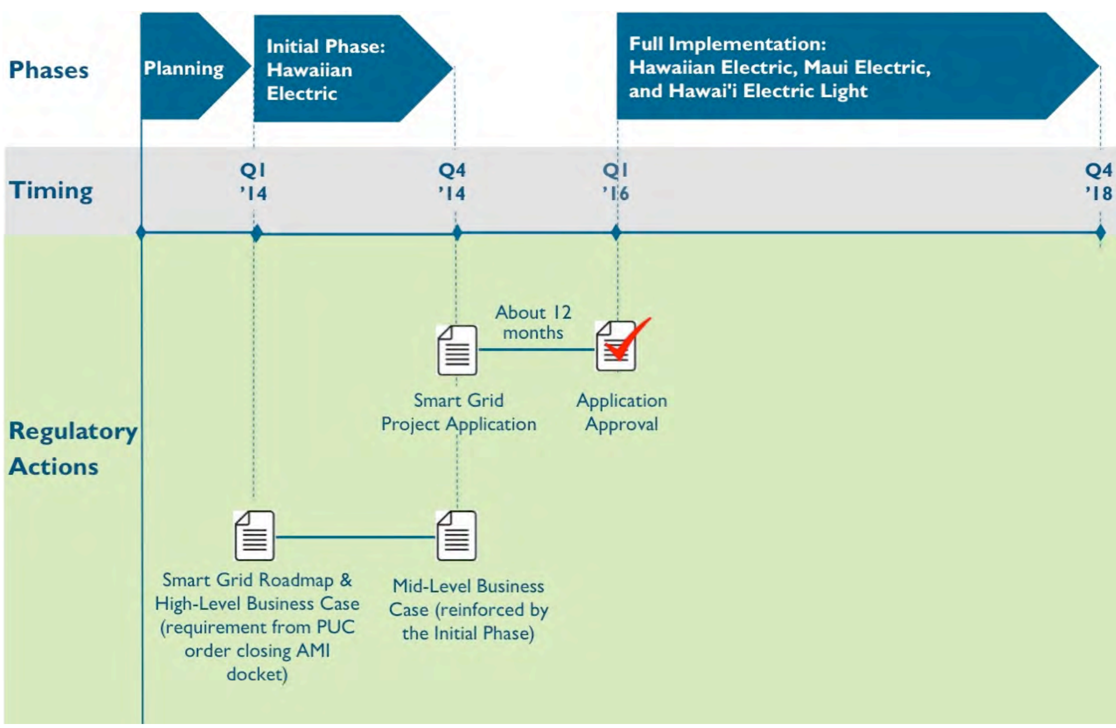


Figure 4: Regulatory Timeline for Smart Grid Roadmap and Business Case

BUSINESS CASE METHODOLOGY

The Hawaiian Electric Companies staff teamed with Silver Spring Networks to develop its high-level smart grid business case. The business case combines the Hawaiian Electric Companies-specific information (such as energy demand profiles, energy prices, customer counts, and operational costs) with benchmarks from publicly available smart grid business case estimates from other national utilities. Together, we used a streamlined methodology (Figure 5) to develop the smart grid business case.

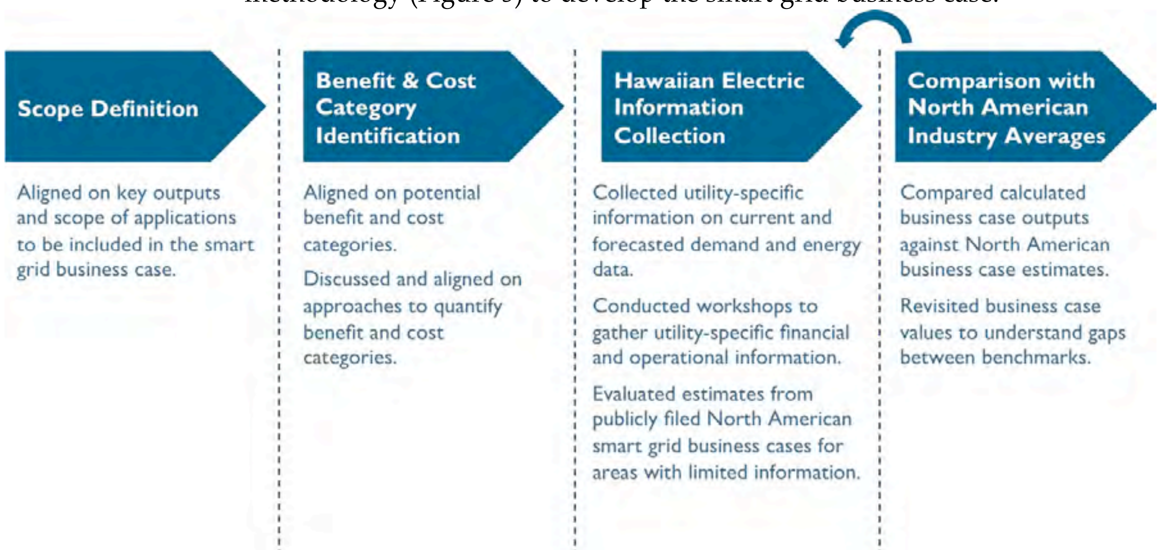


Figure 5: High-Level Smart Grid Business Case Methodology

We began by defining the scope of the project, aligning it with various smart grid applications, and identifying key outputs. Next, the team identified potential benefit and cost categories applicable for the Hawaiian Electric Companies and defined analytical approaches to quantify these categories. Through a series of workshops, we collected baseline information to develop benefits and costs for each smart grid application. When baseline information was not readily available, we used external benchmarks. Finally, we compared the high-level smart grid business case results against a range of North American smart grid benchmarks and revisited business case values to understand gaps between benchmarks.

The high-level smart grid business case accounts for implementation and operational costs for endpoint hardware, smart grid Neighborhood Area Network (NAN) infrastructure, network backhaul, software, back-office systems, and various services required to implement, operate, and maintain the smart grid applications. These costs are weighted against benefits which include operational savings and reduced energy delivered (Table 1).

Application	Benefit	Description	Approach
AMI	Meter Reading	Reduced manual meter reading costs (personnel, transportation, and materials) to conduct regular and off-cycle meter reads by more affordably acquiring more detailed usage data.	Based on the Hawaiian Electric Companies operating costs and estimated personnel reductions. Opt-out rates based on Florida Power & Light, Pacific Gas & Electric, Consumers Energy, Detroit Edison Company, and Central Maine Power Company.
	Field Service Visits	Reduced operating costs (personnel, transportation, materials) to conduct field service requests.	Based on the Hawaiian Electric Companies operating costs and estimated personnel reductions.
	Energy Theft	Avoided energy costs. Increased revenue by converting energy thefts into sales.	Based on the Hawaiian Electric Companies energy prices and average energy consumption forecasts. Percent of energy theft and recoverable based on the EPRI study: *Revenue Metering Loss Assessment*, November 2001; San Diego Gas & Electric, Southern California Edison, and Duke Power.
	Outage Management	Reduced management costs through improved AMI-based outage detection and resolution.	Based on average business case estimates from North American utilities (British Columbia Hydro, Central Vermont Public Service, Baltimore Gas & Electric, and Pacific Gas & Electric).
	Billing	Reduced operating costs (personnel requirements) to manage and process billing estimates.	Based on estimate of the Hawaiian Electric Companies' current operating costs to manage billing exceptions.
	Inactive Meter Consumption	Reduced energy consumption on inactive accounts.	Based on the Hawaiian Electric Companies estimated counts of inactive meters. Reduction in energy consumption on inactive accounts based on Commonwealth Edison (ComEd) business case estimates.
	Bad Debt	Reduced bad debt through allowed service deactivations.	Based on three-year average of the Hawaiian Electric Companies' residential bad debt. Reduction in bad debt based on ComEd business case estimates.
	Call Center	Reduced call volume related to billing delays, estimated bills, and meter reader complaints.	Based on the Hawaiian Electric Companies existing call volumes and operating cost structure. Reduction in call volume based on Pacific Gas & Electric business case estimates.
Customer Energy Portal	Energy Efficiency	Reduced energy consumption by participating customers.	Based on American Council for an Energy-Efficient Economy report: *Advanced Metering Initiatives and Residential Feedback Programs*, June 2010. Energy efficiency assumption based on providing usage information after consumption (indirect feedback).
Prepay	Energy Efficiency	Reduced energy consumption by participating customers.	Based on results from utility implementations at Salt River Project and Oklahoma Electric Cooperative.

Application	Benefit	Description	Approach
Volt/VAR Optimization (VVO)	Energy Efficiency	Reduced energy consumption by supported customers.	Based on results from utility implementations at American Electric Power Ohio, Dominion, and Xcel Energy.
Distribution Automation (DA)	Outage Management	Reduced outage management costs through fault location, isolation, and supply restoration (FLISR) using fault circuit indicators (FCIs).	Based on average Distribution Automation business case estimates from North American utilities (Detroit Edison Company, Edmonton Power Corporation, Duke Energy Ohio, and ComEd).
Demand Response	Direct Load Control and Dynamic Pricing	Avoided generating capacity, fuel, and transmission and distribution from reduced peak demand.	Based on average Demand Response business case estimates from North American utilities (Potomac Electric Power Company, Pacific Gas & Electric, and Southern California Edison).

Table 1: Summary of High-Level Business Case Benefit Drivers

We chose *not* to quantify intangible benefits such as environmental, customer satisfaction, worker safety, service quality, and economic benefits in our smart grid business case. Those benefits, however, are important and might provide significant value. Considering them would further strengthen our case.

Business Case Assumptions

The Hawaiian Electric Companies conducted our cost-benefit analysis with assumptions about state-mandated renewable energy standards, current and forecasted electricity demand, and future fuel costs[10] (Table 2).

Area	Renewable, Demand, and Fuel Assumptions §
Renewable Energy Regulations	No changes to the existing Renewable Portfolio Standards (RPS) of 25% by 2020 and 40% by 2030.
Electricity Demand	Electricity demand remains flat (0.3% compound annual growth rate over 20 years). Customers continue to self-generate. Energy savings falls short of the Energy Efficiency Portfolio Standards (EEPS) set by the current law.
Fuel Prices	Remains high similar to 2012 levels due to continued competition from Asia. Liquefied natural gas (LNG) use starts in 2021. Fuel forecast uses the Gross Domenstic Product (GDP) Implicit Price Deflator chained to 2005. Low sulfur fuel oil for the Hawaiian Electric Companies moves from about $100 a barrel to nearly $250 a barrel by 2034.

§ Based on the 2013 'Stuck in the Middle' Integrated Resource Plan (IRP) scenario.

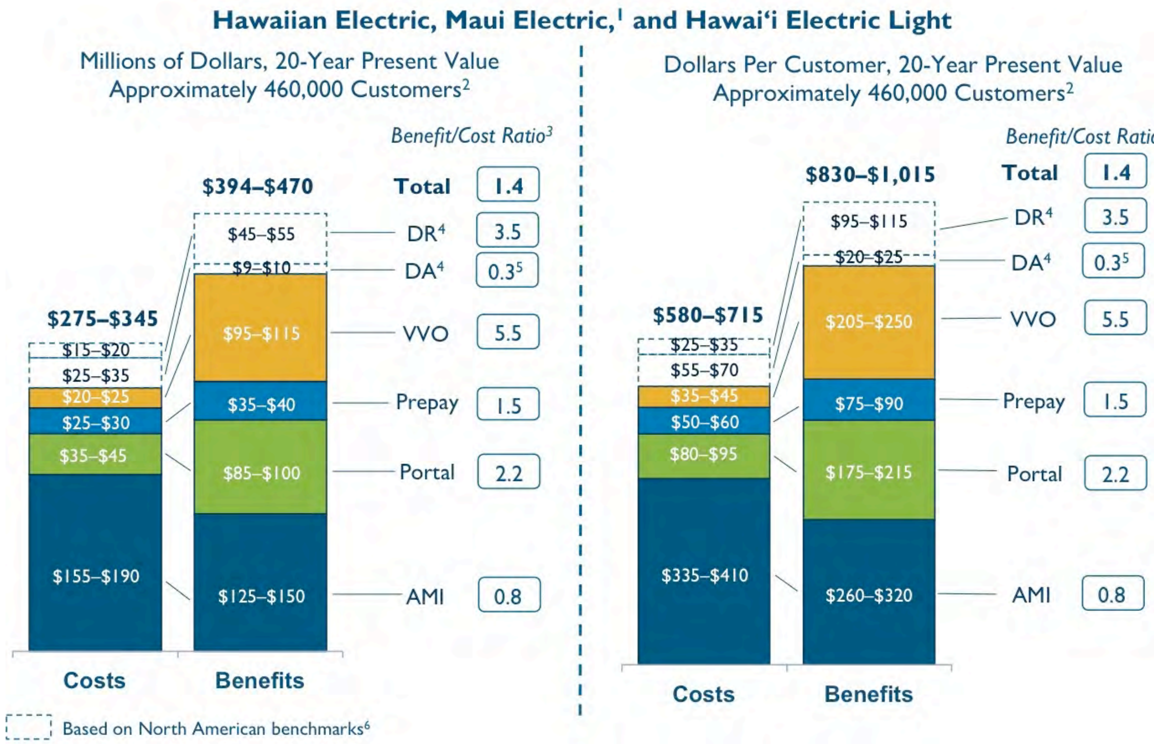
Table 2: Business Case for Renewable Energy, Demand, and Fuel Assumptions

This scenario signals a future compliant with today's circumstances: 25% of electricity from renewable resources by 2020 and 40% by 2030 (keeping with current state law mandates); increased self-generation resulting in demand remaining flat; and traditional fuel costs remaining high.

[10] Docket No. 2012-0036; June 28, 2013, Chapter 6.

Cost-Benefit Ratios

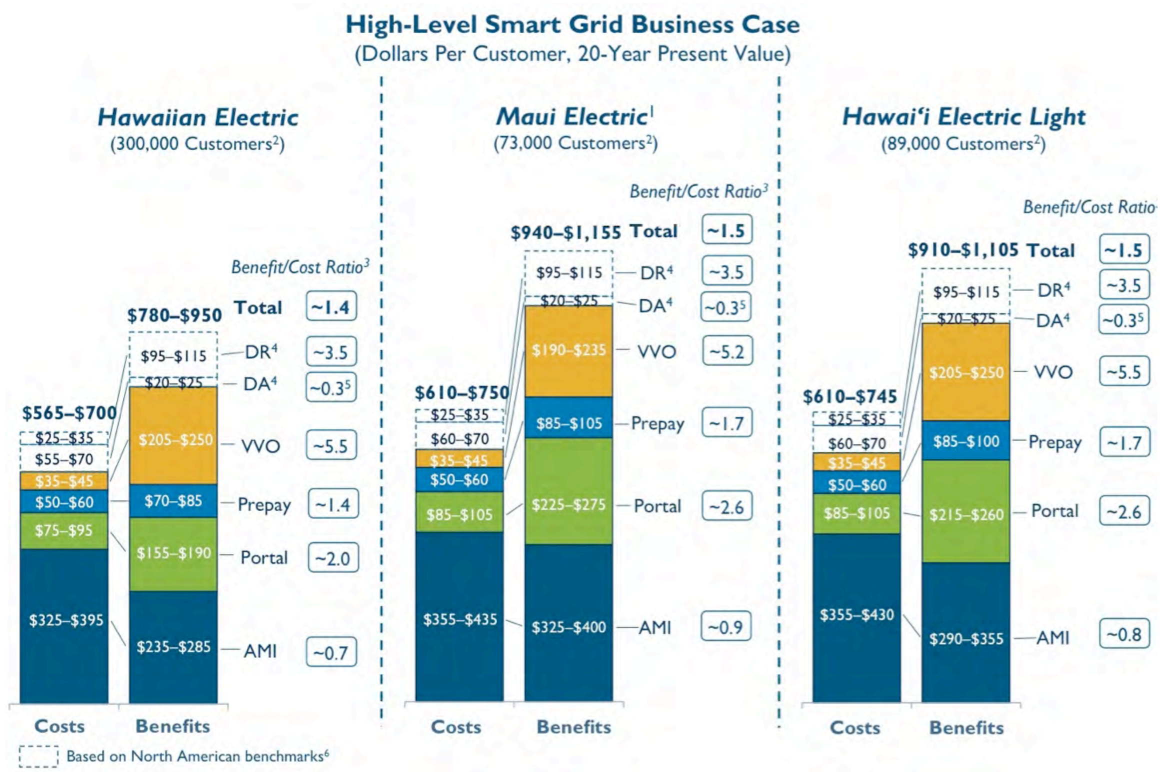
Our smart grid business case estimates total costs (20-year present value) for all three service utilities to be $275–$345 million ($580–$715 per customer) delivering $394–$470 million ($830–$1,015 per customer) in benefits. This results in an average 1.4 benefit-to-cost ratio (Figure 6). Aggregating these amounts, the Hawaiian Electric Companies estimate that smart grid results in $119–$125 million in benefits net of costs (net present value) over the next 20 years, or between $250–$300 per customer in benefits net of costs (net present value) over the next 20 years.



Notes: 1 Maui Electric includes the islands of Maui, Moloka'i, and Lana'i.
2 The estimated number of customers is based upon the completion of full implementation in 2018.
3 Benefit/Cost Ratios are based on the midpoint amounts of the associated ranges.
4 DR is Demand Response; DA is Distribution Automation.
5 The DA benefit/cost ratio does not include value of the 'soft' service benefits from reduced outages.
6 The DR and DA benefits and costs are based on North American business case benchmarks derived from publicly available United States smart grid business-rate cases. We will address DA and DR in a mid-level business case before filing our smart grid application Q4 2014.

Figure 6: Business Case Total Cost and Cost per Customer

The benefit-to-cost ratio for each operating utility ranges from approximately 1.4 to 1.5 (Figure 7), and varies because of different operating cost structures, implementation scale, geography, and forecasted energy costs. Aggregating these amounts, we estimate that smart grid results in $215–$250 per customer in benefits net of costs (net present value) over the next 20 years for the Hawaiian Electric Companies; in $330–405 per customer in benefits net of costs (net present value) over the next 20 years for Maui Electric; and $300–360 per customer in benefits net of costs (net present value) over the next 20 years for Hawai'i Electric Light.



Notes: *ibid.* Figure 6: Business Case Total Cost and Cost per Customer, page 52.

Figure 7: Business Case Cost per Customer by Each Operating Utility

While AMI specifically delivers fewer benefits than costs (a benefit-to-cost ratio of only 0.8), the application does provides direct tangible benefits, enables other smart grid applications to deliver increased benefits, and acts as the platform for future applications.

Chapter 10. Smart Grid Business Case Assumptions (page 87) contains additional details on these business case assumptions.

METRICS

During the full implementation phase, we will track our progress and each smart grid application by a series of quantifiable metrics (Table 3) that will better ensure smart grid is delivering on its expected benefits.

