Smart Grid Strategy and Roadmap

March 2016 Update

Forward

In 2014, the Hawaiian Electric Companies[1] filed a *Smart Grid Roadmap and Business Case* with the Commission,[2] proposing to implement Smart Grid at all three of our operating utilities, on the five islands we serve. As noted in the *Commission's Inclinations*,[3] ". . . the Commission believes Hawaii should be poised to lead the world in the development of advanced grids. . . ." Our Smart Grid will help modernize our power grids, enable integration of more renewable energy, reduce outage times, increase the efficiency of our operations, reduce costs, further public policy goals and deliver benefits to our customers. This *Smart Grid Strategy and Roadmap* ("Smart Grid Plan") supersedes that prior filing, and provides a framework to more comprehensively "connect the dots" between the many components, projects and associated Commission applications needed to execute our Smart Grid vision by investing in new technologies to deliver the benefits of a smart grid to customers.

The evolution of Smart Grid technology is driving unprecedented changes in the energy industry in general and Hawai'i in particular. Implementing a Smart Grid efficiently and cost-effectively is a challenging endeavor. Smart Grid brings major changes for the Companies, our customers and the State of Hawai'i. Our plan reflects our understanding of the complexity of this undertaking and our efforts to lead the way on energy produced from natural resources such as solar, wind and hydropower, which are constantly replenished. This Smart Grid plan is considered to be a "living document" that will be updated periodically in accordance with the Companies' Smart Grid vision, increasingly refined assumptions, applicable technology improvements and the constantly evolving needs and wants of our customers, including reliability, affordability, safety and peace of mind.

This document is specifically intended to provide our policymakers, third-party partners and technology suppliers a more detailed understanding of the Hawaiian Electric Companies' Smart Grid vision, strategy, roadmap and related projects. Collectively, these initiatives represent one of the largest coordinated efforts we have ever undertaken. Throughout its progressive implementation, Smart Grid will play an increasingly pivotal role in Hawai'i's energy future, and the Companies look forward to working with the Commission, the Consumer Advocate and other stakeholders to make Hawai'i's Smart Grid a leading model within the industry, while demonstrating how it will benefit customers, enable more renewable energy and improve customer service.

[1] Hawaiian Electric, Maui Electric and Hawai'i Electric Light are collectively referred to herein as the "Hawaiian Electric Companies" or "Companies."

[2] Filed March 17, 2014 in Docket 2008-0303.

[3] See pages 10-11 of *Appendix A: Commission's Inclinations on the Future of Hawaii's Electric Utilities* to Decision and Order No. 32052, filed April 28, 2014 in Docket No. 2012-0036, referred to herein as the "Commission's Inclinations."

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SMART GRID STRATEGY AND ROADMAP OVERVIEW

Smart Grid is a key component of the Hawaiian Electric Companies' business strategy and ongoing transformation into a next generation energy company that is committed to improving the way energy is delivered using new technologies that benefit customers. Our Smart Grid is defined as the integration and application of real-time monitoring, advanced sensing, communications, analytics and control that enable the dynamic flow of both energy and information to accommodate existing and new forms of energy supply, delivery and use in a secure, reliable and efficient electric power system from generation source to customers.[1]

Our Smart Grid vision is to provide an increasingly intelligent and automated electric system that utilizes technology advancements to leverage capabilities in telecommunications, computing, sensing and controls for transmission and distribution to all service locations via a multi-direction flow of energy and information. Smart Grid will enable our customers and us to control and make more informed and timely energy decisions. We will utilize these technology advancements to better meet customers' expectations, the State's energy policy objectives, communities' energy demands, and our overarching responsibility to provide safe, reliable and secure electric service. Smart Grid will modernize our power grids, enabling a more seamless integration of renewable energy, increasing reliability and efficiency, protecting the environment, lowering costs, and providing customers with greater visibility of their energy usage, as well as more options for energy choices.

The value proposition for a Smart Grid is unique in that many of its related benefits – such as lower dependence on imported fuel, lower greenhouse gas ("GHG") emissions and increased clean energy economic growth – are community based, complex and/or difficult to readily quantify. There are also hard benefits that are not only quantifiable but also realized as a result of implementing our Smart Grid strategy. Hence, we present an overarching compelling case that appeals not only to those who desire direct benefits but also for those who desire to improve our community and environment. As a result, the strategy for realizing our Smart Grid vision is focused on five strategic themes: (A) customer empowerment; (B) distributed energy resource ("DER") integration[2]; (C) power grid efficiency, reliability and resiliency; (D) safety and workforce efficiency; and (E) innovation, information and connectivity. These themes will be supported by one or more of the projects presented herein; and conversely, some of our Smart Grid-related projects will support multiple Smart Grid strategic themes.

Building a Smart Grid in Hawai'i will not be accomplished in a single project effort, but will evolve over time, growing and layering capabilities and functionality that increasingly deliver incremental value to customers. The need for such an iterative and phased approach adds further complexity to the Smart Grid value proposition, as each additional component that is

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[1] As defined by the North American Electric Reliability Corporation ("NERC") Smart Grid Task Force ("SGTF") report: *Reliability Considerations from the Integration of Smart Grid*, dated December 2010, Executive Summary, available at http://www.nerc.com/files/SGTF Report Final posted vl.l.pdf.

[2] DER includes distributed generation ("DG"), distributed storage, demand response ("DR"), energy efficiency and electric vehicles ("EV"s).

layered over the foundational platform leverages existing capabilities, thereby increasing the value of the infrastructure (including renewable energy infrastructure such as customer-sited DG) already in place. When viewed in isolation, some Smart Grid-related projects may not have a positive business case.

However, when taken in their entirety, the overall bundle of benefits and capabilities enabled by Smart Grid supports an overall estimated positive business case that will increase flexible capabilities and lower costs in the long run. The estimated benefit-to-cost ratio of the Smart Grid to our customers is approximately 1.4. Over the next twenty years, the Companies estimate that Smart Grid will result in \$221-\$271 million in benefits net of costs (net present value) to customers or between \$418 and \$511 per customer over the same period.

In the near term, the platform upon which we will build our Smart Grid begins with the base installations planned through the Smart Grid Foundation Project ("SGF Project"), which has already been guided by the results of various pilot projects, peer energy company lessons learned, our strategic partnership with Silver Springs Networks, Inc. ("SSNI") and our Smart Grid Initial Phase demonstration project ("Initial Phase") on O'ahu with approximately 5,047 customers. Other Smart Grid-related near-term initiatives that further build upon this base include the Companies':

- DER Aggregator Contracts;
- Demand Response ("DR") Program Portfolio;
- DR Management System ("DRMS") Project;
- EV Time-of-use Rate Schedules;
- DER Time-of-use Rate Schedules;
- Real-Time Pricing ("RTP") Tariff;
- Distribution Automation ("DA") Project;
- DER Phase 1; and
- DER Phase 2.

Over the longer-term, our Smart Grid efforts will transition from the current "Base Stage" of implementing the foundation into an "Enhancement Stage." In the Enhancement Stage, innovations and new capabilities will be identified, evaluated and layered upon our then-existing Smart Grid infrastructure utilizing our maturing process methodology to address this ever-changing landscape. We will continue to embrace our role as an enabler of clean energy from sources that help reduce our environmental impact and trusted energy advisor for the State and people of Hawai'i.