Application	Metric	Description
AMI	Net meter reading costs	Meter reading costs net of incremental costs
	Field services: remote connects and disconnects	Number and percent of connects and disconnects executed remotely
	Energy theft	Avoided costs from reduced energy theft
		Dollar amount billed for recovered energy theft
	Billing	Reduction in irregular bills (long, short, estimated) as a percent of the total
	Outage management	Reduction in truck rolls from AMI-based outage detection
	Bad debt expenses	Reduction in bad debt expenses from remote connect and disconnect operations
		Reduction in credit and collections costs
	Call center	Cost savings due to reduced number of calls related to billing delays, billing inquiries, and credit-related inquires
	Consumption on inactive meters	Reduction in consumption on inactive meters
Customer Energy Portal	Reduction in energy delivered due to Customer Energy Portal	Reduction in energy delivered to residential and commercial due to portal participants
	Portal participation	Number and percent of residential and commercial customers participating in portal
Prepay	Reduction in energy delivered due to Prepay	Reduction in energy delivered to Prepay participants
	Prepay participation	Number and percent of customers participating in Prepay
VVO	Reduction in energy delivered due to VVO	Reduction in energy delivered to residential and commercial customers due to VVO
Distribution Automation	System Average Interruption Duration Index (SAIDI)	Reduction in average length of time customers are out of power during the year
Demand Response	Demand Response	To be defined during mid-level business case assessment

Table 3: Smart Grid Quantifiable Implementation Metrics

These metrics track three primary benefit types: increased operational savings, reduced energy delivered, and improved reliability.

Operational savings metrics include net reductions in meter reading, field services, and energy theft, primarily driven by AMI together with business process and IT enhancements. We will be tracking reductions in energy delivered through VVO, Customer Energy Portal, and Prepay. Finally we will be using industry standard metrics to track reliability improvements from our smart grid implementation. Many utilities across the country use the System Average Interruption Duration Index (SAIDI) to measure their overall reliability and the efficiency of restoring power during system outages.

We have compiled these metrics based on smart grid implementations at other utilities. We will refine them to better reflect our operating conditions during the implementation of the Initial Phase demonstration.

7. Smart Grid Applications

THE SMART GRID PLATFORM

The smart grid platform operates securely using an industry standard IPv6 network that supports smart two-way communication for a very high number of endpoints, connects with a wide array of smart devices, implements standard utility products, and helps deliver many benefits.

Figure 8: Smart Grid Platform

An industry-leading cyber-security system—the same systems used by banks and other financial institutions—protects smart grid devices and applications, 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 several layers of encryption and multiple authentication measures to ensure no one can improperly access the network or its data.

The smart grid IPV6 platform provided by Silver Spring Networks enables the Hawaiian Electric Companies to implement a number of smart grid applications, both now and in the future. These applications (outlined briefly in "Smart Grid Applications" on page 15) include Advanced Metering Infrastructure (AMI), Customer Energy Portal, Prepay, Volt/VAR Optimization (VVO), Distribution Automation (DA), Demand Response, and Direct Load Control (DLC).

Electric vehicle charging and other applications (such as remotely controlled street lights) could potentially be added in the future.

BEST PRACTICES

From the onset, we decided to learn from the experiences of other utilities. We wanted to review core smart grid applications 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) 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
Applications 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	Silver Spring Networks	Silver Spring Networks	Silver Spring Networks
Number of Endpoints Implemented	832,000	203,000	4,600,000	626,000
Year Network / Technology Operational	2009	2009	2008	2009

Figure 9: Smart Grid Implementations Evaluated

These four utilities were all at different stages of their implementation, which only 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.[11] 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, 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 applications (specifically AMI, Volt/VAR Optimization (VVO), Distribution Automation (DA), Outage Management, and Demand Response) and their realized benefits.
- Customer engagement planning.

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

[11] 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.

Advanced Metering Infrastructure (AMI) Best Practices

The mesh network connecting the smart meters and other devices was available more than 99% of the time and performed efficiently during storms and outages. Full-time staff is necessary to monitor the AMI network daily, and evaluate unread meters and other endpoint devices on the mesh network. Field personnel must address unread meters and devices and, using Silver Spring Networks' services, monitor the software and communications network, especially when starting the implementation (such as during the Initial Phase).

Oklahoma Gas and Electric (OG&E) has implemented a Silver Spring Networks Web portal product called CustomerIQ, 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 CustomerIQ. Feedback has been very positive as it provides an ideal level of information to customers.

Outage Management Best Practices

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

In the Initial Phase, Hawaiian Electric will be observing the Silver Spring Networks Outage Detection System application to see how well it performs with "last gasp" outage notifications. For full implementation, we need to know what is required for our Outage Management System to use these "last gasp" messages, as well as understand how neighbor islands, currently without Outage Management Systems, can also use this outage data.

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.

Hawaiian Electric issued a Request for Proposal to select a Prepay vendor for the Initial Phase project. Each Prepay vendor handles payment transactions with utilities differently. We are working closely with our selected vendor to define exactly how to handle a Prepay transaction.

Distribution Automation (DA) Best Practices

ComEd, FPL, and SMUD have all implemented DA applications. These applications use the AMI network to garner information about meters and consumption, and employ a Silver Spring Networks product called Bridges which provides control information to distribution switches and reclosers.

We continue to evaluate DA, including a review of latency (the delay between signal and response) and security.

Demand Response 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—during which the price of electricity will be 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.

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, and Meter Data Management System.

The Hawaiian Electric Companies do not currently run a Meter Data Management System, nor will we need one for the Initial Phase because only a small number of the smart meters will be installed. We will, however, be further evaluating the information technology and integration requirements needed for our full implementation.

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 Initial Phase is already 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.

SMART GRID APPLICATIONS

The smart grid platform connects hardware devices with smart grid applications. The Hawaiian Electric Companies have chosen a suite of these applications for our smart grid implementation, based mainly on the benefits they can deliver. Figure 10 illustrates some of these applications and the benefits they can deliver.

Benefits	Applications	Description
Lower Electricity Bills	Volt / VAR Optimization	Allows utilities to more accurately control the level of power delivered to the end-consumer.
Expanded Customer Choices	Customer Energy Portal	Allows customers to monitor their bills and usage patterns to reduce energy consumption.
	Prepay	Provides customers the flexibility to pay as they use electricity to avoid deposits and help budget spend.
Increased Reliability	Advanced Metering Infrastructure Outage Management	Enables automated billing for customers, reducing meter reading costs, as well as acts as a sensor for outage detection and many other applications.
	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.
Optimal Integration of Distributed Generation	Direct Load Control	Shapes energy demand to ensure the grid can safely manage variable energy sources such as renewable wind or solar.
Reduced CO_2 Emissions	Electric Vehicle Charging	Enables the scheduling of electric vehicle charging.

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

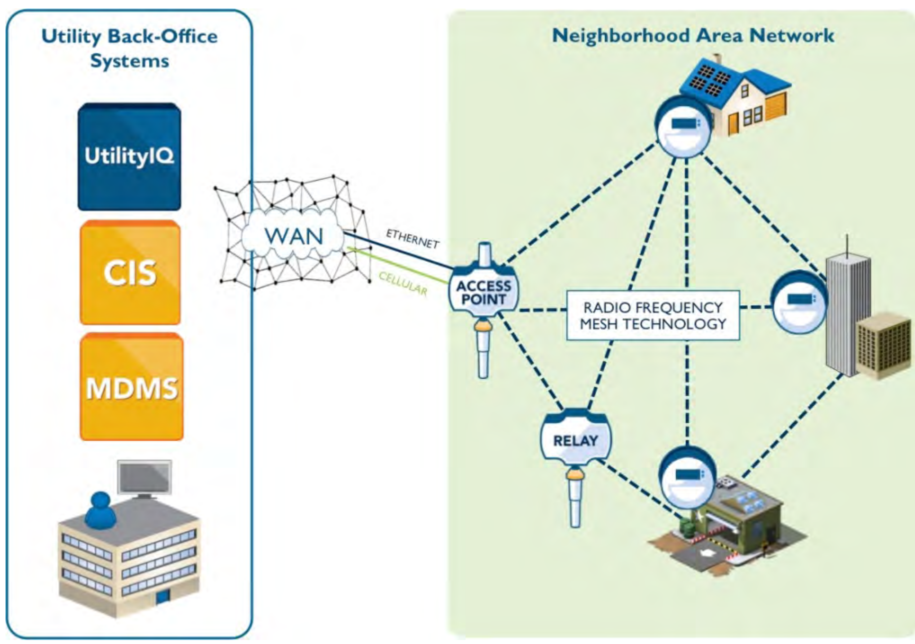
Figure 10: Hawaiian Electric Companies Smart Grid Applications

We will implement a core group of these applications on each of the five islands we serve, customized and adjusted (scaled) to meet the specific needs of each island's grid and customer base. We will implement other smart grid applications on each island based on the benefits they can deliver. Several of these applications work together to better realize their combined benefits.

Advanced Metering Infrastructure (AMI)

Through a wide area network (WAN) and smart meters installed at homes and businesses, AMI provides two-way communications between the Hawaiian Electric Companies and our customers. AMI automates customer bills, reduces manual processes (for example, meter reading and field service operations), and improves the performance of many smart grid applications (such as Outage Management and Volt/VAR Optimization (VVO).

AMI can give customers a wealth of data on their own energy usage, making them 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, Prepay metering, electric vehicle charging, and rooftop solar net energy metering (NEM)) to better manage their energy usage.



Note: UtilityIQ is a back-office system that supports multiple smart grid applications.

Figure 11: Advanced Metering Infrastructure (AMI) Example

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 placed at customer premises and collect detailed, near-real-time information on energy usage, transmitted over a secure network to a meter data management system (MDMS) controlled by the utility.[12]

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 application called an Outage Detection System, 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 Outage Detection System 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 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.

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.

---

[12] Hawaiian Electric has not yet determined if a meter data management system will be necessary. The cost of such a system is included in the high-level business case to show a conservative view of costs.

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 near-real-time 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. A meta-study by the American Council for an Energy-Efficient Economy[13] has shown that giving customers access to more robust data on their energy use leads to less energy consumed and, ultimately, to lower bills.

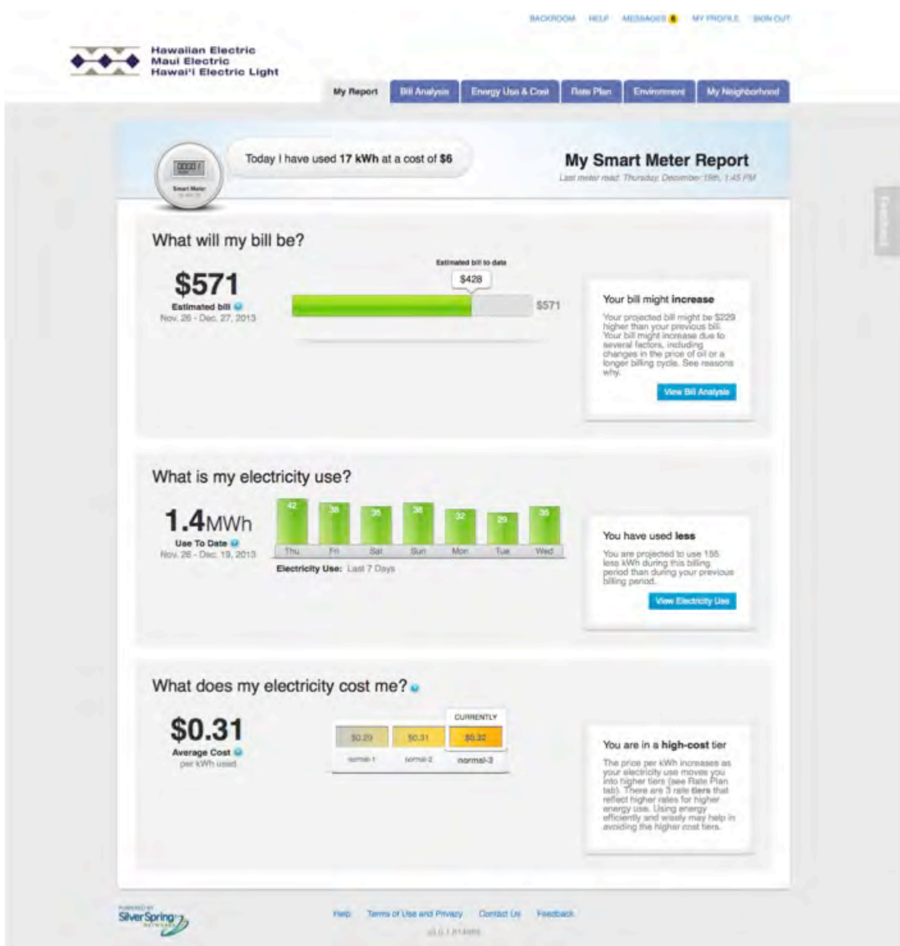


Figure 12: Customer Energy Portal Sample

[13] *Advanced Metering Initiatives and Residential Feedback Programs*, a report created by the American Council for an Energy-Efficient Economy.

Prepay

AMI allows us to offer a Prepay program for our customers. Prepay enables customers to pay, online or over the phone, for electricity before using it rather than receiving a traditional monthly bill.

Using Prepay, customers can review detailed electricity usage information and their existing credit balances. They are notified by phone, text message, or email when to replenish a low or zero balance. If a customer ignores repeated requests 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 them more easily budget their monthly energy expenses. Case studies presented in a 2011 Chartwell Research report 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.

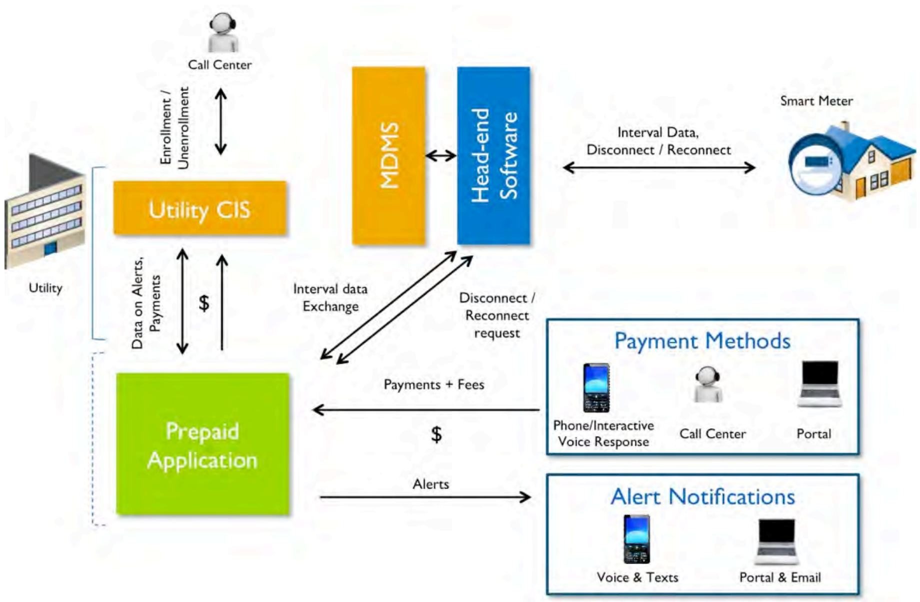


Figure 13: Prepay Example

Prepay is integrated with our back-office systems and AMI (Figure 13). Prepay uses interval-usage data and remote connect or disconnect service requests collected by AMI. Prepay also transmits payment receipts to our back-office customer information system (CIS), and sends out alerts and account balances to customers.

A separate rule and tariff must be defined for Prepay. 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).

We will work with the selected Prepay vendor to define how best to configure and implement transaction processing.

Volt/VAR Optimization (VVO)

A VVO application accurately monitors voltages at customer premises and optimizes them, saving energy.

Tariff specifications govern how distribution voltages at customer endpoints are set and managed. To keep within these specifications, the values are 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, VVO allows these values to be reduced (and flattened) closer to the lower limit of the tariff specifications (Figure 14), resulting in saved energy, lower energy bills, and less carbon dioxide emissions, all without requiring changes in customer behavior.

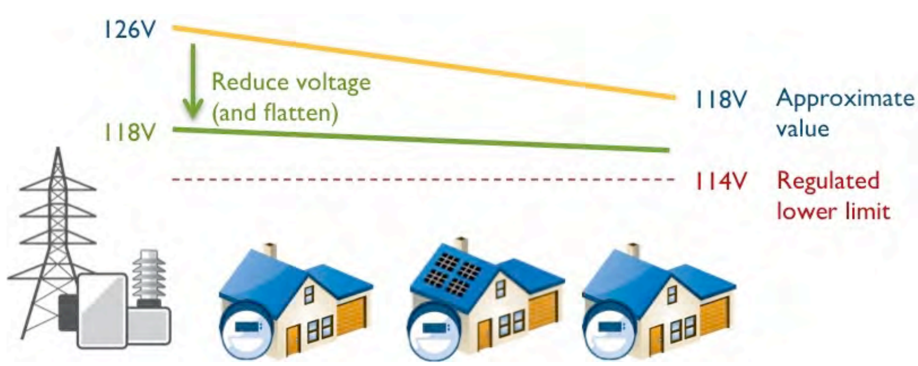


Figure 14: Volt/VAR Optimization Impact on Tariff Specifications

A VVO application reduces the amount of excess voltage flowing on the distribution grid, ensuring that voltage levels remain safely within the regulated range while reducing wasted energy.

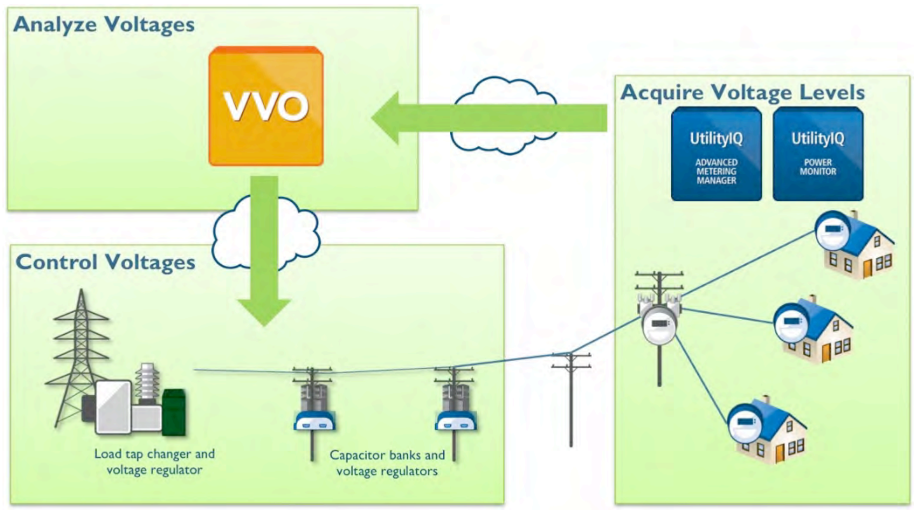


Figure 15: Volt/VAR Optimization Example

The Hawaiian Electric Companies approach (Figure 15) will (1) use AMI to collect customer voltage readings which are then (2) analyzed by VVO to (3) determine voltage set-point 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 and potentially VAR-control the circuit. VVO can monitor and track improvements to validate energy savings.

Distribution Automation (DA)

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

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 will implement devices called fault current 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 (Figure 16). As a result, power is restored more quickly and operational cost savings are passed on to customers. Reliability increases.

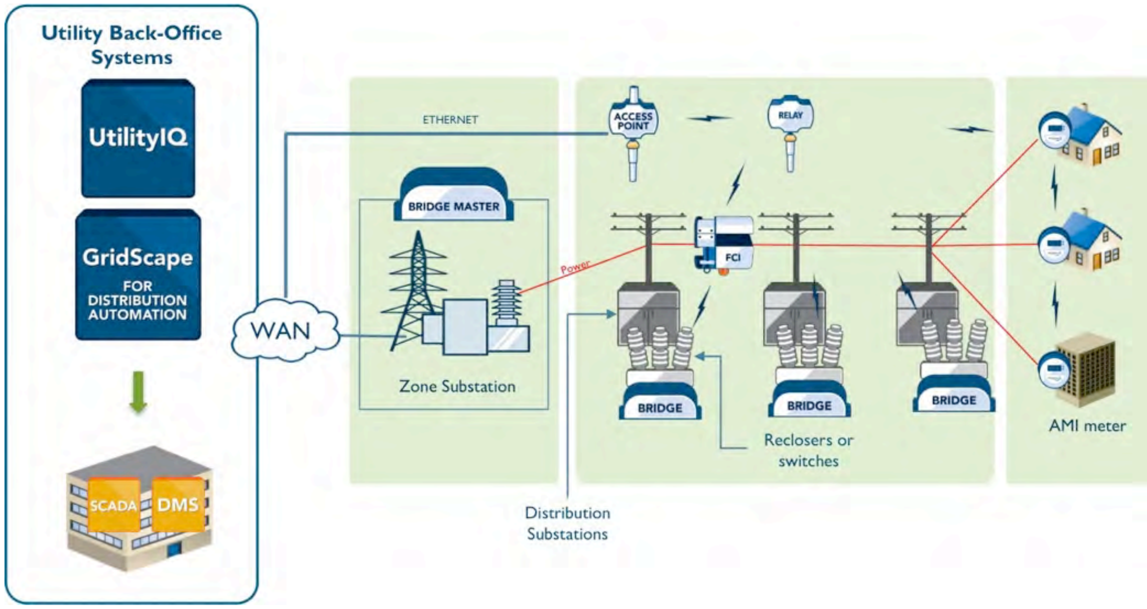


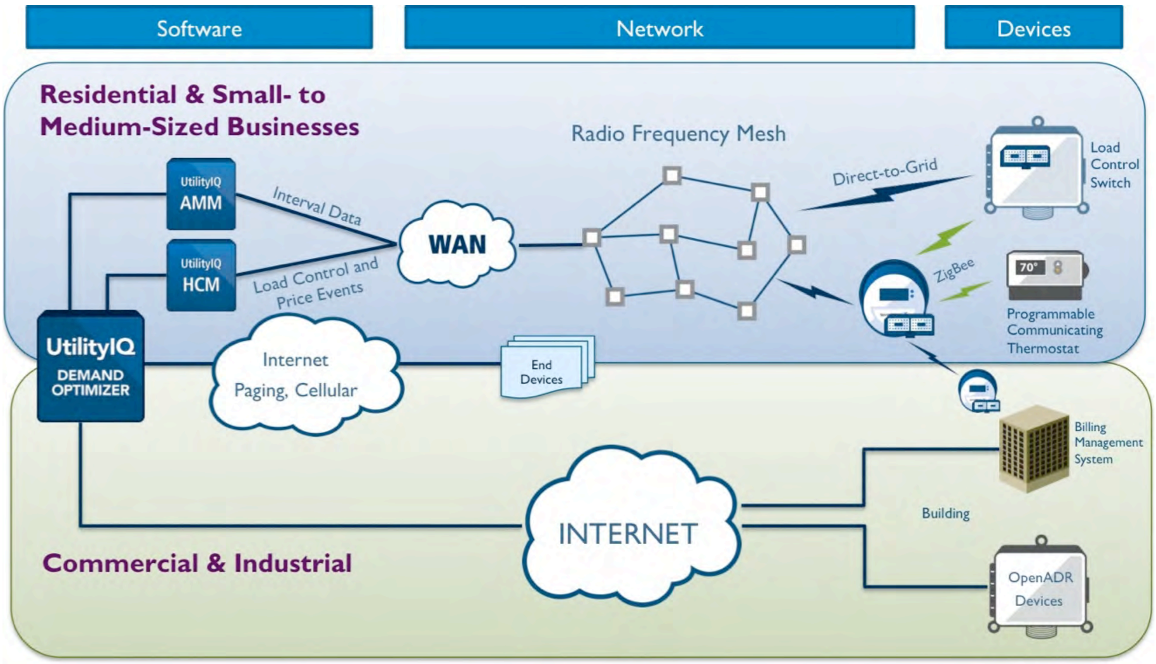
Figure 16: Distribution Automation Example

Direct Load Control (DLC)

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

A Demand Response Management System (DRMS) aggregates all participating customers so that system operation benefits the most. 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 underlying technology of DLC (Figure 17) controls energy usage by manipulating 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 is initiated, the smart grid network spreads the signal to these customer appliance controls. A load control switch will cycle power on and off to a customer appliance (such as a water heater), whereas a programmable communicating thermostat will set the temperature higher on an air conditioner to reduce energy consumption. Thus, energy usage is reduced.



AMM (Advanced Metering Manager) automates the collection of meter data.
HCM (Home-Area-Network (HAN) Communications Manager) administers and manages HAN devices.

Figure 17: Direct Load Control Example

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 asses 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.

FUTURE SMART GRID APPLICATIONS

Smart grid development continuously evolves. As we face new challenges, the smart grid platform can be used for future applications, continuing to take advantage of the convergence of information and energy systems.

Advanced Analytics

As the grid integrates more devices (such as rooftop solar and energy storage), the Hawaiian Electric Companies together with our customers will 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 will help separate information from many different energy sources to provide us with more insight on how their energy is being used within their homes and businesses. Specific actions can then be taken to address energy waste.

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 application, 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.

Community 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 applications are being developed. This storage, when sited at customer or community locations, requires a communication link to the smart grid platform to ensure its use is optimal and coordinated with other generation sources so that frequency and voltage can be regulated.

Electric Vehicle Charging

Electric vehicles can help Hawai'i 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. 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.

Over the longer term, these smart grid applications provide another set of tools to aid the state in its commitment to promoting electric vehicles.

Microgrids for Critical Customers

A microgrid is an energy system consisting of co-located power generation and load that operates as part of, but more likely, independently from a power grid. 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. As microgrids become more prevalent, smart grid technology can help control distribution and storage devices to better balance power and loads within the microgrid.

Networked Street Lights

Through the smart grid infrastructure, Hawai'i 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.

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.

Smart Inverters

Smart inverters can potentially allow us to stabilize the grid by remotely regulating a photovoltaic system's VAR 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. 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 Hawai'i 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.

Other Smart Grid Applications

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 applications, 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.

8. Smart Grid Implementation Roadmap

The roadmap for implementing smart grid across the Hawaiian Electric Companies consists of two implementation phases:

- **The Initial Phase:** where we demonstrate a suite of smart grid applications on a limited number of circuits that represent statewide demographics and geography, and seek to engage our customers in a dialogue about smart grid benefits.
- **Full Implementation:** where we completely install smart grid all at once with a suite of applications deemed to garner the most customer benefit, individualized for each island we serve.

This roadmap lays out the timeline for implementing the smart grid applications, 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, the Hawaiian Electric Companies have been guided by three key design principles:

1. Implement a complete smart grid by focusing on a suite of applications 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. Using the Initial Phase demonstration to reinforce the smart grid business case.

SMART GRID IMPLEMENTATION OVERVIEW

Figure 18 depicts our past and future activities for implementing a smart grid platform.

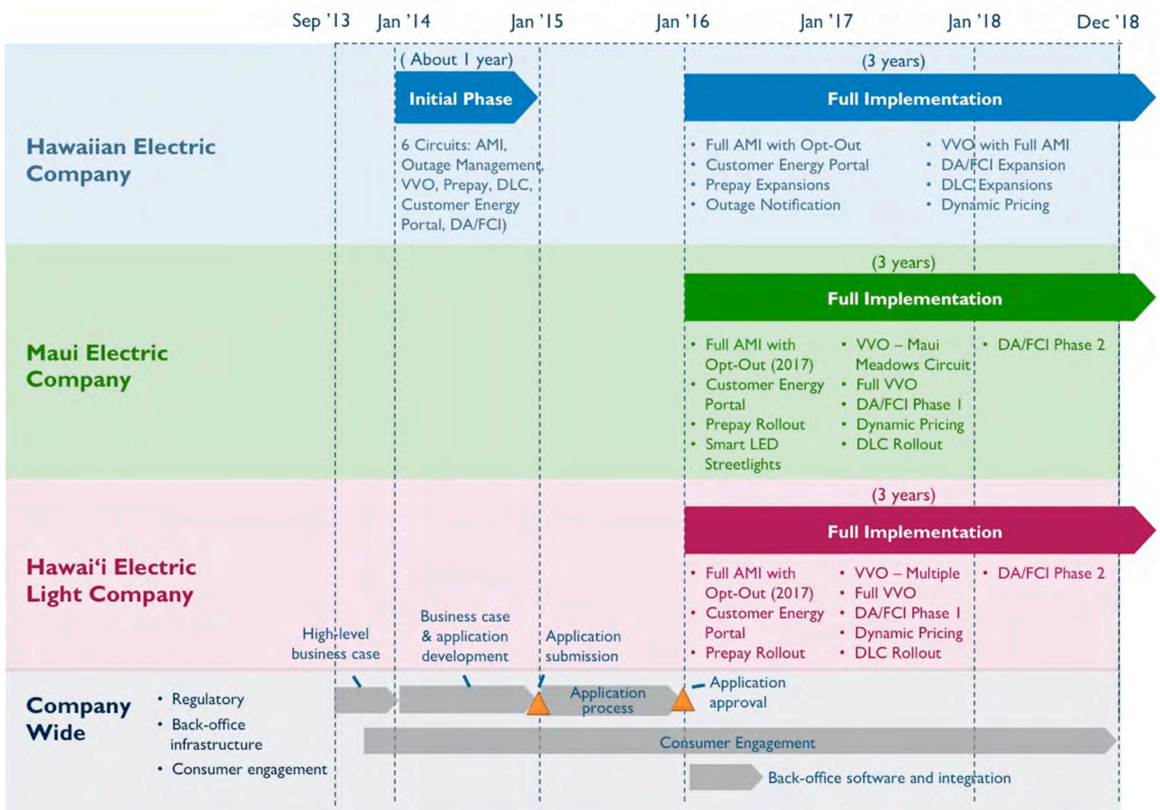


Figure 18: Smart Grid Implementation Overview

The Initial Phase

During the Initial Phase, Hawaiian Electric is implementing a smart grid program on O'ahu with two primary objectives:

- Demonstrate the technology
- Engage customers

The Initial Phase demonstration will implement a suite of smart grid applications including AMI, Customer Energy Portal, Prepay, VVO, Distribution Automation (DA) with fault current indicators (FCIs), Outage Management, and Direct Load Control (DLC) for about 5,200 customers across six circuits (Figure 19). The Initial Phase circuits represent statewide demographics and geography so that smart grid is demonstrated in a broad array of environments.

Notes: § LTC means Load Tap Changer. It allows voltage on a circuit to be incrementally changed.

Figure 19: Overview of the Initial Phase Circuits

We've designed the Initial Phase to demonstrate many critical capabilities (Table 4) that were necessary to test on our grids. We chose not to demonstrate a few capabilities because they have been proven to work at several other utilities.

Technology Capability	Initial Phase	Full Implementation
Automated Meter Reading	Yes	Yes
Billing from Automated Reads	No	Yes
Remote Connects and Disconnects	Partial	Yes
Theft Detection	Yes	Yes
Outage Management	Partial	Yes
Customer Energy Portal	Yes	Yes
Prepay	Yes	Yes
Volt/VAR Optimization (VVO)	Yes	Yes
Distribution Automation (DA) (remote switching / fault circuit indication)	Yes	Yes
Direct Load Control (two-way load control switch)	Yes	Yes
Dynamic Pricing	No	Yes

Table 4: Smart Grid Capabilities for the Initial Phase and Full implementation

While conducting the Initial Phase demonstration, Hawaiian Electric will develop a smart grid project application filing 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.

Also during the Initial Phase demonstration, we will begin engaging our customers to educate them on smart grid and how it can benefit them.

Full Implementation

During Full Implementation, the Hawaiian Electric Companies will build the necessary 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 also install the smart grid applications that can have the most positive impact on our customers: AMI, Customer Energy Portal, Prepay, VVO, DA, and Demand Response.

We expect to complete full implementation for Maui Electric and Hawaiʻi Electric Light in 2017, and for Hawaiian Electric in 2018. 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

Customers realizing benefits early on is crucial to the overall success of our smart grid platform. When customers realize that smart grid innovations can contribute to lower bills, we expect they will be more motivated to participate in the full range of smart grid applications. To that end, communication will be key. We plan to engage our customers from the beginning, make sure they understand the benefits available from a smart grid, and to explain how they can best maximize those benefits.

Before we can start, our Smart Grid Roadmap and its specific timelines for implementation must be approved by the Commission.

SMART GRID IMPLEMENTATION BY OPERATING UTILITY

Hawaiian Electric: O'ahu Initial Phase

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 will be on introducing smart grid application that can contribute the most to lowering monthly energy costs. Figure 20 shows the timeline for planning and implementing, demonstrating and measuring, and sustaining the implementation of these applications.

In the Initial Phase, Hawaiian Electric will demonstrate smart grid features and create positive customer experiences to help encourage acceptance during and after a full implementation.

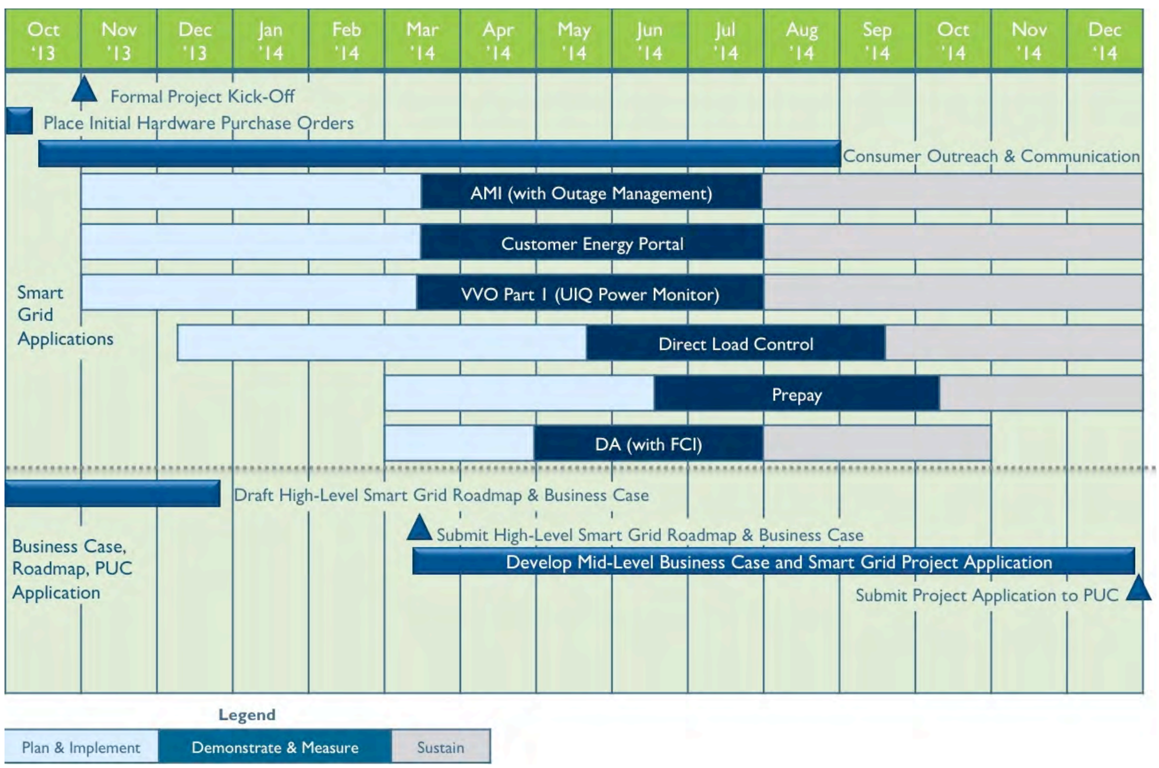


Figure 20: Hawaiian Electric (O'ahu) Initial Phase Plan

Hawaiian Electric: O‘ahu Full Implementation

Hawaiian Electric plans to build the necessary infrastructure to implement its smart grid vision 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 Volt/VAR Optimization (VVO), Outage Management, and the Direct Load Control (DLC) and Dynamic Pricing programs, plus Distribution Automation (DA) to better manage outages.

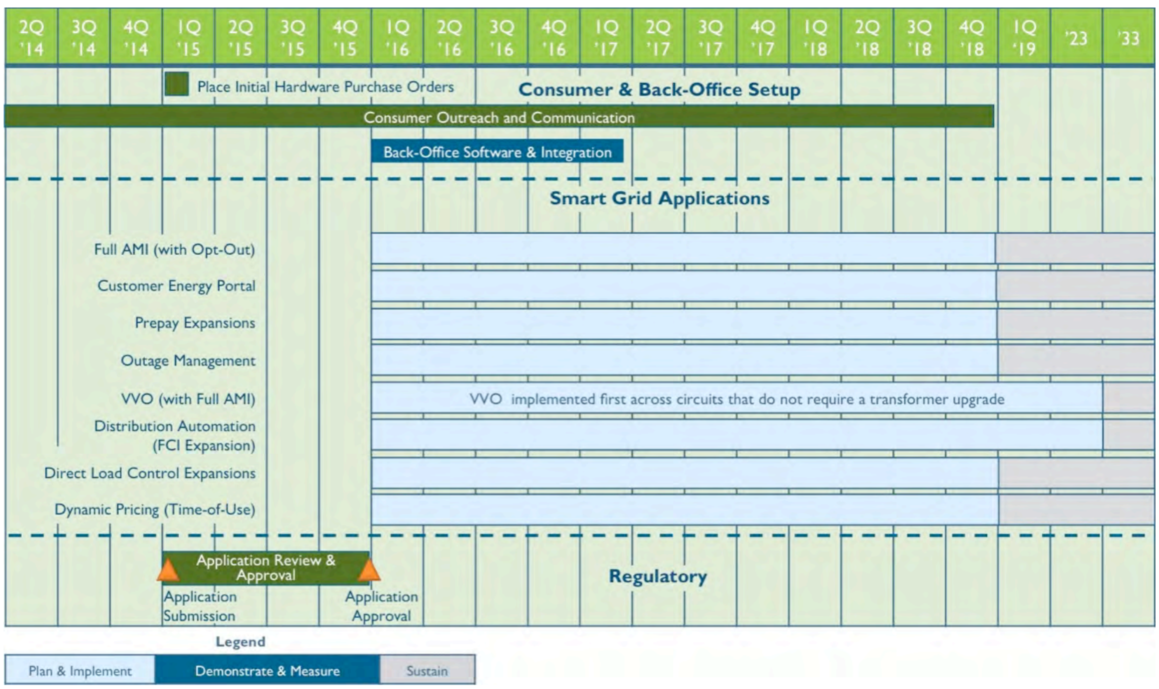


Figure 21: Hawaiian Electric (O‘ahu) Full Implementation Plan

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 will build on Hawaiian Electric's experience in O'ahu and roll out several customer-focused smart grid applications 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), and begin running VVO, Customer Energy Portal, Prepay, the Direct Load Control and Dynamic Pricing programs, Networked Street Lights, plus the first phase of Distribution Automation to better manage outages, all across the island of Maui.