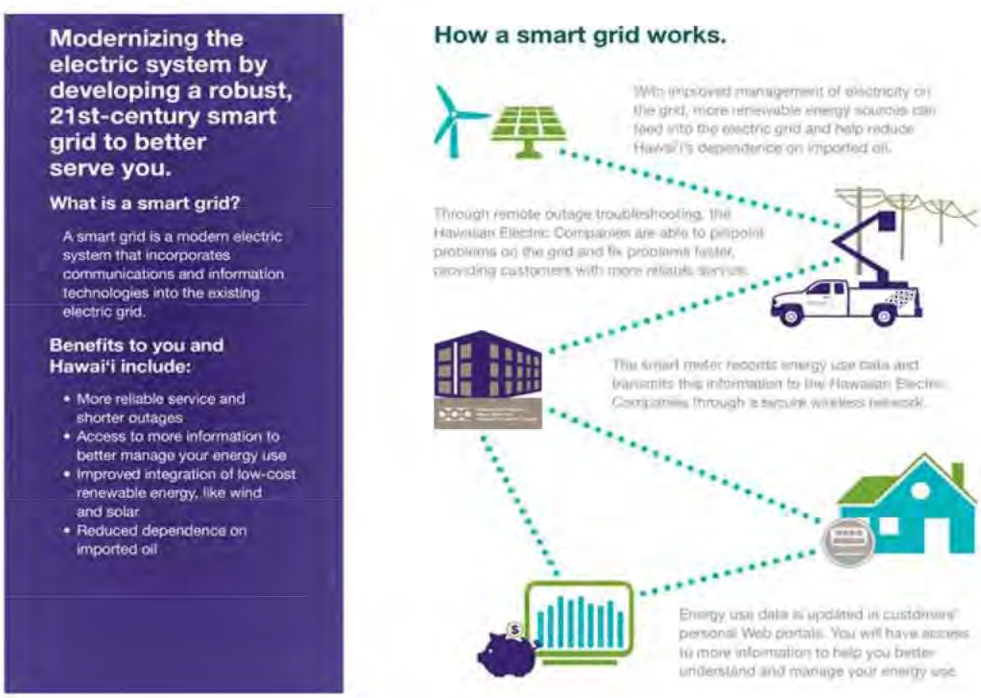
I. What is a Smart Grid? How does it work? Why do we need it?

The energy industry as a whole is faced with many challenges in a world where our energy future is changing. There are many key issues that need to be addressed – including worldwide climate change, energy independence and infrastructure security. These overall high-level challenges are similar for us here in Hawai'i. In fact, we lead the nation in certain areas of small localized energy generating resources, which means that we must modernize our power grid to accommodate more integration of renewables and provide greater flexibility to manage DG from variable energy sources that can only produce power under certain conditions. A key attribute of a next generation energy company is the ability for customers to have more options and control over their energy use and/or generation. By building a smarter energy infrastructure, a safe, secure and economically feasible Smart Grid can increase our ability to address these rapidly changing needs.

So what exactly is a Smart Grid? A Smart Grid is a more dynamic and secure power grid that gives customers more control, greater flexibility and more choices while also responding to outages more quickly, seamlessly connecting to clean energy sources and securing the grid from attacks. This adds increased levels of information exchange and visibility, and possibilities for greater control at the transmission and distribution levels, focusing on how, when and where energy is generated and used. Information is gathered through a multi-directional digital communications network that is added to the existing power grid infrastructure – the wires, poles and substations. Some of this equipment is upgraded to better handle the changing flow and nature of energy on the power grid while other equipment, such as "smart meters," "advanced inverters," and/or "smart storage" are added to increase visibility and understanding of energy production and use, and provide more efficient, effective and reliable control of the modernized power grid. All of these enhancements increase the "intelligence" of information on the grid, and increase our ability to respond to changing conditions.

So how exactly does a Smart Grid work? Figure 1 below provides a high-level overview of how our Smart Grid will work. The base premise is that there will be a network of networks that connect up many smart devices located at the transmission and distribution levels, and ultimately at each customer's premises. This connectivity provides the ability to exchange information and provide controls to optimize the flow and use of energy.

Figure 1 - How Smart Grid Works



So why do we need a Smart Grid? A Smart Grid will provide the technological foundation needed to address Hawai'i's, unique energy challenges. Due to the physical nature of our State – isolated in the middle of the Pacific Ocean and separated by islands with unique topography – we are challenged with a relatively high cost of energy because electric power cannot currently be transmitted among neighboring islands or from surrounding systems as is done on most of the U.S. mainland. This geographic isolation makes balancing supply and demand more difficult, since we cannot rely on neighboring utilities to help address short-term imbalances or take advantage of regional differences in energy markets to help reduce costs to customers.

Our State's physical location, however, does enable us to be a leader in renewable energy. At the end of 2015, 23% of our customers' energy needs were met by renewable resources – more than twice the percentage of just five years ago and well on the way to achieving Hawai'i's 2045 renewable portfolio standards ("RPS") goal of 100%.[3] Much of that renewable energy is from variable resources (i.e., distributed solar photovoltaics ("PV"), wind and run of the river hydroelectric). In fact by the end of 2015, more than 14% of our residential customers were generate a majority of the electric energy providing power for their individual homes from their private rooftop PV systems. This renewable generation benefits both our customers and the environment. At the same time, this accomplishment presents challenges in system resiliency, reliability, safety and efficiency: Solar and wind renewable generation are variable and there is lack of visibility and control over distributed PV (e.g., actual PV generation information is not shared with the utility); and customer-generated solar energy, for the most part, is not efficiently distributed around the entire distribution network.

A Smart Grid is needed to help manage these complexities. The evolution of Smart Grid technologies is paving the way for new products and services that will help customers manage their energy use while providing the utility with the necessary information and control to ensure on-going service quality and reliability. Smart Grid technologies also enable greater visibility by grid operators and customers into how the power grid is functioning. Grid operators can better see how customers or groups of customers are interacting with the grid. With increased roof-top PV and growth in EVs, customers are becoming "prosumers" – i.e., both producers of energy being placed onto the power grid as well as consumers of energy being taken from the grid. The deployment of smart devices will modernize the power grid by enabling multi-directional data interchange and control between field, back office and customer devices. Timely and actionable information will allow grid operators to better monitor local power grid conditions to improve reliability and operational efficiencies such as circuit voltage optimization that will flow through to ultimately lower customer bills. These capabilities will lower costs, expand customer choices, increase reliability and optimize integration of DER.

Over the past decade, the concept of a "smarter grid" has been identified in numerous federal, state and regulatory forums as being a critical capability and the foundational functionality necessary to achieve energy policy goals and objectives. For example, the Energy

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[3] See *The Hawaiian Electric Companies' 2009 Corporate Sustainability Report*, page 6, and the Hawaiian Electric Companies' news release dated March 3, 2016 titled, *"Hawaiian Electric Companies report record high renewable energy use."*

Policy Act of 2005 identified Smart Grid as a foundational capability necessary to support energy efficiency goals.[4] Additionally, Title XIII of the Energy Independence and Security Act of 2007 identified the specific capabilities the power grid must demonstrate in order to achieve the federal policy goals of modernizing the U.S. power grid. This is intended to make improved digital information available to customers to empower customer choice, facilitate the integration of renewable DER, improve grid reliability and resiliency, and support the integration of EVs.[5]

In Act 109 of 2014, the Hawai‘i Legislature also identified the need for grid modernization, and in turn, directed the Commission to consider grid modernization in its planning and evaluate the potential of smart technologies to mitigate technical barriers of integrating large amounts of DG.[6] Integration of DER, along with cost-effective, utility-scale renewable generation from wind and solar, will be required in order to achieve Hawai‘i's RPS goal of 100% by 2045,[7] as well as support Hawai‘i's GHG reduction objectives.[8]

The Commission's Inclinations, the Commission further articulated its perspective on the vision, business strategies and regulatory policy changes needed to best serve Hawai‘i's energy consumers, including specific guidance on strategies, planning and projects to create a modern transmission and distribution network.[9] Collectively, these energy policies have guided the development of our Smart Grid vision.

II. Our Smart Grid Vision

The Hawaiian Electric Companies' Smart Grid vision is to enable our customers and us to control and make more informed and timely energy decisions by providing an increasingly intelligent and automated electric system that utilizes technology advancements to leverage capabilities in telecommunications, computing, sensing and controls for transmission and distribution to all service locations via a multi-direction flow of energy and information.

Our Smart Grid vision is a key component of our business strategy and plans. It directly supports our efforts to transform our Companies into a next generation energy company.[10] The Companies' strategy for developing and deploying a Smart Grid uses a phased and iterative approach, recognizing that core infrastructure and basic functionality must be put in place first (i.e., Base Stage). Moreover, the Companies recognize that power grid modernization is a complex, network-centric process and will need to be accomplished not only in stages over time but also in conjunction with other initiatives we are undertaking to transform all aspects of electric service.

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[4] Title II, Section 921; Title XII, Section 1251-1252, Energy Policy Act of 2005.
[5] Title XIII-Smart Grid, Section 1301, Energy Independence and Security Act of 2007.
[6] Act 109, 2014 Haw. Sess. L. ("Act 109").
[7] See HRS § 269-91.
[8] See Act 234, 2007 Haw. Sess. L., Greenhouse Gas Emissions Reductions.
[9] See generally the Commission's Inclinations.
[10] See Hawaiian Electric's 2015-2020 Strategic Transformation Plan, filed as Attachment 1 to the response to CA-IR-376 in Docket No. 2015-0022. Also summarized and referenced in Applicant's Exhibit-65, pages 5-8.

While our Smart Grid vision and development strategy support ambitious federal and State policy objectives, we also recognize that building a Smart Grid is a process of evolution in addition to implementation. Some of the technologies needed to realize our vision are still in the early stages of development. While many show great promise, more investigation and evaluation is required to ensure that the desired results can be reliably and cost-effectively achieved. In order to address this ever-changing landscape of innovation, we have put in place a continuous process for the identification and evaluation of technologies that will help us develop and deploy our Smart Grid over the next 20 years. As a result, our Smart Grid will be developed and deployed through a number of related yet separate initiatives and projects over this timeframe. The first implementation of projects in the near term (e.g., the Initial Phase, DRMS, DER policy framework, and the SGF Project) are part of the Base Stage and is foundational to the success of the subsequent projects/initiatives.

Our Smart Grid vision and strategy includes deploying technologies that provide high customer value. This vision and strategy also includes identifying and evaluating "best-fit/least cost" technologies that provide solutions to achieve policy objectives that may not immediately, or on a stand-alone basis, have positive business cases, but deliver community benefits nonetheless.[11]

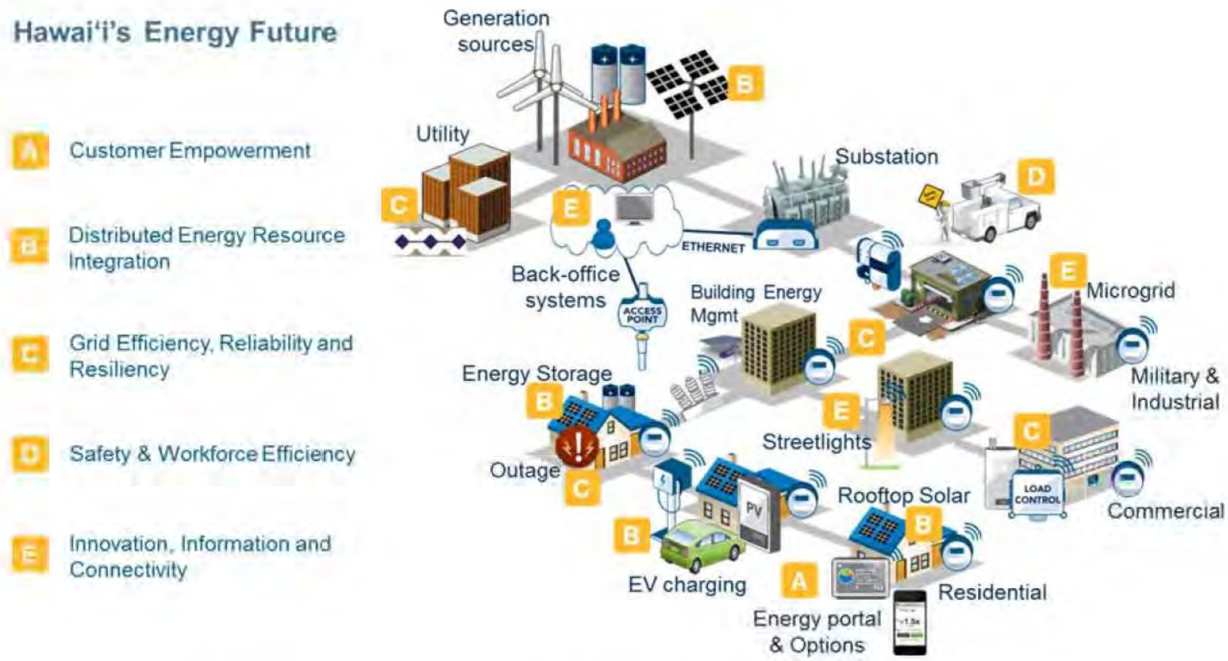
III. Key Strategic Themes to Accomplish our Smart Grid Vision

Our Smart Grid vision is focused on obtaining and implementing specific Smart Grid solutions that provide the capabilities defined within the following five key strategic themes: (A) customer empowerment; (B) DER integration; (C) power grid efficiency, reliability and resiliency; (D) safety and workforce efficiency; and (E) innovation, information and connectivity.

Figure 2 below provides a high-level view of a modern and fully integrated Smart Grid and its associated key strategic themes. It illustrates the role of our Smart Grid in enabling Hawai'i's energy future.

[11] In Decision 07-04-043, the California Public Utilities Commission discussed the consideration of "non-quantifiable" or "difficult to quantify" benefits in connection with San Diego Gas & Electric's advanced metering infrastructure ("AMI") application. See id., pages 21-22, 70-71.

Figure 2 - Smart Grid Strategic Themes for Hawaii's Energy Future



This section provides details about the specific capabilities and example deliverables within each strategic theme. Additionally, in Section VI, our Smart Grid near-term roadmap is laid out by strategic theme and its corresponding timeframes.

A. Customer Empowerment

The "Customer Empowerment" strategic theme encompasses key capabilities that will enable our customers to be aware of relevant energy conditions, and to participate in, monitor and control their energy usage/generation while reducing their carbon footprint and energy costs. This is also a key component of our Companies' overall strategic vision.[12] In order to accomplish this, the following capabilities are required:

- Timely access to and use of energy information: Provide access to energy information that encourages customers to understand their usage/generation, participate in programs that lower their energy costs and provide suggestions on what they could do to optimize their energy use;

- Timely access and feedback to power grid conditions: Develop capabilities that provide customers with access to near-real-time information that promotes customer situational awareness about relevant power grid conditions and outages (e.g., automated outage visibility by meter pings, estimated restoration times, potential mobile customer reporting of issues);

[12] The Hawaiian Electric Companies' vision statement is, "Empowering our customers and communities with affordable, reliable, clean energy."

- Multiple viable customer options: Implement technologies that increase power grid agility and enable increased offerings of relevant customer products and services (e.g., DR programs, community solar, EV charging stations to applicable customer segments); and

- Customer advocacy and trust: Establish trust with our customers through greater transparency of energy information, and be an advocate of our customers' interests as they relate to developing cost-effective and interoperable smart consumer technology solutions and services by promoting Smart Grid standards development and market adoption that drives competition and reduces costs for our customers.