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

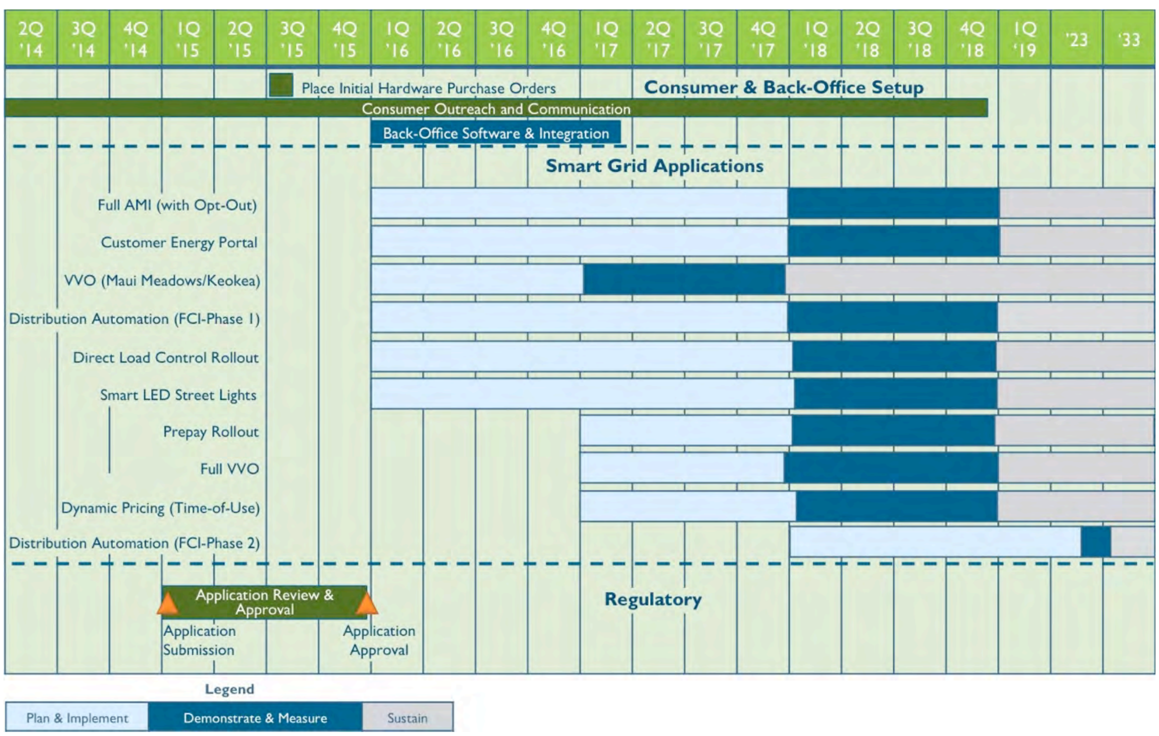


Figure 22: Maui Electric (Maui) Full Implementation Plan

Maui Electric: Lanaʻi and Molokaʻi Full Implementation

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 on Lanaʻi and Molokaʻi. Once completed, the rollout continues with the implementation of VVO and Distribution Automation with fault current indicators (FCIs), plus a Direct Load Control program if it's applicable for these two islands.

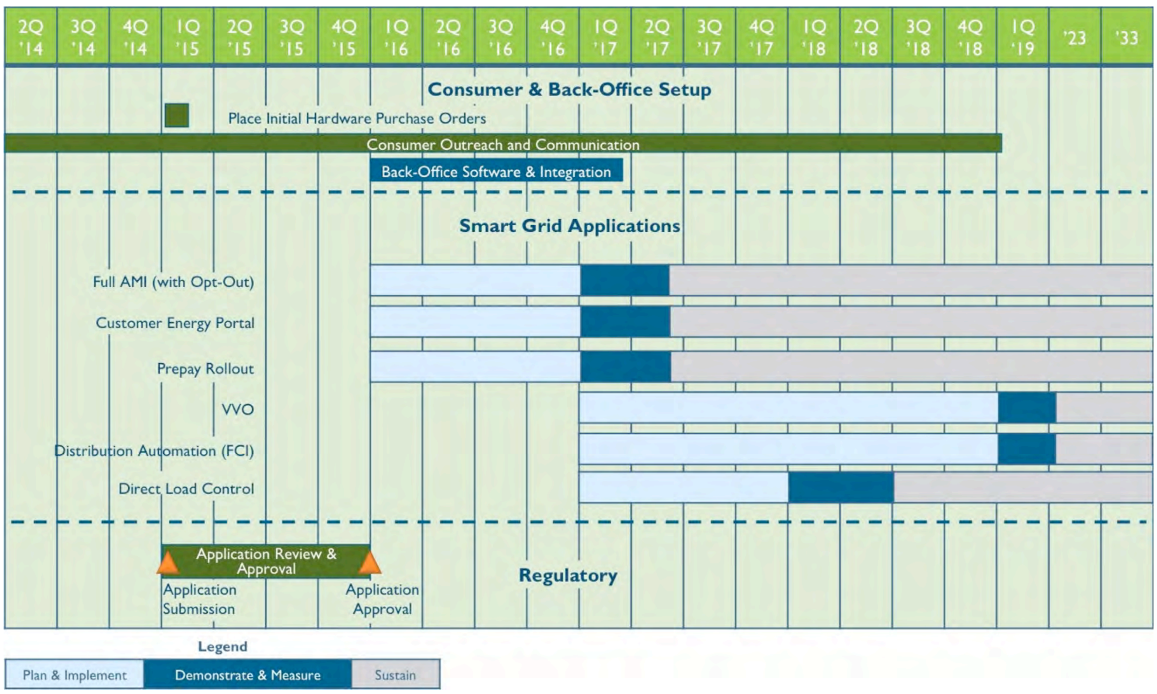


Figure 23: Maui Electric (Lanaʻi and Molokaʻi) Full Implementation Plan

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 VVO to deliver immediate benefits to its customers. The utility also plans to implement a Customer Energy Portal, Prepay, and Direct Load Control and Dynamic Pricing programs, plus the first phase of Distribution Automation to better manage outages.

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

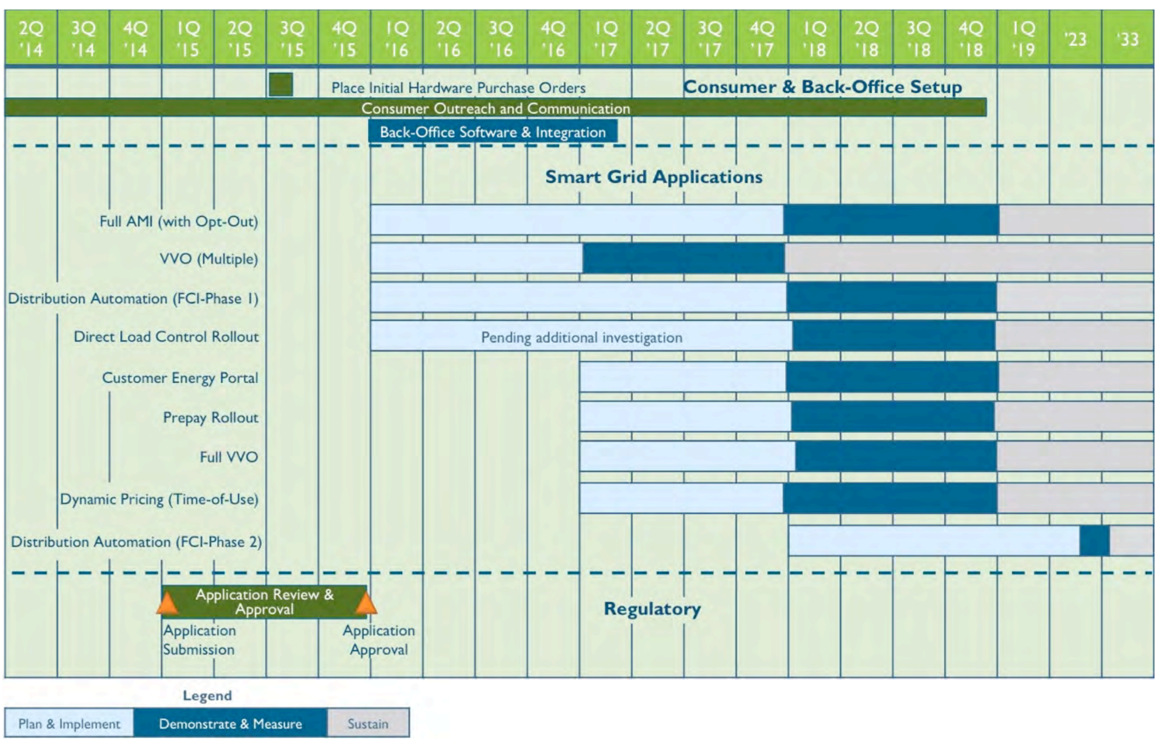


Figure 24: Hawai‘i Electric Light (Hawai‘i Island) Full Implementation Plan

9. Strategic Partnership

The Hawaiian Electric Companies decided early on that it needed a strategic partner with proven experience working with electric utilities to help implement smart grid. After careful and thoughtful consideration, we chose Silver Spring Networks, an industry leader in smart grid technology.

Silver Spring Networks will be acting as our strategic advisor, delivering the smart grid platform, and bringing together the right team of utility and industry partners to help us implement smart grid technology in the most efficient, intelligent ways possible.

Over the past ten years, Silver Spring Networks has networked 17 million homes and businesses for more than 30 utilities. Silver Spring Networks offer proven, fourth-generation smart grid technology which includes customer engagement software, cloud services, and unified grid-management software tools. The company's network tools include best-in-class security features at every level of its smart grid platform, ensuring that the Hawaiian Electric Companies' data network will be secure from both internal and external attacks.

In choosing to work with Silver Spring Networks, we also committed to installing 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 applications. The company is also working collaboratively with us to develop its business case, smart grid strategy, and customer engagement plan.

Silver Spring Networks has experience working with more than 75 technology companies and device manufacturers. The company, based in California, has the largest United States market share for AMI.

The strategic partnership between the Hawaiian Electric Companies and Silver Spring Networks will account for an estimated 10% of the utility's full smart grid implementation. The remaining 90% of the project's scope will be 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.

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

10. Smart Grid Business Case Assumptions

The Hawaiian Electric Companies based our roadmap and high-level business case on a comprehensive review other smart grid implementations and on fundamental assumptions. The analysis was based on the 'Stuck in the Middle' scenario from our 2013 Integrated Resource Planning (IRP) Report.[14]

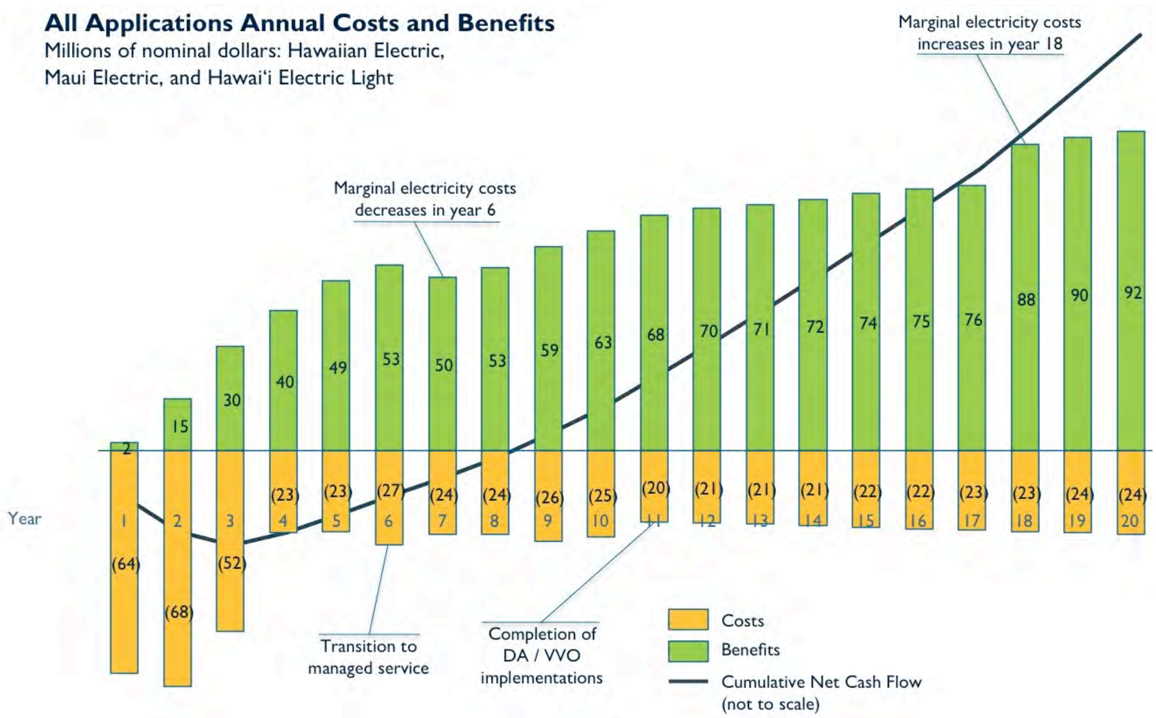
In the months ahead, we will refine our cost estimates to develop a more detailed mid-level business case. And, we will use the results from these updated and more site-specific analyses as the basis for our application requesting approval for full implementation that will be submitted to the Commission later this year.

Many assumptions are based on publicly available North American smart grid business and rate cases, and includes Silver Spring Networks' internal estimates. Some are based on Commonwealth Edison's *Advanced Metering Infrastructure Evaluation Final Report* of July 2011). Still others are based on data from other utilities.

This chapter contains the details of those assumptions.

[14] Hawaiian Electric submitted its *2013 Integrated Resource Planning Report and Action Plan* to comply with the Decision and Order by the Hawai'i Public Utilities Commission on June 28, 2013 in Docket No. 2012-0036.

Smart Grid Applications Annual Cash Flows



Year 1 is assumed to be 2016.

Figure 25: Smart Grid Applications Annual Cash Flows

Smart Grid Business Case Overarching Assumptions

Drivers	Approach and Assumptions
Scope	Twenty year timeline from 2016 to 2035. Across all Hawaiian Electric, Maui Electric, and Hawai'i Electric Light service territories.
Financial	Long term weighted average cost of capital is 9.185%.
Inflation	Baseline operating expenses. Labor and other expenses are inflated at 2% per year (based on Enterprise Resource Planning / Enterprise Asset Management Program Submission of Benefit Analysis) and grow in line with customer growth. Purchased hardware (except AMI hardware such as meters, network interface cards, access points, and relays) and software inflation rate assumed to be 2%. AMI hardware costs assumed to remain flat.
Range	±10% benefit and cost range on AMI, VVO, Customer Energy Portal, Prepay, Demand Response programs, and Distribution Automation.
Customer Demographics	Forecasted customer count.[§]
Energy Economics	Current and forecasted energy prices.[§] Electricity consumption demand.[§] System and marginal generational cost rates.[§]

Note: § Assumptions are based on the 2013 Integrated Resource Planning (IRP) 'Stuck in the Middle' scenario.

Table 5: Smart Grid Business Case Overarching Assumptions

Smart Grid Business Case Assumptions by Application

Application	Cost	Benefit
AMI[15]	♦ Hardware pricing is based on budgetary pricing. ♦ The software model is assumed to be Software as a Service (SaaS) during implementation and transitions to a managed service model after implementation. ♦ Other costs include estimates for system integration, endpoint installation, Silver Spring Networks professional services, internal labor headcounts (business operations, IT and call center), and customer engagement.	♦ Reduction in meter reading and field services positions can be claimed as a savings for the business case. ♦ Benefits accrue in line with the AMI implementation, however are delayed by 12 months. ♦ About 1% of meters will not be automated because customers opt-out (based on reviewed AMI implementations with opt-out fees).
Customer Energy Portal[16]	♦ Software costs include the Customer Energy Portal for additional future applications starts after 10 years. ♦ Services costs include Customer Energy Portal customization, system integration, professional services, and utility program maintenance and training.	♦ 20% of residential customers participate, starting with a 3% reduction in energy delivered per participant and ramping to 7% by year 10. ♦ 25% of commercial customers participate, staring with 1.5% reduction in energy delivered per participant and ramping to 3.5% by year 10. ♦ Financial benefits of reduced energy delivered are based on current and forecasted marginal cost of electricity.
Prepay[17]	♦ Includes Prepay software costs. ♦ Assumes marketing acquisition costs ($80 per customer) and an 8% customer churn after four years.[18] ♦ Requires 2 full-time equivalent (FTE) staff as the Prepay program is implemented and tapers to 0.5 FTE after the program is established. ♦ Customer communication includes text messages as well as inbound and outbound calls. ♦ 20% of the transactions result in a $2.42 payment fee.[19]	♦ 10% of residential customers participate in Prepay.[20] ♦ 11% reduction in energy delivered per Prepay customer[20]. ♦ Reduction in paper billing costs for Prepay customers. ♦ Financial benefits of reduced energy delivered based on current and forecasted marginal cost of electricity.

[15] See Table 11 (page 96) and Table 12 (page 98) for more details an AMI costs and benefits.

[16] See Table 13 (page 102) for more details on Customer Energy Portal costs and benefits.

[17] See Table 14 (page 106) for more details on Prepay costs and benefits.

[18] Based on Duke Energy Progress and Peninsula Light Company projects.

[19] Based on the Oklahoma Electric Cooperative PayGo program

[20] Based on Salt River Oklahoma Electric Cooperative projects.