B. Distributed Energy Resource Integration

The DER Integration strategic theme encompasses key capabilities that will increase and improve integration and interconnection services that facilitate the use of fair and affordable DER while maintaining grid stability, reliability, efficiency and safety. In order to accomplish this, the following capabilities are required:

- Collaborative DER policy framework development and institutionalization: Work collaboratively with stakeholders and the Commission in order to set the appropriate policy framework that fairly and affordably increases integration of DER;

- Timely access to and use of granular distribution and service location grid information: Increase information granularity and visibility of distributed energy in order to support hosting capacity analysis and transmission and distribution planning;

- Responsive power quality mitigation: Investigate and deploy appropriate energy storage solutions that support the integration of variable renewable energy resources that mitigate power quality issues while providing power grid support (e.g., frequency regulation);

- Capture and harness excess energy generation: Investigate and deploy appropriate energy storage solutions that support the efficient integration of variable renewable energy resources by storing excess generation for economic use at a future time;

- Real-time visibility and control of DER: Investigate and deploy a system that allows for the real-time visibility and control of DER (e.g., customer, energy company and/or aggregator); and

- Electrify transportation: Implement technologies that promote the electrification of transportation as a good source of DER via the use of potential virtual power plants.[13]

[13] See, e.g., A. Zuborg. *Unlocking Customer Value: The Virtual Power Plant,* Power World 2010,ABB/Ventyx, available at http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/ABB_Attachment.pdf.

C. Grid Efficiency, Reliability and Resiliency

The strategic theme for "Grid Efficiency, Reliability and Resiliency" encompasses key capabilities that will improve and optimize the performance, reliability, power quality and operational efficiency of the power grid. The following capabilities are required to accomplish this:

- Real-time visibility and utility control of grid assets: Implement automation at multiple layers of the power grid to increase visibility, utility control and performance of grid assets;
- Proactive and timely grid data analysis and modelling: Provide granular data analytics that support proactive modelling and understanding of the various factors that must be considered to make prudent investments in the power grid that meet customers' future energy needs;
- Real-time visibility to manage and control voltages at a granular level: Implement technologies that provide the capability to reduce line losses and increase power grid capacity and efficiency;
- Self-healing/autonomous grid controls: Increase power grid reliability by adopting and expanding smart technologies that can predict/prevent/reduce outages and align with appropriate North American Electric Reliability Corporation ("NERC") standards;[14] and
- Automated and enhanced grid resiliency: Implement security and outage management measures that improve power grid resiliency, protect against cyberattacks and can withstand natural disasters.

D. Safety and Workforce Efficiency

The "Safety and Workforce Efficiency" strategic theme encompasses key capabilities that will improve customer and employee safety, as well as workforce efficiency in the changing environment of a next generation energy company. Accomplishing this requires the following capabilities:

- Fully automate manual processes: Increase workforce safety by automating manual tasks and/or confirmation of no back feed of power on a line. Employ automation so that staff need not be exposed to electrical hazards;

[14] NERC (the North American Electric Reliability Corporation) is a not-for-profit international regulatory authority whose mission is to assure the reliability of the bulk power system in North America. NERC develops and enforces Reliability Standards; annually assesses seasonal and long-term reliability; monitors the bulk power system through system awareness; and educates, trains and certifies industry personnel. NERC's area of responsibility spans the continental U.S., Canada, and the northern portion of Baja California, Mexico. NERC is the electric reliability organization for North America, subject to oversight by the Federal Energy Regulatory Commission (FERC) and governmental authorities in Canada. NERC's jurisdiction includes users, owners and operators of the bulk power system, which serves more than 334 million people. Hawaiian Electric is not required to comply with NERC, but where applicable it is referenced as a utility best practice.

- Smart process automation: Increase safety by reducing and mitigating opportunities for operating errors via automated process steps and the use of smarter tools; and
- Re-focus workforce resources on critical tasks: Increase workforce productivity via the use of remote control and auto-sensing devices that can automate recurring processes and allow skilled workforce resources to focus on critical and complex tasks that require manual intervention.

E. Innovation, Information and Connectivity

The strategy for "Innovation, Information and Connectivity" encompasses key capabilities that will provide secure innovative information and communications environments to support flexible, scalable, and efficient multi-directional data and information exchange across the power grid. This theme requires the following capabilities:

- Innovative, robust and flexible Smart Grid architecture: Evaluate, promote and adopt a flexible, cost-effective and unified Smart Grid architecture that enables efficient information exchange, and innovation and technology improvements over time;
- Relevant, cost-effective and timely innovation: Partner, develop, implement and maintain highly reliable information systems and smart technologies that meet the future needs of a Smart Grid that supports market demand and prosumer choice;
- Timely massive data processing and analysis: Implement scalable "big data" warehousing and analytic solutions that promote efficient processing and storage of data to enable timely access to information for planning, modelling and simulations;
- Secured, interconnected and efficient network communications: Develop and implement telecommunications that provide connectivity across the power grid and enable the operation of an interconnected and integrated network of networks for transmission, sub-station, field and customer communications; and
- Data privacy resiliency: Heightened capabilities to protect and automatically respond to data privacy threats.

IV. Our Smart Grid Value Proposition

A key objective of our Smart Grid strategy is to modernize the energy company via the use of cost-effective technologies that provide significant customer value, while at the same time supporting policy objectives that potentially may not have immediate direct customer value, but may provide broader benefits to customers and society as a whole over time. It is important to note that traditional cost/benefit models will not be able to account for the total value derived from many Smart Grid investments because portions of the benefits are societal in nature – which includes addressing State priorities such as the 100% RPS mandate.

As indicated by the U.S. Department of Energy ("DOE") National Energy Technology Laboratory ("NETL"), benefits such as lower dependence on imported fuel, lower GHG emissions and increased clean energy economic growth are complex and often difficult to quantify. In addition, certain aspects of these benefits may not directly accrue to customers but rather to our broader community as a whole. However, when considered in their entirety, the overall bundle of benefits and capabilities enabled by Smart Grid supports a positive business case that will help to lower costs in the long run for all beneficiaries.[15] As additional projects and initiatives are developed, the Companies will continue to provide transparency into each application's business case.

With this in mind, our Smart Grid value proposition is presented as a portfolio of investments for modernizing grid capabilities, building upon each other over time. The overall Smart Grid benefits are broken down into three general categories: (1) direct customer benefits; (2) indirect customer benefits via operational improvements;[16] and (3) community benefits. Table 1 below provides a further breakdown of these benefit categories, along with examples of how the benefits will be achieved and what specific solution when implemented will deliver such benefits. Detailed descriptions and definitions for each solution are provided in Appendix A. The overall Smart Grid business case and cost per customer is also presented by solution below.

Table 1 - Smart Grid Benefit Categories

Direct Customer Benefits	Example Customer Benefits	Solution
Increase the value and relevance of electric products and services	• Enhance customer communications, data transparency and privacy, increase additional relevant products and services, and the speed/quality of existing electric services. This will help increase customer satisfaction and foster greater trust.	• CFS • AMI • CPO • DA • DR
Increase customer options	• Make available distributed energy options in generation and storage. This will help customers to maximize their energy investments (e.g., rooftop PV, EV).	• AMI • DER • DR
Reduce customer losses and improve reliability	• Avoid or reduce electric service disruptions that cause loss of revenue and inconvenience to customers.	• DA • AMI

[15] The DOE NETL published their study DOE/NETL-2010/1413, "Understanding the Benefits of the Smart Grid" on June 18, 2010. That publication explicitly outlines the fact that residential and commercial customer benefit-cost cases are not compelling and that they are only compelling when societal/community benefits are also considered. The benefits for Smart Grid are only positive when its value proposition is viewed from this overall perspective to unite all beneficiaries.

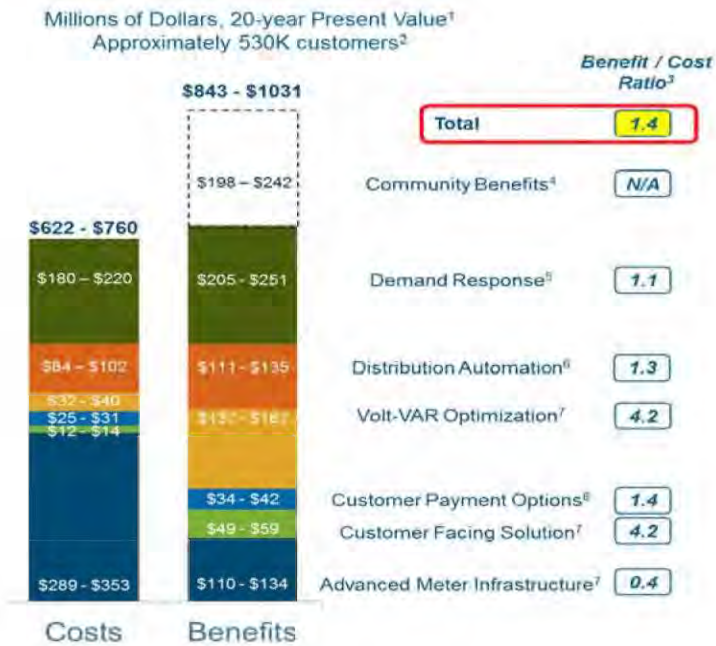
[16] The indirect customer benefits are also referred to as "Operational Benefits".

Lower customer bills	• Lower fuel consumption by optimizing voltage. • Ability to self-supply or grid supply customer-sited generation. • Ability to adjust energy usage through greater visibility and participation in cost-saving programs.	• VVO • DER • DR
Indirect Customer Benefits	**Example Operational Benefits**	**Solution**
Increase workforce safety and productivity	• Implement intelligent assets that reduce operational liability and improve efficiencies.	• DA
Avoid, reduce or defer capital investments	• Increase capacity utilization, enhance asset life and introduce new technologies that may replace the need for net new generating capacity.	• DER • DR
Reduce operating expenses and avoid revenue losses	• Restructure workforce by retiring old positions (e.g., meter readers) and by introducing more efficient processes that lower operating costs with automation. • Increase revenue protection capabilities that help reduce theft.	• AMI • DA
Reduce costly peak demand	• Introduce load shifting capabilities in order to balance variable (or as-available) generation with energy resources that can consistently generate reliable energy 24 hours a day.	• DR • AMI
Community Benefits	**Example Community Benefits**	**Solution**
Reduce carbon / GHG emissions	• Enable the integration of more renewable energy resources, making the generation of power cleaner and more efficient. • Increase energy efficiency, resulting in less fossil fuel generation and reducing our carbon footprint.	*All Smart Grid solutions provide community benefits
Promote energy independence	• Supporting our nation's and State's goal to reduce dependence on imported fuel by facilitating the increase in local renewable energy generation and electrification of transportation. This will help reduce geopolitical and economic risks.	
Promote clean energy economic growth	• Supporting our State's clean energy initiative for economic and associated job growth.	

Many of the Smart Grid solutions provide benefits to more than one benefit category; therefore, the overall Smart Grid business case is presented as costs and benefits by Smart Grid solution. Figure 3 below shows the overall projected Smart Grid costs and benefits. Our overall estimates as of the end of 2015 for the Smart Grid total costs (20-year present value) for all three service utilities is $622-$760 million ($1173-$1434 per customer) delivering $843-$1031 million ($1591-$1,945 per customer) in benefits. This results in an average overall benefit-to-cost ratio

("BCR") of 1.4. Aggregating these amounts, the Hawaiian Electric Companies estimate that Smart Grid will result in $221-$271 million in benefits net of costs (net present value) over the next 20 years, or between $418-$511 per customer in benefits net of costs (net present value) over the next 20 years.

Figure 3 - Overall Smart Grid Business Case



<u>Notes</u>:

1 Present value is calculated using a discount rate of approximately 8.1%.
2 Estimated customer counts are based upon the projected 20-year forecast.
3 Benefit/cost ratios are based on the midpoint amounts of the associated ranges.
4 Community benefits are estimated at a very high level primarily based on the estimated energy savings of each solution translated into CO_2 emissions reduction and a very small potential local economic growth in wage/salary jobs driven by the Smart Grid investments.[17]
5 DR benefits and costs are based on the recent DR Portfolio application filed on December 30, 2015 in Docket No. 2015-0412.
6 DA benefits include "value of service" benefits modeled as approximately $1.18/customer/minute at 15 minutes per company per year.
7 Volt/VAR Optimization, Customer Facing Solution, and AMI benefits and costs are based on the Companies' SGF Project Exhibit B to the accompanying Application.
8 Customer Payment Options benefits and costs are based on general national averages.

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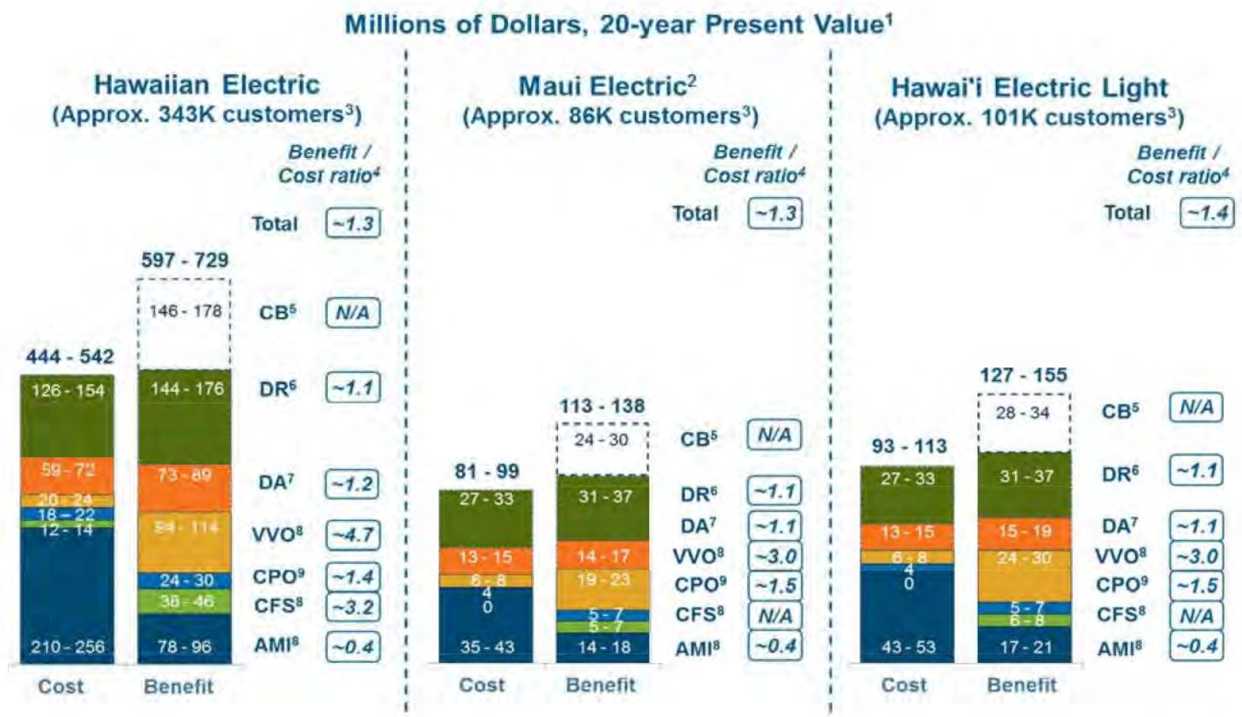
[17] NETL also cited examples of societal/community benefits related to GHG reductions, economic growth and reduction in foreign oil dependency. In their conclusion, when <u>all</u> benefits are taken into consideration, it cited example cases from EPRI and the West Virginia Smart Grid Implementation Plan as having BCRs of 4 or 5 to 1 and 6.7 to 1, respectively. The Companies have not quantified as high an overall BCR as more work needs to be done in partnership with local stakeholders in order to solidify and localize these estimates. The existing estimate for the community benefits utilize information from the Environmental Protection Agency's Green Power Network and the Department of Business, Economic Development, and Tourism's Actual and Forecast of Key Economic Indicators for Hawaii: 2011 to 2016.