Application	Cost	Benefit
VVO[21]	♦ VVO is implemented over a 10-year period and is based on AMI voltages. ♦ Network hardware includes Beckwith communications, Shark meters, and SCADA (if necessary) for selected circuits. ♦ Software costs include VVO software licenses. ♦ Services costs include project management and system integration between SICAM and VVO software.	♦ 2% reduction in energy delivered (where implemented) across 80% of residential and commercial customers (residential and commercial customers represent approximately 75% of energy usage) ♦ Financial benefits of reduced energy delivered based on current and forecasted marginal cost of electricity
Distribution Automation	♦ Based on average Distribution Automation business case estimates from North American utilities (for example, Detroit Edison Company, Edmonton Power Corporation, Duke Energy Ohio, and Commonwealth Edison ComEd) ♦ Typical cost drivers include Distribution Automation software systems, Distribution Automation and substation communication and grid hardware ♦ Benchmark includes both Distribution Automation fault location, isolation, and supply restoration (FLISR) and VVO costs. The Hawaiian Electric Companies VVO costs are subtracted from the average Distribution Automation benchmark to provide a high-level estimate of Distribution Automation FLISR costs	♦ Based on average Distribution Automation business case estimates from North American utilities (Detroit Edison Company, Edmonton Power Corporation, Duke Energy Ohio, and ComEd) ♦ Typical benefit drivers include advanced grid monitoring and fault location, isolation, and supply restoration (FLISR)
Demand Response	♦ Based on average Demand Response business case estimates from North American utilities ♦ Typical cost drivers include home and business area networks enablement, system integration, interval billing systems, Demand Response software, project and program management and call center / support	♦ Based on average Demand Response business case estimates from North American utilities (for example, Potomac Electric Power Company, Baltimore Gas & Electric, Pacific Gas & Electric, Southern California Edison) ♦ Typical benefit drivers include reduced peak demand from direct load or dynamic pricing programs and avoided transmission and distribution and capacity costs

Table 6: Smart Grid Business Case Assumptions by Application

[21] See Table 15 (page 110) for more details on VVO costs and benefits.

AMI COSTS AND BENEFITS

See Table 6 (page 91) for a summary of the costs and benefits for AMI.

AMI Costs and Benefits by Operating Utility

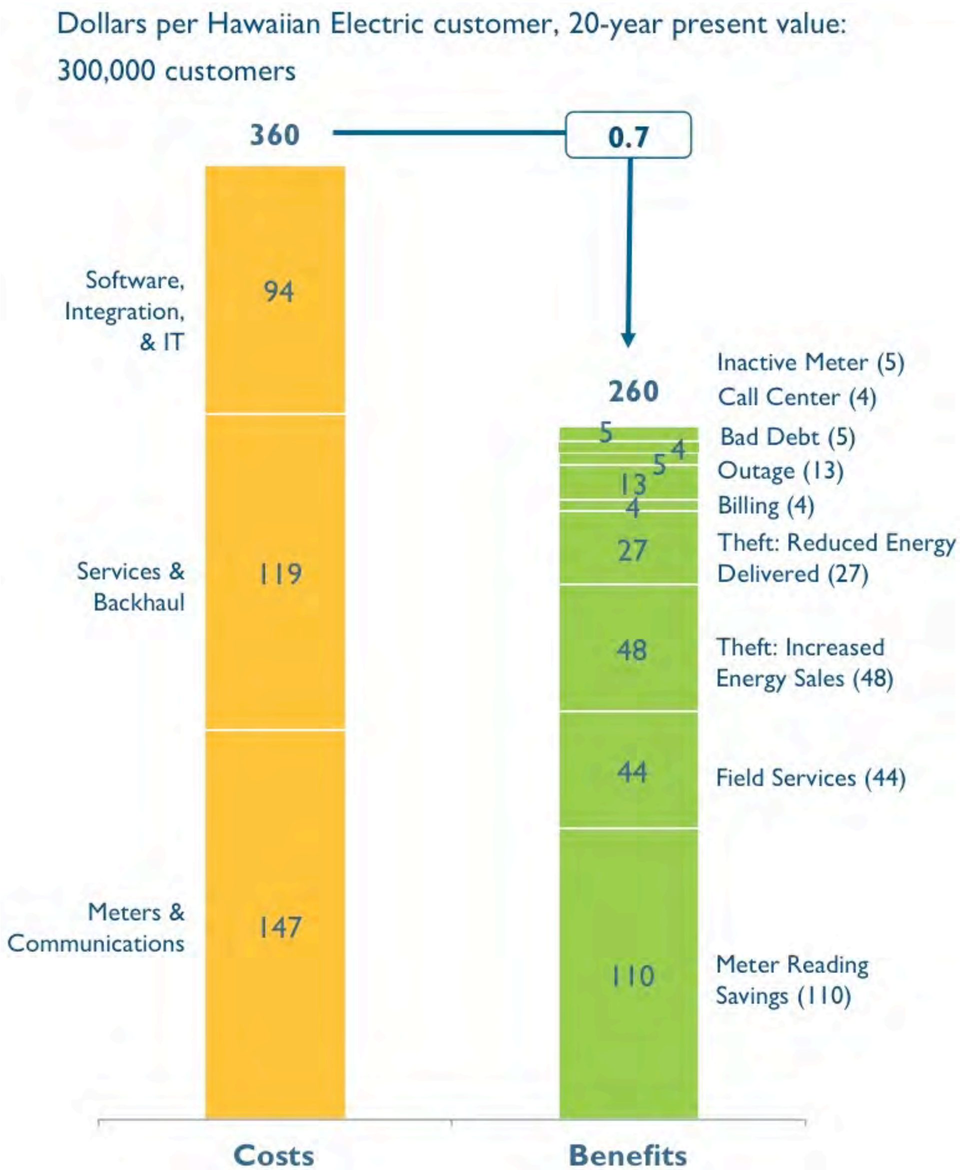


Figure 26: AMI Costs and Benefits: Hawaiian Electric

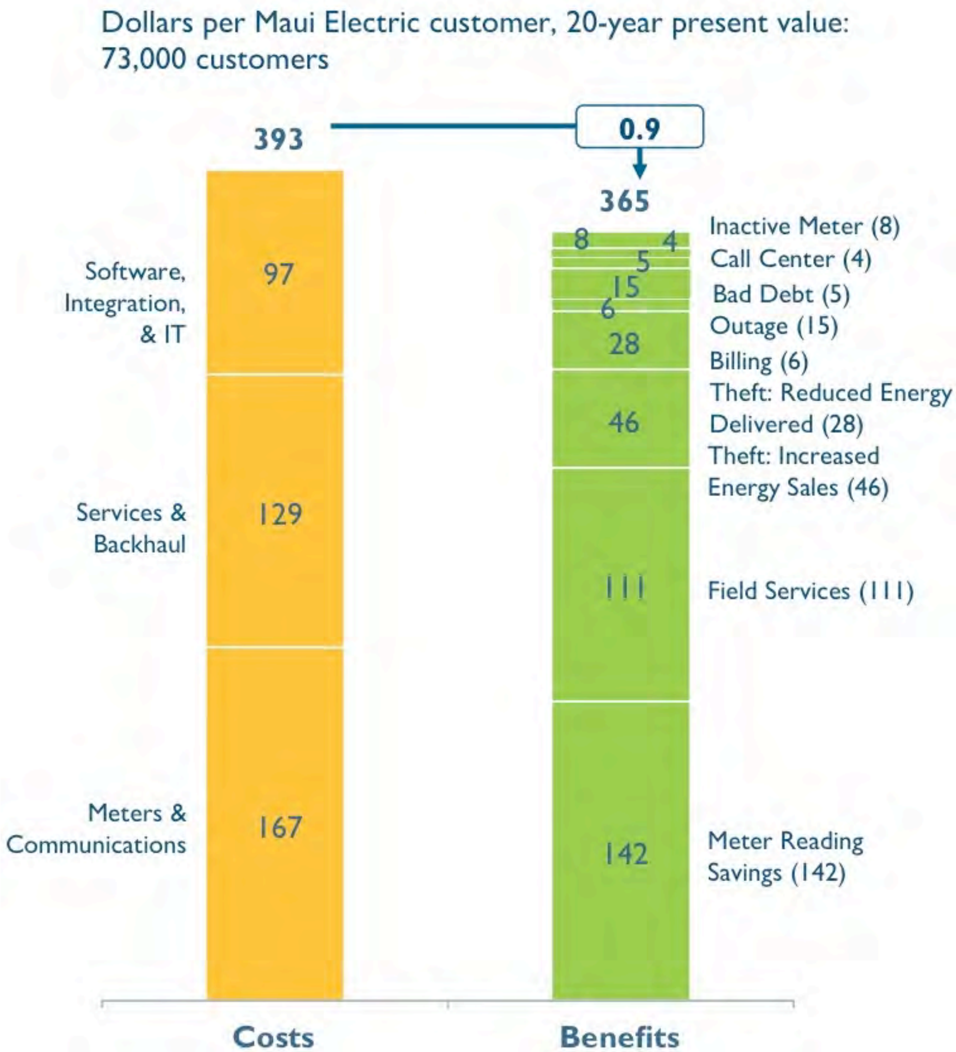


Figure 27: AMI Costs and Benefits: Maui Electric

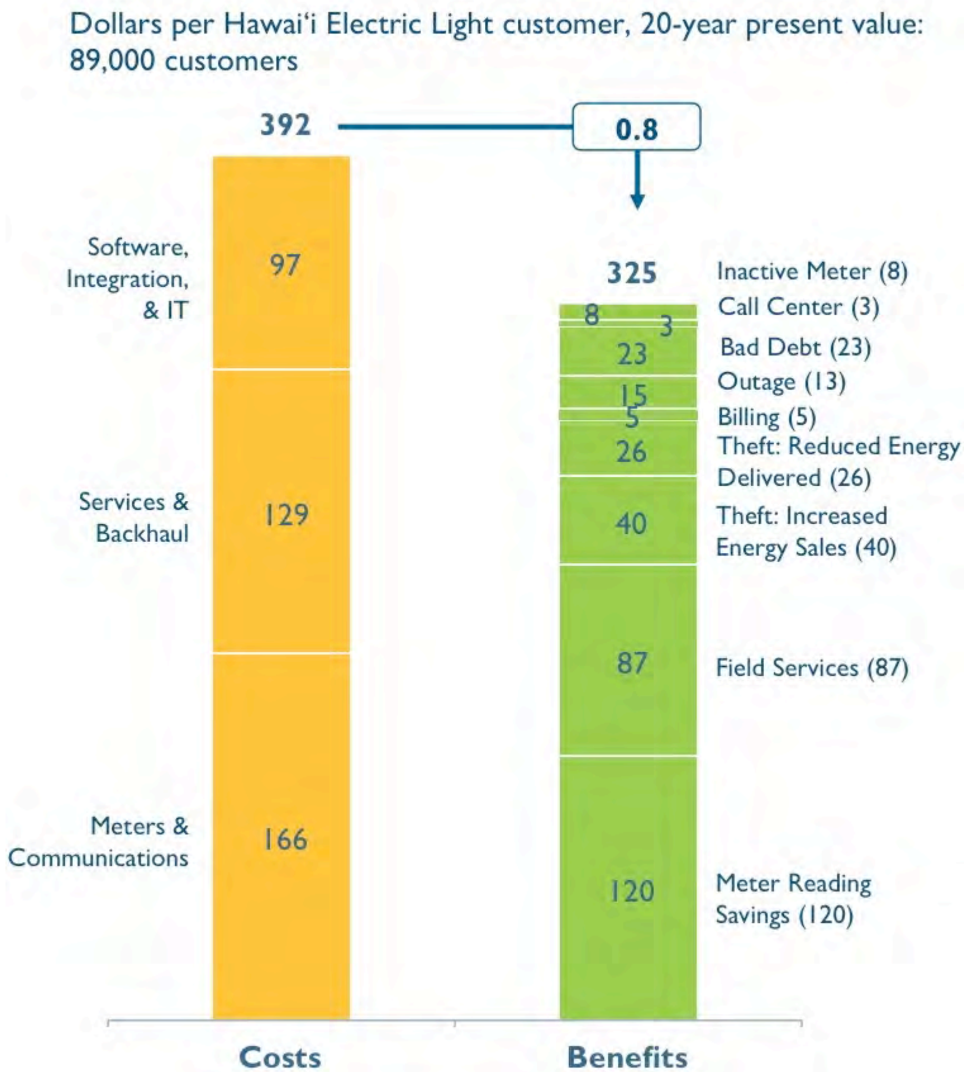
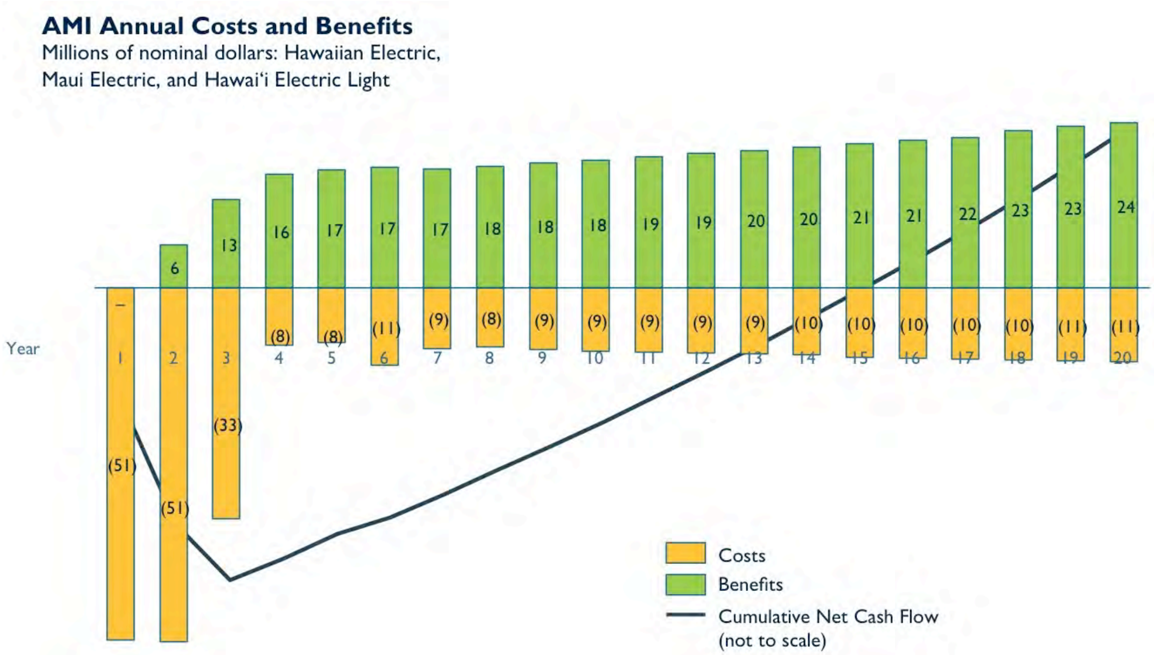


Figure 28: AMI Costs and Benefits: Hawai'i Electric Light

AMI Annual Cash Flows



Year 1 is assumed to be 2016.

Figure 29: AMI Annual Cash Flows

AMI Meter Reading Costs and Benefits

See Figure 30 for graphs related to the information in Table 7.

Utility	Costs	Benefits
Hawaiian Electric	Based on 2014 meter reading budget of $4.2 million per year: ♦ Includes labor, materials, outside services, maintenance, and transportation. ♦ Meter reader budget accounts for a growth in forecasted customer count and labor cost.	Estimated 89% reduction in meter reader costs, adjusted based on AMI implementation ramp and labor inflation: ♦ Anticipated savings reflect a reduction of 34 meter readers (92%) and 1 Supervisor: a 50% cost savings. ♦ A management position, 2 meter readers, and 1 clerical position retained to manage and administer the meter reading system. ♦ Assumed that manual meter reads will be in less condensed areas resulting in 60% reduced productivity by remaining meter readers.
Maui Electric	Based on 2014 meter reading budget $1.54 million per year: ♦ Includes operation and maintenance project and non-project costs and represents nine meter readers.	Estimated 63% reduction in meter reader costs, adjusted based on AMI implementation ramp and labor inflation: ♦ Anticipated savings reflect a reduction of 7 out of 9 total meter reading staff. ♦ A supervisor position (allocated between meter reading and field service) and 2 meter readers retained to manage and administer the meter reading system. ♦ No cost savings assumed for Moloka'i meter reader or field service and 50% cost savings for Lana'i, and Hana. ♦ Estimated that less meters read per day as meters will be in less condensed areas and unheard meters will be harder to access (for example, basement locations). ♦ The motor vehicle repair shop (MVRS) maintenance contract cost is a fixed, and thus no reduction.
Hawai'i Electric Light	Based on 2014 meter reading budget of $1.6 million per year: ♦ Includes labor, materials, outside services, maintenance, and transportation.	Estimated 64% reduction in meter reader costs; adjusted based on AMI implementation ramp and labor inflation: ♦ Anticipated savings reflect a reduction of 7 meter readers (70%) of total meter reading staff, and reduction of 1 Supervisor: a 50% cost savings. ♦ A management position and 3 meter readers are retained to manage and administer the meter reading system. ♦ Assumed that manual meter reads will be in less condensed areas resulting in 89% reduced productivity by remaining meter readers.

Table 7: AMI Meter Reading Costs and Benefits

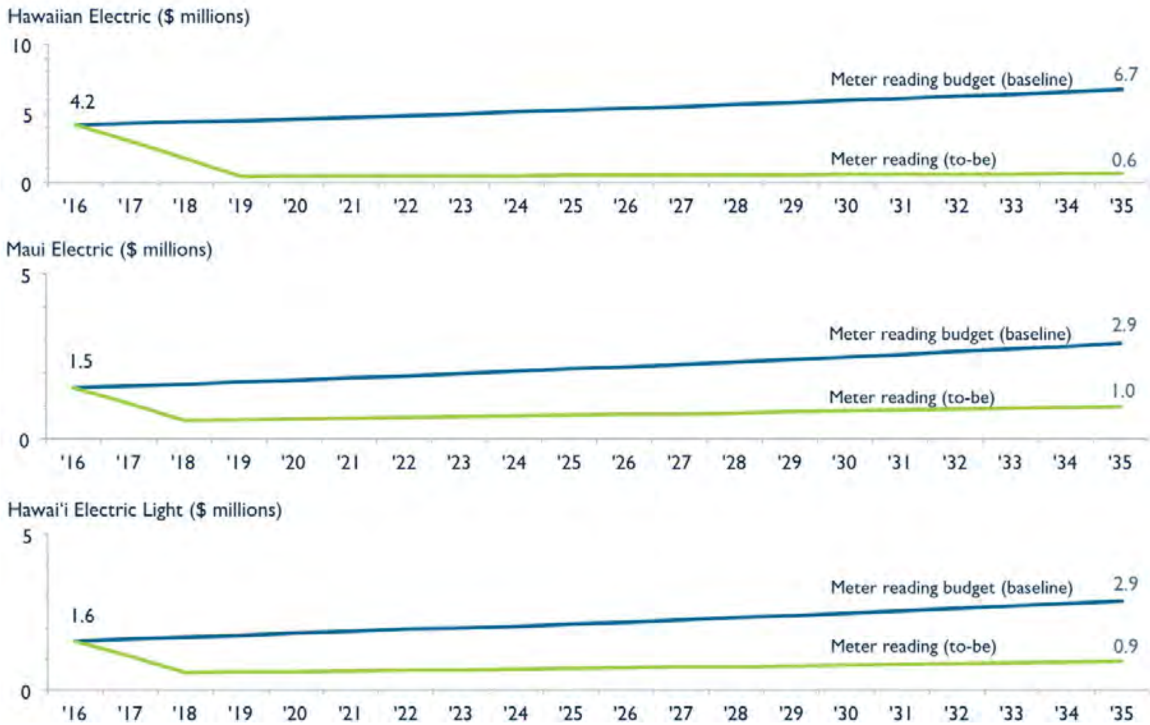


Figure 30: AMI Meter Reading Cost and Benefit Graphs

AMI Remote Service Switch Costs and Benefits

See Figure 31 for graphs related to the information in Table 8.