Figure 4 below provides the same overall Smart Grid benefits and costs broken out by each operating utility. The spread between each operating utility is based on the planned physical location of specific utility assets in the field, the central allocation of back-end systems that are needed regardless of whether Smart Grid is implemented at Maui Electric or Hawai'i Electric Light, and the proportional customer spread for shared services.

The BCR for each operating utility ranges from approximately 1.3 to 1.4, and varies due to different operating cost structures, implementation scale, geography and forecasted energy costs. We estimate that over the next 20 years, Smart Grid will result in a net present value (i.e., benefits net of costs, discounted for the time-value of money) of $446–$545 per customer in at Hawaiian Electric; $325–398 per customer at Maui Electric; and $308–376 per customer at Hawai'i Electric Light.

Figure 4 - Overall Smart Grid Business Case by Operating Utility



Notes:

1 Present value is calculated with discount rate of approximately 8.1%. Numbers will not tie due to rounding.
2 Includes Maui, Moloka'i and Lana'i.
3 Estimated customer counts are based upon the projected 20-year forecast.
4 Benefit/cost ratios are based on the midpoint amounts of the associated ranges.
5 Community benefits are estimated the same as previously stated.
6 DR benefits and costs per overall is split between utilities using 70-15-15.
7 DA benefits include "value of service" calculated the same as previously stated.
8 Volt/VAR Optimization, Customer Facing Solution, and AMI benefits and costs are based on the Companies' SGF Project Exhibit B to the accompanying Application.
9 Customer Payment Options benefits and costs is split between utilities using 70-15-15.

While there are components of Smart Grid that deliver fewer quantifiable benefits than costs (i.e., components with a benefit-to-cost ratio of less than 1.0), it is important to take into account the non-quantifiable benefits and the overall Smart Grid portfolio of capabilities. Some base components such as AMI are considered foundational and therefore, may not have a positive business case by themselves but are required in order to enable the future capabilities needed for our Smart Grid. For example, to deliver certain DR programs, such as real-time pricing (RTP), AMI is needed to deliver RTP schedules in a timely and cost-effective manner. Similarly, the AMI network delivers enhanced value to existing DR programs by allowing for near real-time communications and usage information to the energy company and customers alike; it is leveraged to provide network connectivity for more than just the smart meters.

V. Our Smart Grid Development and Approach

At the heart of our Smart Grid is an extensive and secured multi-directional "network of networks" that is expandable, extensible and capable of evolving as new smart technologies are developed over time.[18] It will include advanced sensors and distributed computing technology that will not only improve the efficiency, reliability and safety of power delivery and use, but also unlock the potential for entirely new services and improvements to existing ones. The multi-directional Internet Protocol version 6 ("IPv6") communications infrastructure will support not only near-term applications, but also unanticipated applications that will arise in the future.[19] This results in a Smart Grid platform of integrated capabilities and functionality as illustrated in Figure 5 below. It further emphasizes that our Smart Grid development and approach must also be able to grow and adapt over time, especially given the rapidly evolving customer needs and technological innovations.

With this in mind, our Smart Grid development and approach leverages and integrates many capabilities via a solid platform that is coordinated and standardized through proactive architecture and design. This allows for a structured process methodology in which new innovations can be introduced, tested and utilized effectively as implementations progress. Our premise is to avoid technology incompatibility and potential stranded assets due to rapid technological changes, as well as to ensure that the rapid change that Smart Grid brings can be successfully innovated, tested, demonstrated, implemented and institutionalized.

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[18] "Network of networks" is defined by Christine Hertzog in the "Smart Grid Dictionary", 6th edition published on October 2014. It refers to a network comprised of smaller, heterogeneous public and private networks that connect to each other, and is meant that planners must identify potential relationships between networks and design solutions that leverage these synergies. This approach encourage creative use and reuse of resources for multiple purposes instead of single-use applications, and are especially important when dealing with complex systems and networks like Smart Grids.

[19] IPv6 is the most recent version of the communications protocol standards that provides identification, location and traffic of "things" on a network. This definition is broadly summarized from, William Stallings' article called *"IPv6: The New Internet Protocol"* published in the IEEE Communications Magazine, July 1996 issue.

Figure 5 - Our Smart Grid Platform

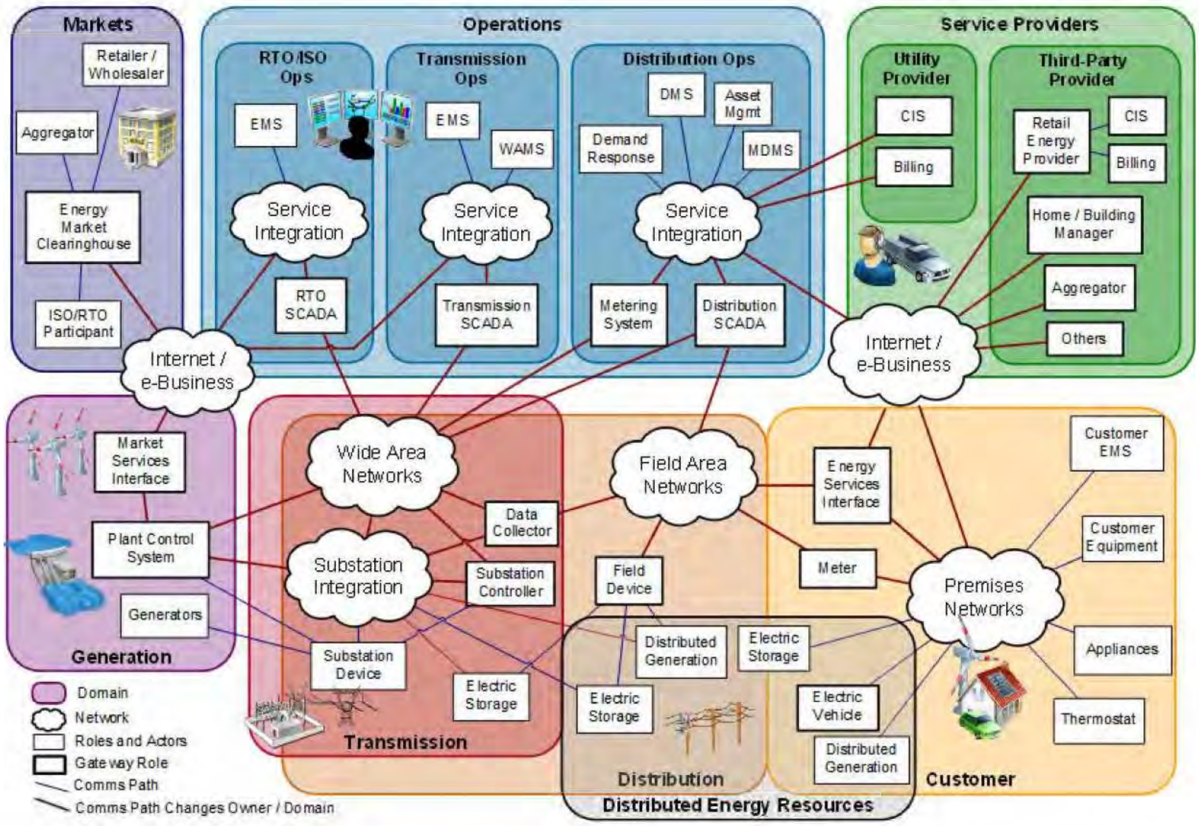
A. Guiding Principles for Smart Grid Architecture and Design

In order to ensure our Smart Grid investments have lasting impact and use, we have defined the following guiding principles that help frame and inform our decision making processes for our integrated Smart Grid architecture and design:

- Deliver a consistent, easy to understand and engaging customer experience;
- Implement proven technologies that are competitive, stable and reliable;
- Innovate in selected focus areas via strategic partnerships and collaborations;
- Monitor results, benchmark and learn from others;
- Leverage common infrastructure for broader use;
- Utilize and support industry standards that are relevant for Hawai'i; and
- Ensure a safe, secured and protected data environment.

By broadly applying these guiding principles, the Companies will be able to build a Smart Grid that modernizes the energy company to be more cost-optimized, flexible and responsive to customer needs. In addition, the Companies subscribe to the National Institute of Standards and Technology ("NIST") standards for establishing our Smart Grid architecture. NIST provides an integrated view of the general reference model and framework in which the relationship between the applicable generation, transmission, distribution and customer elements are shown in Figure 6 below:

Figure 6 - NIST Smart Grid Framework v3.0



Further details on our Smart Grid architecture, as aligned with energy industry based standards from NIST, the Institute of Electrical and Electronics Engineers ("IEEE") and Electric Power Research Institute ("EPRI") are provided in Appendix B.[20]

B. Overall Process Methodology

We have developed a measured, thoughtful and detailed approach to iteratively identify, test, evaluate, select and implement Smart Grid technologies that will deliver reliable, cost-effective products and services that customers value. This approach includes strategically partnering with SSNI, a leader in Smart Grid applications and networks, as well as working with other utilities that have implemented or are in the process of implementing their Smart Grids to identify, understand and adopt best practices and leverage related industry experience.[21] We

[20] NIST Smart Grid references can be found at http://www.nist.gov/smartgrid/ (primarily for framework, green button, and cybersecurity components). EPRI's Smart Grid references can be found at http://smartgrid.epri.com/ (primarily for distribution automation, reliability cost of service and CVR verification). IEEE Smart Grid references can be found at http://smartgrid.ieee.org/ (primarily for technical standards and long range technology road-mapping).

[21] Detailed level interactions have been carried out with five utilities – Oklahoma Gas and Electric (OG&E), Commonwealth Edison (ComEd), Florida Power and Light (FPL), Sacramento Municipal Utility District (SMUD) and Kauai Island Utility Cooperative (KIUC) – each of which use Smart Grid technologies similar to the what we are considering to implement in our service territories. They provided helpful and valuable discussions, exchanged

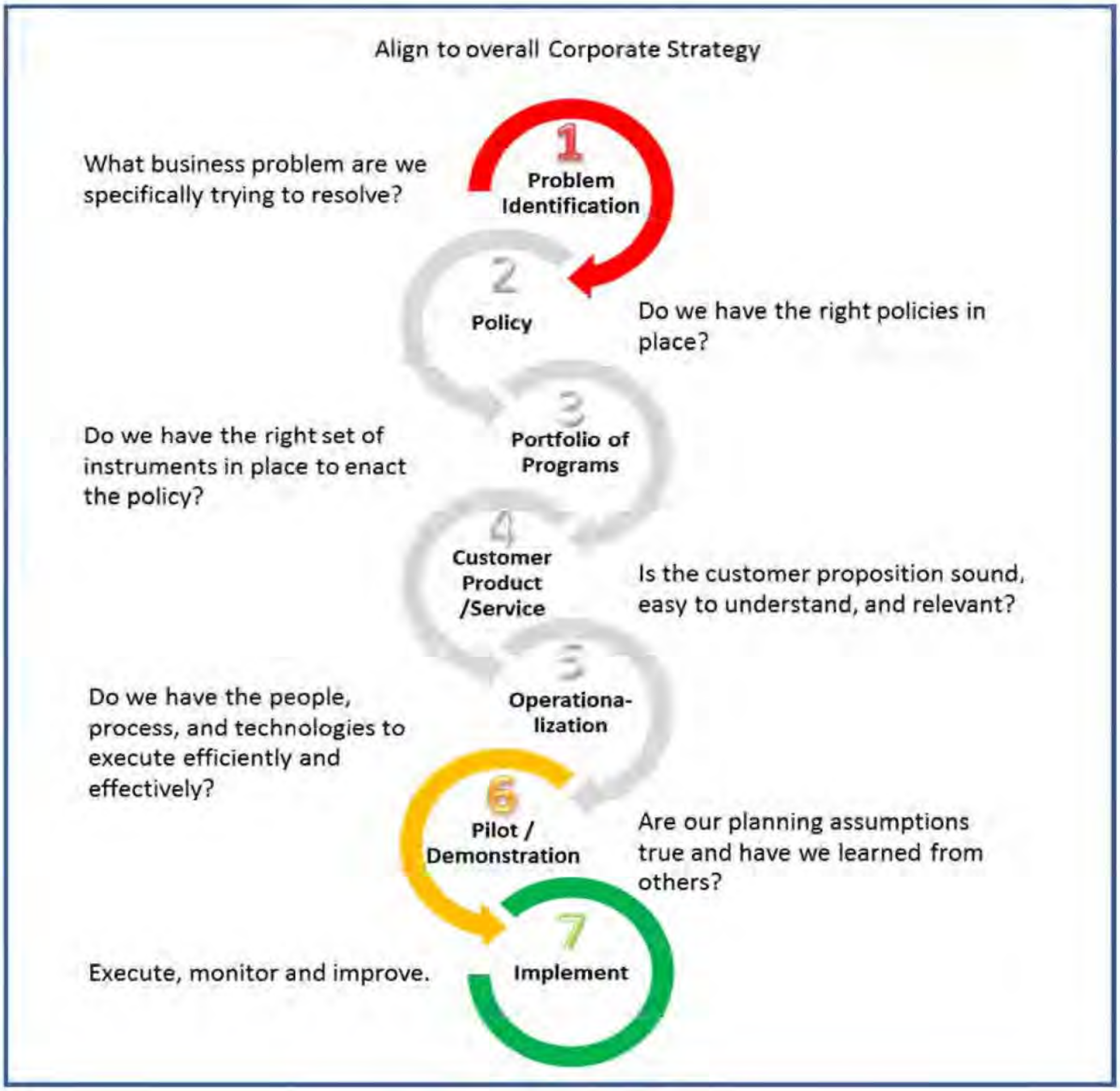
have also conducted, are conducting and/or will conduct Smart Grid technology demonstration projects within our service territories to more closely evaluate available technology solutions that will best deliver long-term value for our customers.[22]

The mix of both certain and developing solutions requires that we have a robust process methodology that will allow us to not only implement sound Smart Grid technologies that can be leveraged over time, but to also be able to successfully evaluate and forecast what the future will bring. This involves an iterative and inter-connecting process as defined in Figure 7 below. Ideally, these steps would be executed in sequential order. However, it is possible that the discovery and setup phase which includes steps to address policy, the portfolio of programs, customer product/service and operationalization (two to five) highlighted in gray, may be executed iteratively and simultaneously depending on the circumstances at the time and the level of third-party stakeholder involvement.

ideas and shared best practices. These were then applied in the execution of the Smart Grid Initial Phase, through which the Companies have now gained a better understanding of, and confidence in, the commercial maturity and performance of Smart Grid technologies, systems, operations, maintenance, organizational processes and customer engagement requirements that will be needed to successfully build our Smart Grid.

[22] The past and present demonstration projects include the JUMPSmart Maui Demonstration, Greater Maui Project and Department of Energy Renewable & Distributed Systems Integration Maui Smart Grid. The participants include Japan's New Energy and Industrial Technology Development Organization (NEDO) and U.S. Department of Energy (DOE), Hawaiian Natural Energy Institute (HNEI), Silver Springs Networks, Hitachi, Fonius, Pepco Holdings, Inc., Standard Solar, Silver Springs Networks, Maui Electric and Hawaiian Electric. The technologies evaluated under the demonstration projects included distribution management system ("DMS") and micro-DMS system to aggregate and control DER, 200 AMI meters and supporting communications network, customer home gateways and automated distribution network circuit switches. The projects include the Ulupono Grid Resiliency Pilot, PV Impact Analysis, DVI EDGE Product Development demonstration and Hawaii Energy's (a customer-funded energy conservation and efficiency program) Smart Grid Implementation Project. These projects are intended to demonstrate applications of new technologies like Fault Current Indicators ("FCI") for improved distribution network monitoring and control, advanced smart inverters to control grid-connected PV, advanced DR and EV charging management systems to help mitigate DER integration), new advanced data analytics and power engineering/distribution network modeling tools and in-home devices to allow customers to integrate and monitor home energy use and use an interactive web portal for access to Hawaii Energy's various energy efficiency applications. Partners and industry stakeholders include Ulupono Initiative, DBEDT, MetaTech, HNEI, DVI Grid Solutions, Hawaii Department of Defense, IBM, Hawaiian Electric, PACOM, and Hawaii Energy.