Utility	Field Service Costs	Savings Rate
Hawaiian Electric	Based on the number of disconnects and connects per year for bad debt, move-outs, or other service requests. Based on 2014 field services costs of $2.5 million. Assumes $31 per credit related disconnect and reconnect and $26 per move-in/move-out which includes labor, material, transportation, and other services. Assumes 80% reduction in the number of trips based on remote activities only being conducted on residential customers (89% of customers). Proposed field services FTE counts assumes: ♦ Minimum number of FTE required to provide island-wide coverage in 7 geographic areas. ♦ 1 additional FTE required for absence coverage (vacation and sick hours). ♦ Estimated 20 daily orders completed for 7 geographic areas. ♦ Same-day turn-on service continues. ♦ Collection orders completed within 10 days. ♦ 1 clerk required for dispatching duties and support for Senior Investigators.	Results in a 58% savings rate
Maui Electric	Approximately 29,000 field service requests annually at an average $44.24 per request. Annualized 1,148 disconnects and reconnects for bad debt. 27,569 move-out and other service requests.	Assumes 60% savings rate (based on savings rate from Hawaiian Electric)
Hawai'i Electric Light	Approximately 18,000 field service requests annually. 2,528 bad debt activities at $145 per activity for 2 FTE (2014 budgets) 15,800 disconnects and reconnects at $54 each, based on 5 FTE (2014 budgets)	Assumes 60% savings rate (based on savings rate from Hawaiian Electric)

Table 8: AMI Remote Service Switch Costs and Benefits

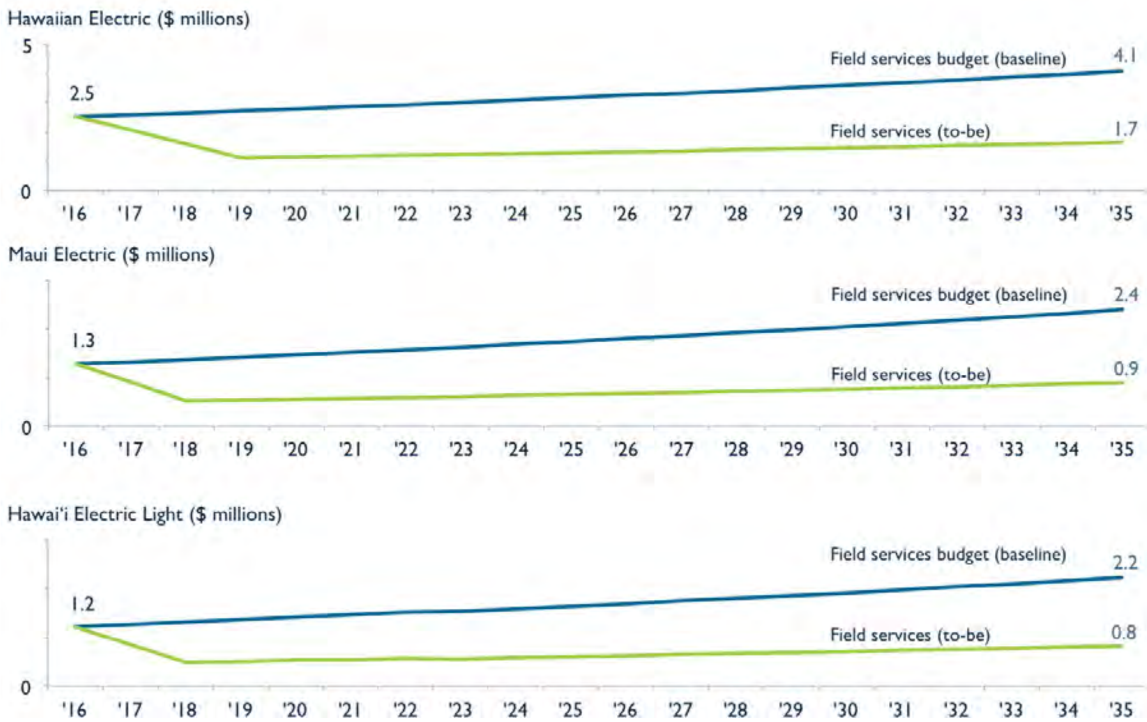


Figure 31: AMI Remote Service Switch Cost and Benefit Graphs

AMI Opt-Out Rates

Utility	One-Time Cost	Monthly Cost	Opt-Out Rates	Source
DTE Energy Michigan[22]	$67.20	$9.80	1%	http://www.mlive.com/business/index.ssf/2013/05/dte_energy_allowed_to_charge_c.html
Central Maine Power[22]	$20.00	$10.50	1%	https://www.cmpco.com/MediaLibrary/3/6/Content%20Management/Suppliers%20And%20Partners/PDFs%20and%20Doc/sect12.pdf
Central Maine Power[23]	$40.00	$12.00		
Consumers Energy	$69.00–$124.00	$9.72	About 1%	http://www.mlive.com/business/index.ssf/2013/08/group_of_consumers_energy_cust.html
Florida Power & Light	Not yet established	Not yet established	0.35%	http://www.miamiherald.com/2013/04/24/3362760/fpl-completes-smart-meter-upgrade.html
Pacific Gas & Electric[23]	$75.00	$10.00	< 0.5%	http://www.pge.com/en/myhome/customerservice/smartmeter/optout/faqs/index.page?
Pacific Gas & Electric (CARE)	$10.00	$5.00		

Table 9: AMI Opt-Out Rates

[22] Smart meter with radio turned off.

[23] Analog meter.

AMI Electricity Theft Reduction Benefits

All improvements in detecting energy thefts apply to 80% of our service territory. We assume that 0.5% of energy delivered is stolen each year (based on theft estimates from Table 10). We further assume that 25% of this stolen energy (0.125% of total energy) is billed thus increasing electricity sales, and that 25% of stolen energy (0.125% of total energy) is avoided electricity costs.

Energy Theft Estimates							
		Losses Recoverable with AMI			*Revenues Recoverable with AMI*		
	Revenue Lost from Energy Theft	Minimum	Maximum	Midpoint	Minimum	Maximum	Midpoint
EPRI Study	1.0%	20.0%	30.0%	25.0%	0.200%	0.300%	0.250%
San Diego Gas & Electric	0.30%	n/a	n/a	8.5%	n/a	n/a	0.026%
Southern California Edison	0.25%	n/a	n/a	25.0%	n/a	n/a	0.063%
Duke Power	0.50%	n/a	n/a	25.0%	n/a	n/a	0.125%
Dominion Power	—	n/a	n/a	n/a	n/a	n/a	0.100%
Average					0.20%	0.30%	0.11%
Minimum					0.20%	0.30%	0.03%
Maximum					0.20%	0.30%	0.25%
Midpoint							***0.138%***

Notes: a. *Revenue Metering Loss Assessment*, EPRI Technical Report 1000365, November 2001.
b. Rebuttal testimony of James Teeter, September 7, 2006, in San Diego Gas & Electric's application to the California Public Utilities Commission for adopting AMI.
c. *AMR for Theft Detection: The Truths and Myths*, by Chartwell Inc., March 2003.
d. Ali Ipakchi, consultant for KEMA (Keuring van Elektrotechnische Materialen te Arnhem), an energy service provider.

Table 10: AMI Electricity Theft Reduction Benefits

AMI Outage Reduction Benchmarks

Better outage detection and resolution can result in $15 savings per customer.[24]

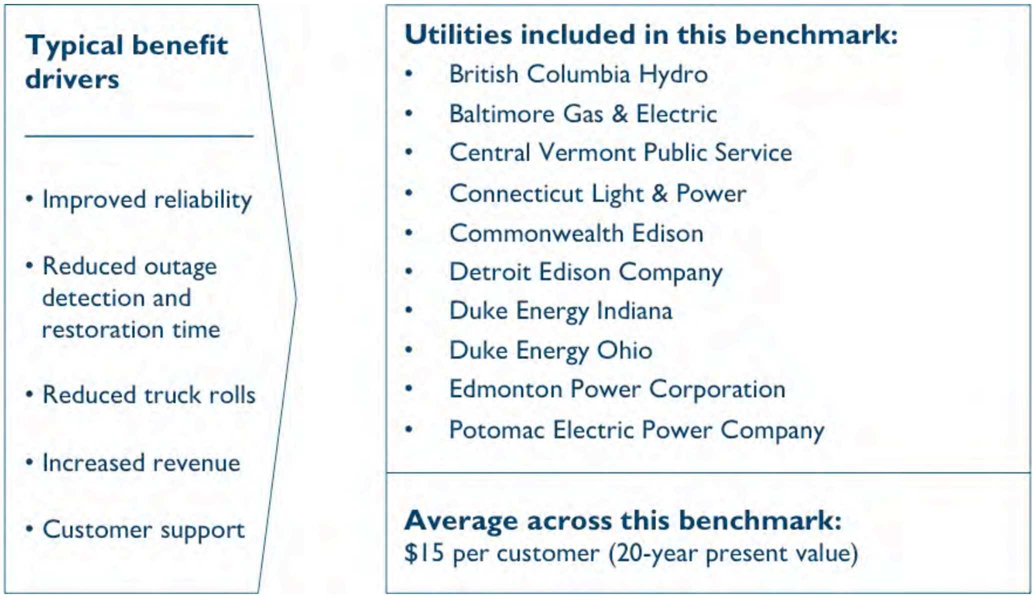


Figure 32: AMI Outage Reduction Benchmarks

[24] Based on publicly available North American Smart Grid business and rate cases, and includes Silver Spring Networks' internal estimates.

AMI Financial Benefits

Benefit	Hawaiian Electric	Maui Electric	Hawai'i Electric Light
Billing	♦ 25% reduction ($150,000 per year) of billing staff; assumes not spending 100% of time manually processing bills while performing additional AMI support activities. ♦ Based on existing billing staff of 5 billing representatives and 1 supervisor: About $600,000 current total cost annually.	♦ 25% reduction ($40,000 per year) of staff associated with billing estimates. Currently, $158,000 estimated annual cost to manually process bills (represents 1 FTE).	♦ 25% reduction ($44,000 per year) of staff associated with billing estimates. Currently, $175,000 estimated annual cost to manually process bill (represents 1 FTE). ♦ Estimated at maximum of 1 FTE; includes unread automatic meter readings or turtle meters that need to be billed, no access or skipped reads, or any accounts that exceed one estimated bill.
Bad Debt	♦ Assumes a 25% reduction in residential bad debt by incorporating new business practices in conjunction with remote disconnects to shut-off services in a timelier manner.[25] ♦ Bad debt baseline grows over time in line with growth in electricity prices and consumption.		
	♦ Based on a 3-year average, assuming a reduction of $150,000 per year in bad debt at full implementation (25% reduction off residential bad debt which represents about 45% of total bad debt).	♦ Projected total bad debt in 2014 is $301,000 based on 3-year bad debt average from 2010–2012. ♦ $135,000 projected residential bad debt assuming 45% of bad debt stems from residential customers (based on Hawaiian Electric data). ♦ Assumes a reduction of 25% in bad debt, saving $34,000 per year.	♦ $926,000 projected total bad debt in 2014 based on 3-year bad debt average from 2010–2012. ♦ $640,000 projected residential bad debt (represents about 70% of total bad debt). ♦ Assumes a reduction of 25% in bad debt, saving $160,000 per year.
Call Center	♦ Assumes 50% reduction in number of calls related to billing delays (based on Pacific Gas & Electric). ♦ Estimated calls for billing delays do not include the impact of interactive voice response systems because these options do not deflect these type of billing issues		
	♦ Estimated 11,000 calls (based on 2012 actuals) due to billing delays; at $1 per call per minute; average call time is 6:40 resulting in $6.40 cost per call.	♦ Estimated 4,300 call reduction through AMI;[26] $2.34 per call per minute; average call time is 6:40 resulting in $15 cost per call.	♦ Estimated 5,100 calls (25% of total calls) calls due to billing delays at $8.80 cost per call.

25 Estimate based on Commonwealth Edison business case (*Advanced Metering Infrastructure Evaluation Final Report*, July 2011) which assumed a 50% reduction in bad debt.

26 Assumes 5.3% of total calls received for estimated bills, billing delays, and meter reader complaints based on Pacific Gas & Electric's business case.

Benefit	Hawaiian Electric	Maui Electric	Hawai'i Electric Light
Inactive Meter Consumption	♦ Assumes about 2.6% of meters are not assigned to a customer account; based on 8,000 meters out of 306,000 customers that have been identified as inactive accounts for Hawaiian Electric. ♦ Assumes consumption on inactive accounts is about 3% of residential consumption.[27] ♦ Assumes 80% reduction in consumption on inactive accounts through the usage of remote disconnect and connect technology along with business process changes.[28]		

Table 11: AMI Financial Benefits

[27] Based on Commonwealth Edison (*Advanced Metering Infrastructure Evaluation Final Report*, July 2011) which identified 435 gigawatt hours of consumption across a monthly average of 139,000 inactive accounts.

[28] Based on Commonwealth Edison (*Advanced Metering Infrastructure Evaluation Final Report*, July 2011) which assumed 90%.

AMI Costs

Drivers	Approach and Assumptions
Meters	♦ Assumes meters have disconnect capability and based on budgetary pricing for the Hawaiian Electric Companies' full implementation. ♦ Residential and control and implementation meter quantities based on current and forecasted customer counts. ♦ Hardware replacement based on estimated projected failure rates.
Communications	♦ Residential and control and implementation network interface card pricing based on budgetary pricing for full implementation. ♦ Annual firmware maintenance fee for years 1 through 20 for network interface cards, access points, and relays. ♦ Assumes 100% mesh network.
Network Infrastructure Costs	♦ Access point and relay costs based on budgetary pricing for full implementation; assumes each network infrastructure device will receive a battery back-up. ♦ 80% urban and suburban and 20% rural split. ♦ Access point and relay counts based on vendor estimates. ♦ Additional network infrastructure (such as mounting kits, power cables, coax cables) based on the Initial Phase quantities and scaled up to full implementation.
Network Backhaul	♦ Assumes access points are backhauled via cellular network. ♦ Connectivity to each access point is anticipated to cost $25 per unit per month based on network backhaul based on the Hawaiian Electric Companies rate table. ♦ Assumes backhaul price decreases 3% annually.
Total Software, Integration, and IT Costs[29]	♦ Assumes conservatively the Hawaiian Electric Companies total IT costs will be about 75% of maximum benchmark, which is $129 per customer (20-year present value). ♦ Maximum benchmark is from Consumers Energy. Elements included in Consumers Energy estimate: computing and data network communication equipment, head-end, meter data management system equipment, disaster recovery, work management systems, SAP Project Systems module, device asset management system, licensing of the SAP AMI for Utilities software, labor for blueprinting system modifications, and systems development costs.
Software	♦ Assumes SaaS head-end software for years 1–5 and managed for years 6–20. ♦ SaaS and managed costs based on budgetary pricing for full implementation. ♦ Meter data management system assumes license model and costs based on budgetary pricing for full implementation. ♦ Theft analytics application assumes SaaS model and costs based on budgetary pricing for full implementation.

[29] Based on publically available North American Smart Grid business and rate cases for IT and System Integration costs for smart grid implementations.

Drivers	Approach and Assumptions
Integration and IT Costs	♦ System integration costs are estimated to be $30 per meter across the implementation period. ♦ Determined by subtracting known IT costs (software, hardware, and internal IT labor) from 75% of the maximum North American IT and System Integration benchmark. ♦ Managed appliance will be required for years 6–20.
Services	♦ Estimated internal Hawaiian Electric Companies' AMI resources during implementation and sustain period (resources required based on Silver Spring Networks' preliminary estimates): business operations: 2/1 FTEs; credit analysts to perform a review of prospective credit related disconnects: 2/2 FTEs; business analyst: 2/1 FTEs; Meter data management systems IT manager: 1/1 FTE per year; meter shop technicians: 2/1 FTEs; field operations: 2/1 FTEs; mesh engineer: 2/1 FTEs. ♦ Meter and network installation: residential installation costs based on previous quote from an installation provider; Control and implementation installation costs based on Hawaiian Electric Companies' internal estimates; network device (access points and relays) installation costs based on budgetary pricing estimate from Silver Spring Networks. ♦ Preliminary Silver Spring Networks estimates of professional services across all application areas include: project managers, field engineer, a system integration manager, advanced technical services, project administration, design engineers, and network operations and information security. ♦ Internal and ongoing customer engagement assumes 80¢ per customer per year for the duration of the project and includes customer outreach and events, customer communication, and marketing materials such as door hangers, brochures, and billing inserts.[30] ♦ Internal upfront customer engagement assumes three customer engagement vehicles for Hawaiian Electric, one for Maui Electric, and one for Hawai'i Electric Light at $30,000 per vehicle. ♦ External support customer engagement assumes $200,000 for start-up in year 2014 and $100,000 a year for 2016–2018. ♦ Call center assumes 2% of meters installed will result in a call into the call center, at 10 minutes per call at $1 per minute.[31] ♦ Assumes one revenue protection person for every 125,000 customers.[32]

Table 12: AMI Business Case Costs

[30] Based on average North American customer engagement benchmark which includes estimates from Detroit Edison Company, British Columbia Hydro, Southern California Edison, and Connecticut Light & Power.

[31] Based on E.ON Sverige [a Swedish utility] and Hawaiian Electric inputs on costs.

[32] Based on American Electric Power Ohio.

CUSTOMER ENERGY PORTAL COSTS AND BENEFITS

See Table 6 (page 91) for a summary of the costs and benefits for the Customer Energy Portal.

Customer Energy Portal Costs and Benefits by Operating Utility

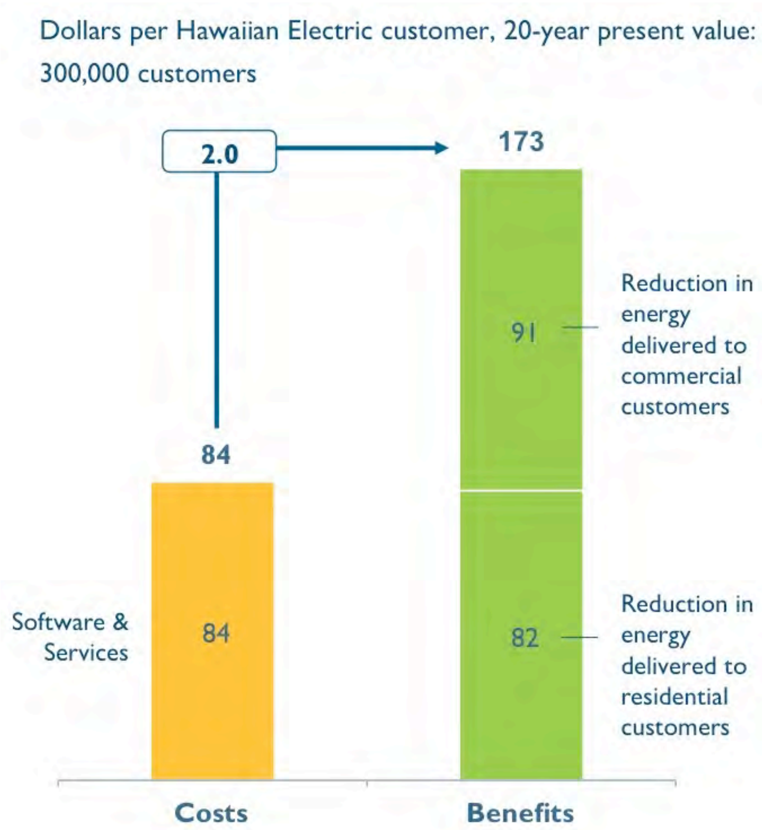


Figure 33: Customer Energy Portal Costs and Benefits: Hawaiian Electric

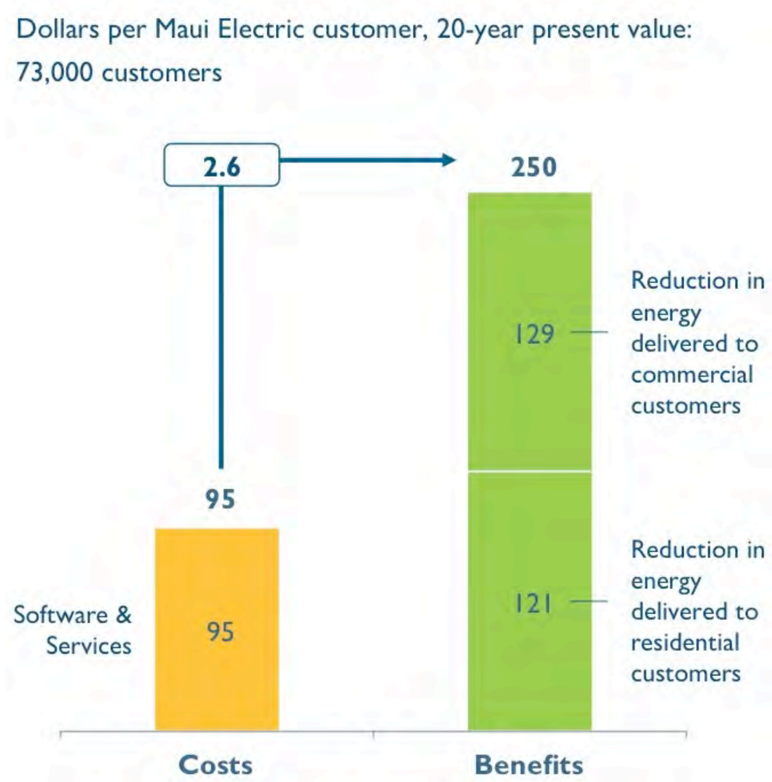


Figure 34: Customer Energy Portal Costs and Benefits: Maui Electric

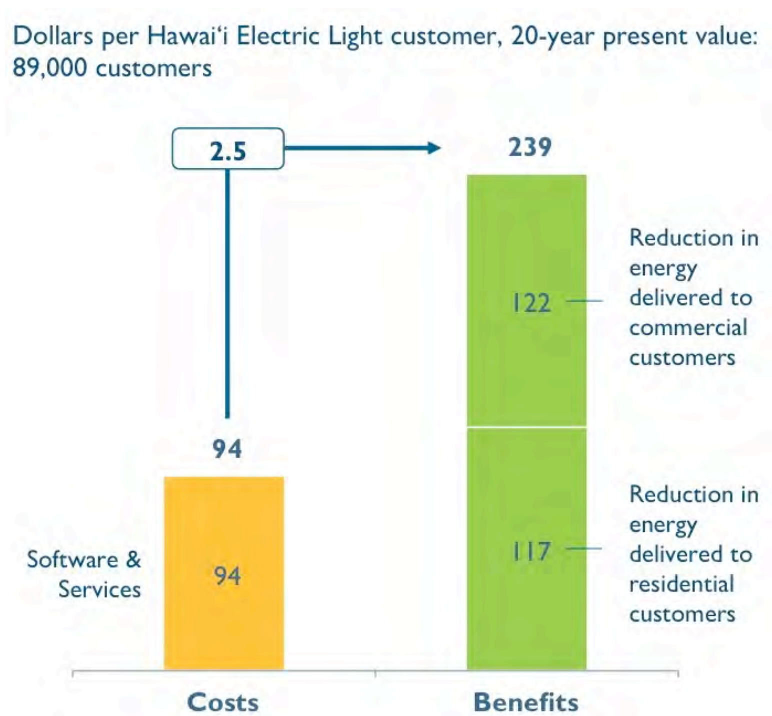
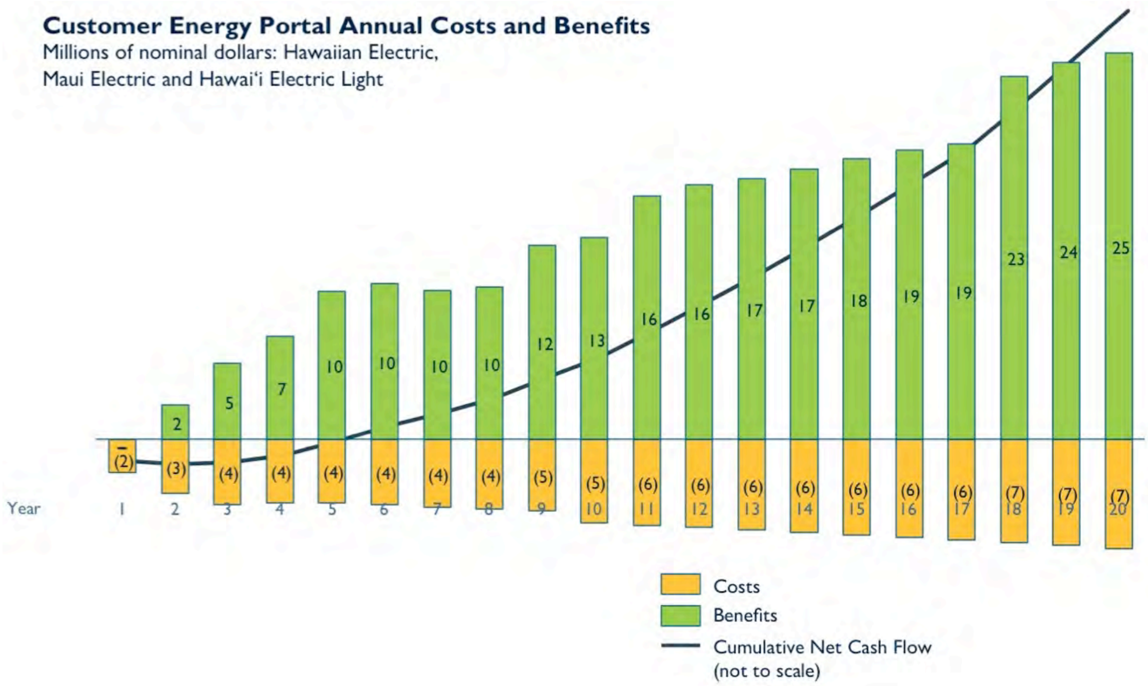


Figure 35: Customer Energy Portal Costs and Benefits: Hawai'i Electric Light

Customer Energy Portal Annual Cash Flows



Year 1 is assumed to be 2016.

Figure 36: Customer Energy Portal Annual Cash Flows

Customer Energy Portal Cost and Benefit Assumptions

Drivers	Approach and Assumptions
Costs	
Software	♦ SaaS fee per customer includes production, disaster recovery, and test environments, and is based on budgetary pricing estimates. ♦ Estimated additional SaaS costs starting after year 10 for future advanced software applications to drive higher energy reduction percentages.
Services	♦ Assumes software and services is customized to integrate user experience. ♦ System integration for single sign-on and between the Customer Energy Portal software, SAP's AMI for Utilities software, and a meter data management system. ♦ Professional services for implementation and ongoing maintenance support. ♦ Internal utility program maintenance. ♦ Staff training.
Benefits	
Reduction in Energy Delivered	♦ 20% of residential customers participate; starts with a 3% reduction in energy delivered per participant and ramps to 7% by year 10. ♦ 25% commercial customers participate; starts with a 1.5% reduction in energy delivered per participant and ramps to 3.5% by year 10. ♦ Energy reduction assumptions[33] based on providing usage information after consumption (indirect feedback). ♦ Financial benefits of reduced energy delivered based on current and forecasted marginal cost of electricity.

Table 13: Customer Energy Portal Cost and Benefit Assumptions

[33] Based on American Council for an Energy-Efficient Economy (*Advanced Metering Initiatives and Residential Feedback Programs*, June 2010).

PREPAY COSTS AND BENEFITS

See Table 6 (page 91) for a summary of the costs and benefits for the Prepay program.

Prepay Costs and Benefits by Operating Utility

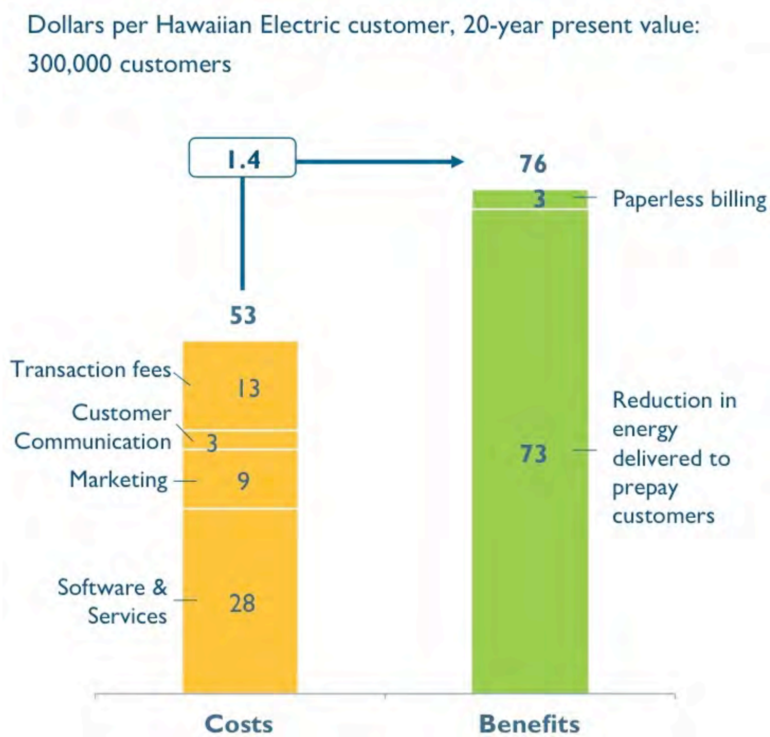


Figure 37: Prepay Costs and Benefits: Hawaiian Electric

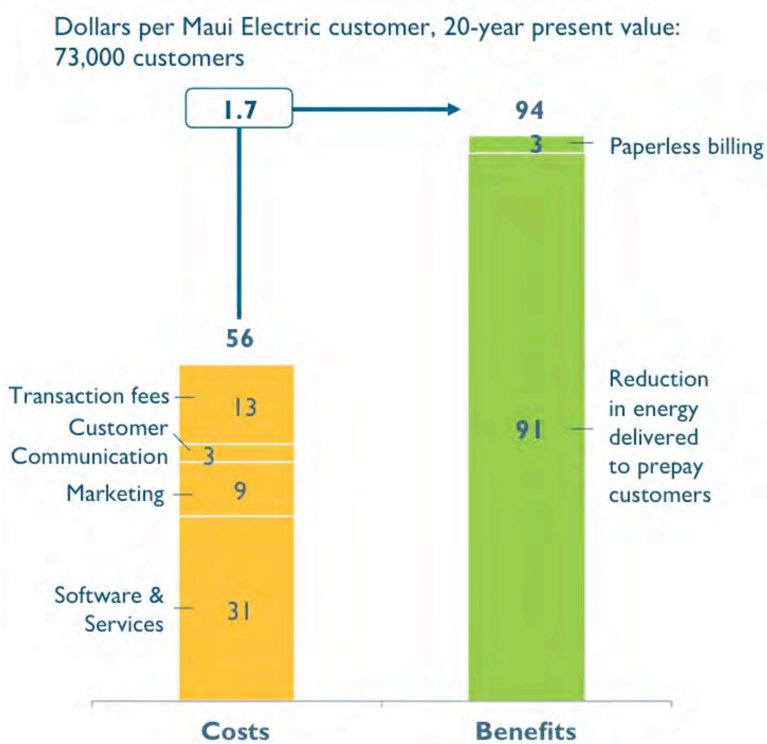


Figure 38: Prepay Costs and Benefits: Maui Electric

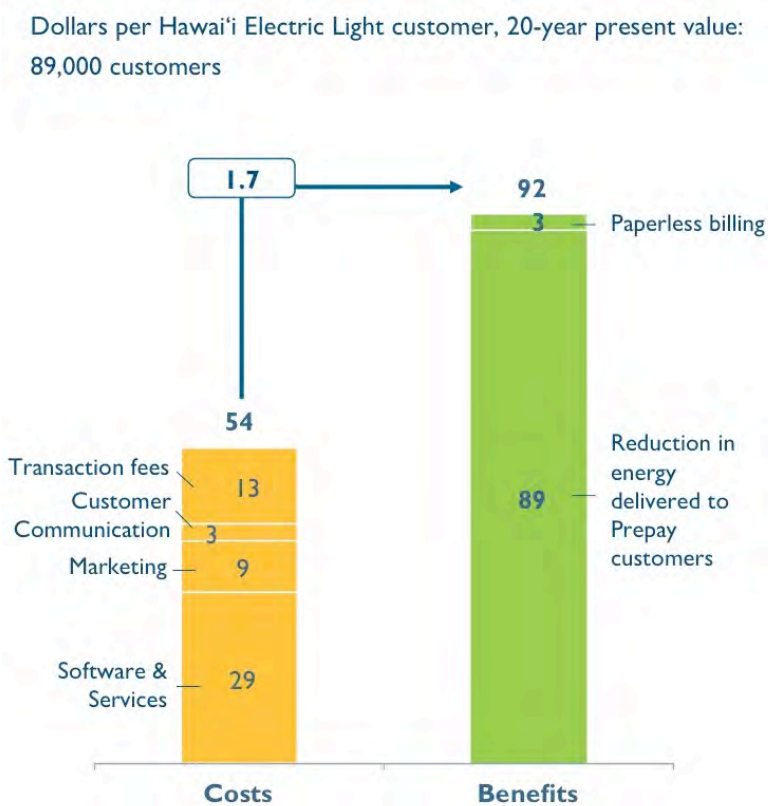
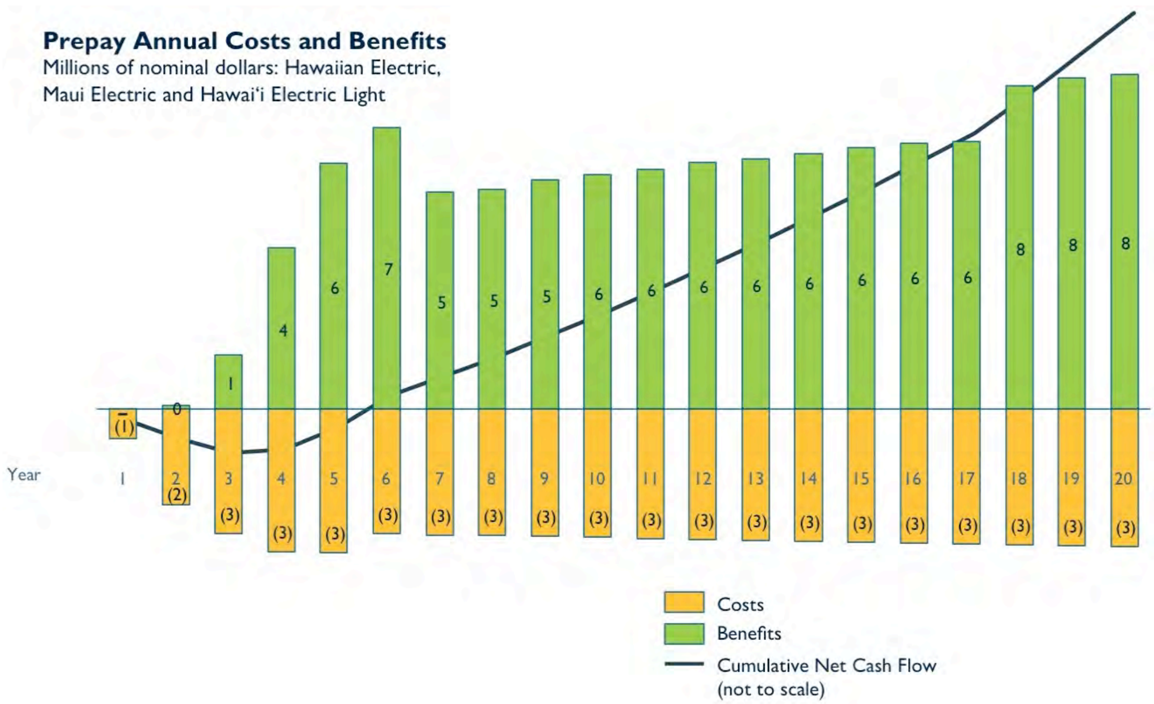


Figure 39: Prepay Costs and Benefits: Hawai'i Electric Light

Prepay Annual Cash Flows



Year 1 is assumed to be 2016.

Figure 40: Prepay Annual Cash Flows

Prepay Cost and Benefit Assumptions

Drivers	Approach and Assumptions
Costs	
Software	♦ Prepay software costs include SaaS, hosting, and setup fee based on budgetary pricing from the selected Prepay vendor.
Marketing	♦ Assumes $80 per customer in acquisition marketing costs. ♦ After year 4, assumes an 8% customer churn (based on Duke Energy Progress and Peninsula Light Company).
Services	♦ Project management across all operating companies assumes about two FTEs as Prepay program is implemented and tapers to about one FTE after the program is established. ♦ Assumes integrating the Prepay software, a meter data management system, and a Customer Information System (CIS).
Other	♦ $2.42 fee per transaction with the utility paying the fee (based on Oklahoma Electric Cooperative). ♦ Assumes 20% of transactions result in fees (based on experience of Prepay vendors). ♦ 3.5 transactions per Prepay customer per month (based on experience of Prepay vendors).
Customer Communication	♦ Assumes customer communication takes advantage of Prepay application features (based on experience of Prepay vendors). ♦ Text messages assume 13.9 messages per month per customer at 1¢ per message. ♦ Inbound communication assumes 0.7 calls per month per customer at 2¢ per call per minute with an average call duration of 3 minutes. ♦ Outbound communication assumes 9.7 calls per month per customer and 2¢ per call per minute with an average call duration of one minute.
Benefits	
Reduction in Energy Delivered	♦ Assumes 10% of residential customers participate in the Prepay program (based on Salt River and Oklahoma Electric Cooperative projects). ♦ Assumes 11% reduction in energy delivered per Prepay customer (based on Salt River and Oklahoma Electric Cooperative projects). ♦ Financial benefits of reduced energy delivered based on current and forecasted marginal cost of electricity.
Paperless Billing	♦ Includes avoided cost of providing paper billing for Prepay customers; assumes paper billing is $5 per customer per year (based on input from Hawaiian Electric).

Table 14: Prepay Cost and Benefit Assumptions

VOLT/VAR OPTIMIZATION (VVO) COSTS AND BENEFITS

See Table 6 (page 91) for a summary of the costs and benefits for VVO.

Volt/VAR Optimization (VVO) Costs and Benefits by Operating Utility

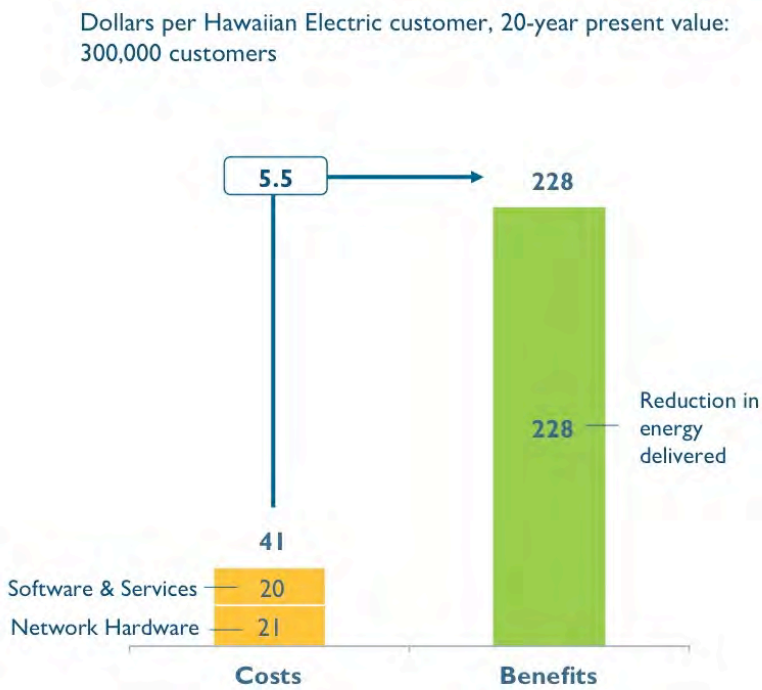


Figure 41: Volt/VAR Optimization Costs and Benefits: Hawaiian Electric

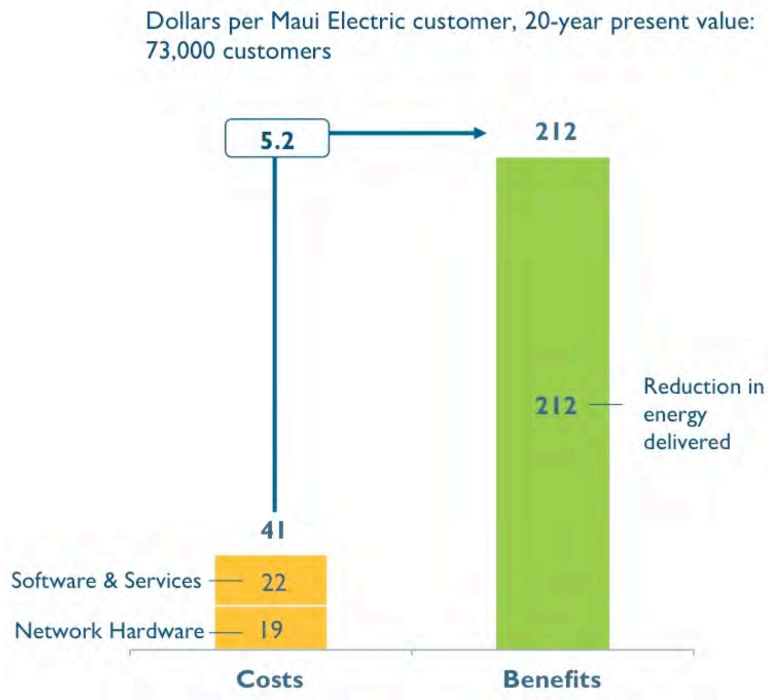


Figure 42: Volt/VAR Optimization Costs and Benefits: Maui Electric

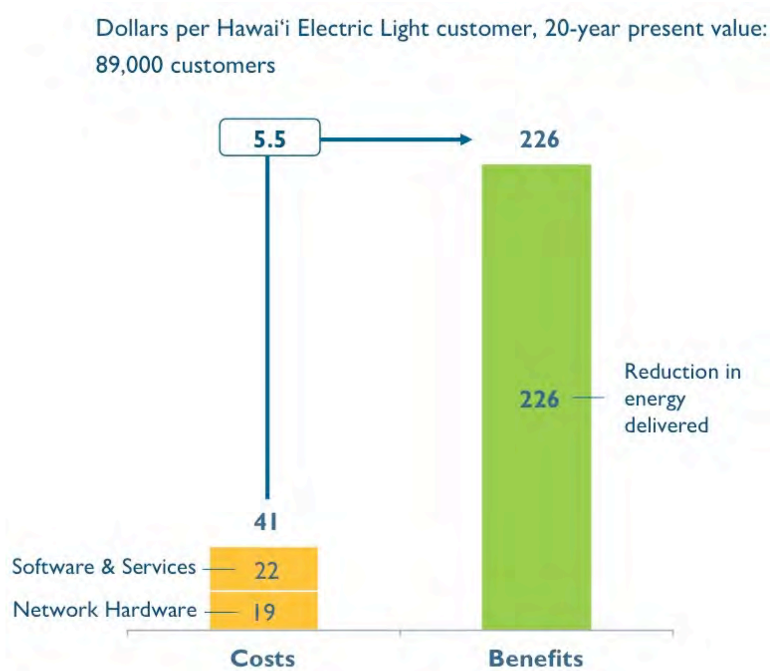
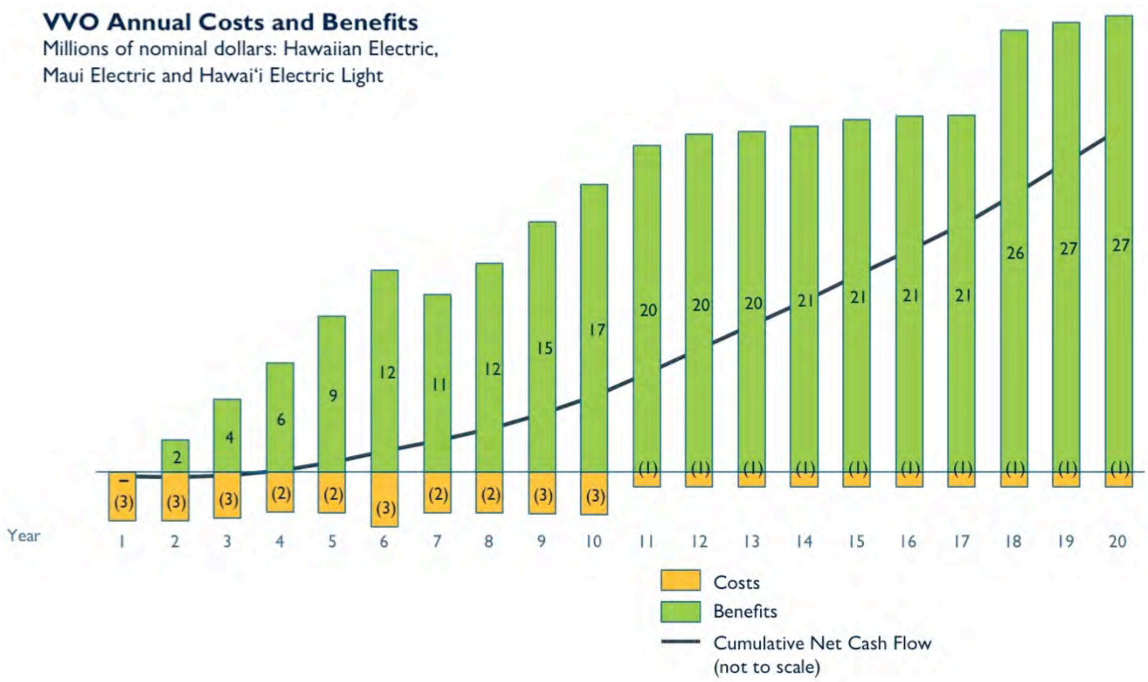


Figure 43: Volt/VAR Optimization Costs and Benefits: Hawai'i Electric Light

Volt/VAR Optimization Annual Cash Flows



Year 1 is assumed to be 2016.

Figure 44: Volt/VAR Optimization Annual Cash Flows

Volt/VAR Optimization Cost and Benefit Assumptions

The VVO business case assumes and 80% penetration across residential and commercial customers with a 10-year implementation period.

Drivers	Approach and Assumptions
Costs	
Software	Assumes VVO software includes: ♦ Initial device license and annual maintenance. ♦ Standard server license and annual maintenance. ♦ Power Monitor software SaaS for years 1–5 and licensed for years 6–20.
Services	♦ System integration between VVO software and SICAM. ♦ Silver Spring Networks professional services across the total implementation period.
Grid Hardware	♦ VVO is implemented over a 10-year period. ♦ Communications hardware includes Beckwith upgrades, Shark meter, and SCADA communications. ♦ Costs for switchgear upgrades are included as part of regular capital upgrades. Hawaiian Electric communications hardware upgrades assumes: ♦ Beckwith and Shark Meter upgrades are needed if a transformer is between 5 and 25 years old regardless of whether the substation has SCADA. ♦ Only communications are needed if there is no SCADA and the transformer is 5 years old or less. ♦ No upgrades are needed if the transformer is less than 5 years old and has SCADA. ♦ If a substation received a switchgear upgrade, a Beckwith upgrade would be required but the substation would not require a Shark Meter (assumes Shark Meter was part of the switchgear replacement). Maui Electric communications hardware upgrades assumes: ♦ Chose 12kV circuits for VVO that had the following: an existing load tap changer and not used for pumping or used as a spare. Also, circuits that did not have a low-voltage rating of 4.16 / 24 / 22 or already had SCADA were not considered candidates for VVO. ♦ Assumes all eligible VVO circuits will require a Beckwith upgrade and Shark Meter. Hawai'i Electric Light communications hardware upgrades assumes high-level estimate based on the per customer upgrade costs of Maui Electric.
Benefits	
VVO	♦ 2% reduction in energy delivered (where implemented) across 80% of residential and commercial customers (residential and commercial customers represent approximately 75% of total energy usage). ♦ Based on results from other utility implementations at American Electric Power Ohio, Dominion, and Xcel Energy. ♦ Financial benefits of reduced energy delivered based on current and forecasted marginal cost of electricity.

Table 15: Volt/VAR Optimization Cost and Benefit Assumptions

DISTRIBUTION AUTOMATION COSTS AND BENEFITS

See Table 6 (page 91) for a summary of the costs and benefits for Distribution Automation.

Distribution Automation Benefit Benchmarks

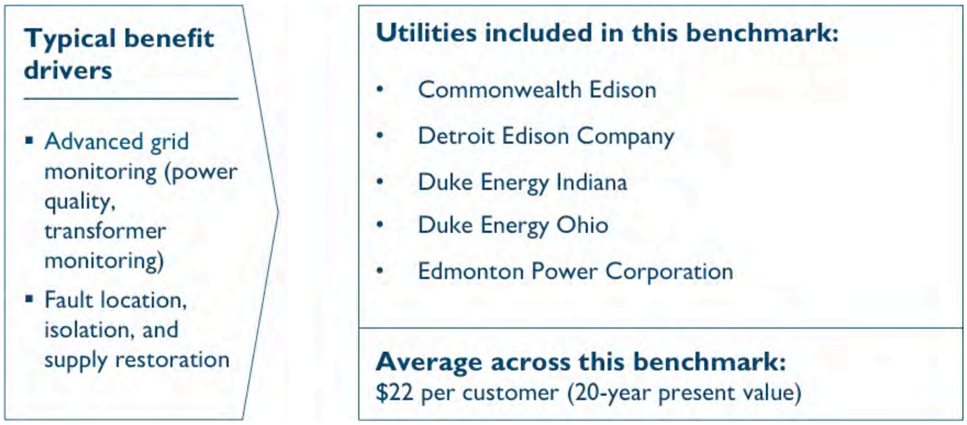


Figure 45: Distribution Automation Benefit Benchmarks[34]

Distribution Automation Cost Benchmarks

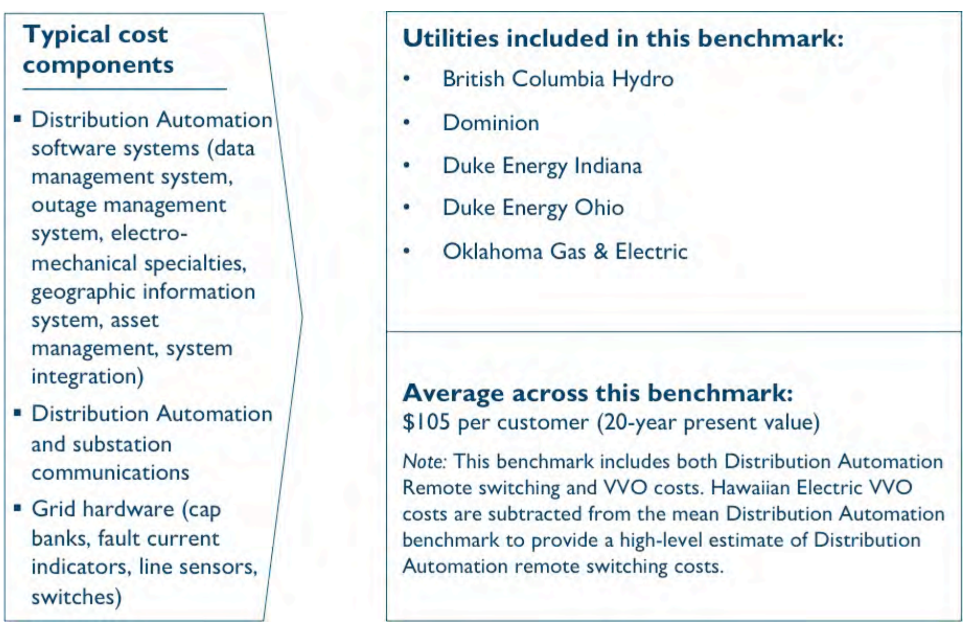


Figure 46: Distribution Automation Cost Benchmarks[35]

[34] Based on publicly available North American Smart Grid business and rate cases, and includes Silver Spring Networks' internal estimates.

[35] *Ibid.*

DEMAND RESPONSE COSTS AND BENEFITS

See Table 6 (page 91) for a summary of the costs and benefits for Demand Response.

Demand Response Cost Benchmarks

Typical cost components

- Home and business area networks enablement
- System integration
- Interval billing systems
- Demand Response software
- Project and program management
- Call center and customer support

Utilities included in this benchmark:

- Baltimore Gas & Electric
- Central Vermont Public Service
- Connecticut Light & Power
- Consumers Energy
- Duke Energy Ohio
- Duke Energy Indiana
- Pacific Gas & Electric
- Potomac Electric Power Company
- Oklahoma Gas & Electric
- Southern California Edison

Average across this benchmark:
$30 per customer (20-year present value)

Figure 47: Demand Response Cost Benchmarks[36]

Demand Response Direct Load Control Benefit Benchmarks

Typical benefit drivers

- Reduced peak demand from utility controlled demand response devices (programmable communicating thermostats, load control switches)
- Avoided transmission and distribution and capacity costs

Utilities included in this benchmark:

- Consumers Energy
- Pacific Gas & Electric
- Potomac Electric Power Company
- Southern California Edison

Average across this benchmark:
$60 per customer (20-year present value)

Figure 48: Demand Response Direct Load Control Benefit Benchmarks[37]

[36] *Ibid.*

[37] *Ibid.*

Demand Response Dynamic Pricing Benefit Benchmarks

Typical benefit drivers

- Reduced peak load and demand due to pricing signals (critical peak pricing, time-of-use, real-time pricing) sent to customers
- Creates incentives for energy conservation during peak demand times

Utilities included in this benchmark:

- British Columbia Hydro
- Baltimore Gas & Electric
- Central Vermont Public Service
- Connecticut Light & Power
- Consumers Energy
- Pacific Gas & Electric
- Potomac Electric Power Company
- Southern California Edison

Average across this benchmark:
$72 per customer (20-year present value)

Note: This benchmark average excludes Baltimore Gas and Electric; including Baltimore Gas and Electric creates a benchmark of $137 per customer.

Figure 49: Demand Response Dynamic Pricing Benefit Benchmarks[38]

[38] *Ibid.*

A. Definitions

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

Advanced Metering Infrastructure (AMI): The hardware and software, together with the telecommunications services, that enables automated meter reading and other capabilities.

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

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. The Company provides payments as an incentive to participate in Demand Response programs.

Demand Response Management System (DRMS): An application that optimizes Demand Response programs offered by an electrical utility. This application 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 application also accurately measures and verifies load shed events.

Direct Load Control (DLC): A Demand Response program in the Demand-Side Management[39] category. DLC 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.

Distribution Automation (DA): An application that quickly detects and isolates outages and service interruptions, thus enabling restoration crews to efficiently restore power.

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.

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.

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.

---

[39] Demand-Side Management (DSM) refers to the planning, implementation and monitoring of activities designed to encourage consumers to modify patterns of electricity usage, including the timing and level of electricity demand. Please see the definition in Appendix A of Docket No 2012-0036 (the Hawaiian Electric Companies' 2013 Integrated Resource Planning Report).

Full Implementation: The Hawaiian Electric Companies' plan to install the smart grid to electricity customers across the five island, O'ahu, Maui, Lana'i, Moloka'i, and Hawai'i Island, including but not limited to applications such as AMI, Customer Energy Portal, Prepay, VVO, DA, and Demand Response over a period of time.

Initial Phase: 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 initial phase will allow 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 the Companies' Full Implementation phase.

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.

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 Silver Spring Networks software application that manages outage-related messages from electricity meters, including "last gasp" and power restore messages.

Outage Management System (OMS): A computer aided system that allows an electrical utility to receive customer calls or indications from the SCADA system to manage and restore electrical outages.

Prepay: An application 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).

Silver Spring Networks: An industry leader in smart grid technology, who for more than a decade, has implemented their smart grid mesh technology that currently serves over 17 million homes and businesses for more than 30 utilities.

SmartHours Dynamic Pricing: A Demand Response program offered by Oklahoma Gas & Electric to its customers. SmartHours gives customers advance notice of the next day's peak price so that they can then use this information to better manage their energy use.

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.

UtilityIQ: A software software suite from Silver Spring Networks that includes utility applications 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 (UIQ AMM), 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 (UIQ DO) 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 application 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): The Hawaiian Electric Companies' 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 Companies' enterprise back-office systems (such as Customer Information Systems (CIS), Energy Management Systems (EMS), and Geographic Information Systems (GIS)) reside. The WAN is a dispersed telecommunications network (in contrast to a LAN or NAN which are localized networks) and often includes public networks.