Figure 7 – Overall Process Methodology and Steps



The result of this overall process methodology is reflected in the Smart Grid roadmap presented in Section 7 below, which depicts both components that are already planned for implementation, as well as those that are still being tested and evaluated.

C. Engaging Our Smart Grid Customers

We believe a proactive, transparent and sustained communication effort to educate and engage our customers is critical to the success of achieving our Smart Grid vision. Our efforts to be relevant and engaging to our customers underscore our commitment to continually improve customer service, modernize the power grid and integrate distributed renewable energy. We intend to proactively engage customers about installing smart meters and other advances that give them more information and control over how they use their energy, share information about other Smart Grid benefits, and address concerns about safety, security and privacy. Key to this is helping customers understand that, at its core, Smart Grid technology will offer them more information than ever before about their energy use and generation, and give them tools and programs to help make decisions about their energy choices that complement their lifestyles; be it to be more environmentally green, to help manage their energy use, or to simply understand what options they have available to them.

Our customer communication program is based on tested and proven industry best practices, and is customized based on research conducted in Hawai'i on how to best reach/interact with 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 to most effectively reach out to them. Taking the lessons learned from our Initial Phase, we have found that being transparent from the start and preserving customer choices up front are critical to maintaining our customer's trust.

Our efforts to engage our customers – indeed, all our stakeholders – will be guided by four fundamental communication guidelines:

1. Proactive: Anticipate stakeholder needs and develop approaches to meet those needs.
2. Collaborative: Work with stakeholders to design and improve the experience, products, and services they receive.
3. Responsive: Respond promptly and transparently to all inquiries.
4. Flexible: Expect and accommodate continual process and communication improvements.

While researching other Smart Grid implementations, and during our own Initial Phase demonstration, we found that our customers and the news media consistently raised concerns about three issues: (1) the safety of smart meters and radio frequency emissions; (2) security of the communications infrastructure; and (3) privacy of customer data. We have diligently identified 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 access to experts and the available educational information on these three issues.

1. 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. In our own local analysis, we have found that our Initial Phase 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.

2. 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 have incorporated the latest and most advanced security enhancements available to-date and will continue to do so as it further improves over time.

3. Privacy

We are committed to ensuring the privacy of our customers' data. Our customer 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.

4. Communications Plan

As part of our customer communications plan, we will proactively utilize the following tactics, tools, and capabilities to engage our customers:

- Community outreach;
- Customer education;
- Government relations;
- Third-party engagement;
- Media relations;
- Customer research;
- Employee engagement; and
- Customer service support.

We understand how important it is to remain flexible and to adapt to the dynamic needs of our customers, throughout our Smart Grid journey. 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 implementation.

D. Partnerships and Third-Party Collaborations

In order to best serve our customers, our community and the environment as a whole, we believe that it will take the overall joint efforts of many to deliver on the promise of Smart Grid benefits. Smart Grid is a very broad and complicated concept that can be more successful when strategically aligned and tactically coordinated. This is especially true in Hawai'i's communities that face unique challenges and opportunities. In recognition of this, we intend to work closely with Hawai'i's policy makers, our strategic partners and third-party collaborators in developing suitable Smart Grid solutions, leveraging investments and solidifying standards that will deliver value to our State. Collaborative discussion and alternative viewpoints on emerging standards and solutions are encouraged, in order to produce and implement the best solutions in a timely fashion. Joint efforts to coordinate customer solutions are also needed in order to foster healthy competition and maximize value to customers.

In 2013, we formed a strategic partnership with SSNI, 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 23 million homes and businesses at more than 30 utilities. Together, we have planned and designed the appropriate blend of Smart Grid applications that is expected to deliver on our vision. SSNI also helped us with our Initial Phase, in which we have successfully implemented our target AMI solution to approximately 5,000 homes and businesses on O'ahu.

A number of third-party stakeholders have expressed their support for Smart Grid. Copies of documentation of some of that support are provided as Attachment 1.

VI. Our Smart Grid Roadmap

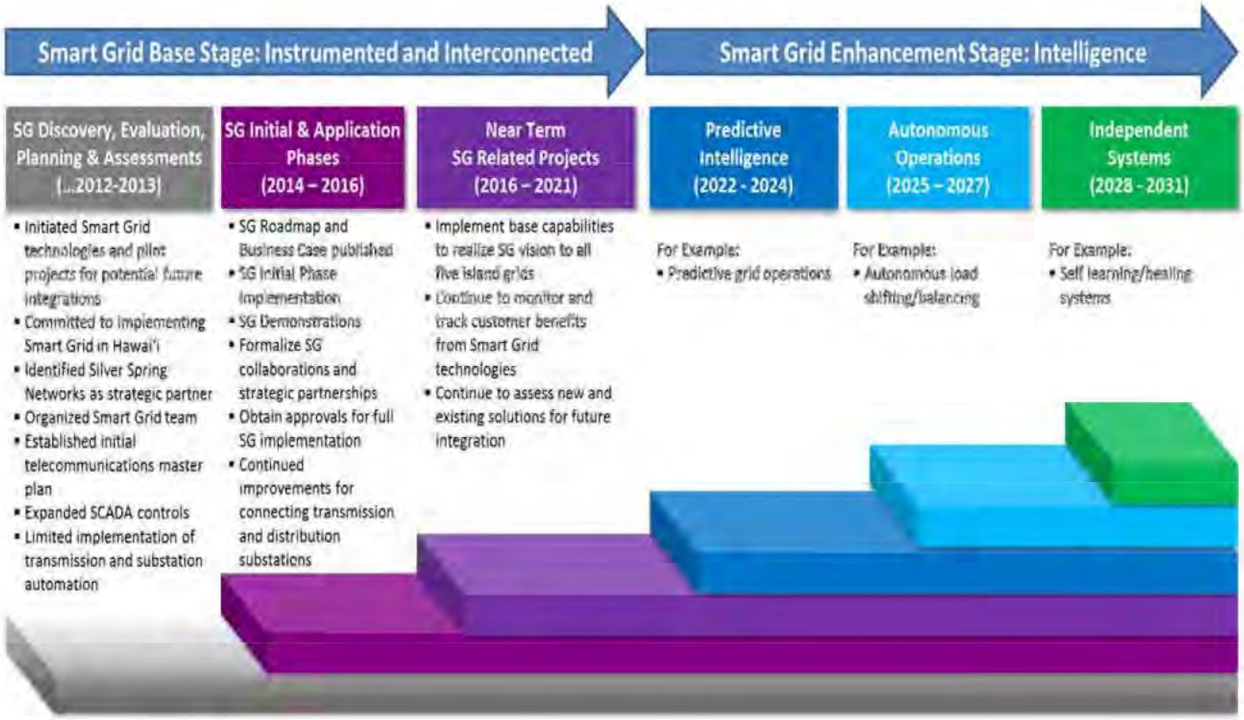
As explained above, the Companies' Smart Grid deployment strategy uses a phased approach, with the core infrastructure and basic functionality put in place first, followed by progressive incorporation of additional solutions over time due to the reality that some solutions do not yet commercially exist. Accordingly, the Companies have mapped the delivery of our Smart Grid vision along two main time horizons: (1) the overall twenty-year long-term (2012-2031); and (2) the sub-set near-term Smart Grid Related Projects (2016-2021).

A. Overall 20-Year Long-Term Smart Grid View (2012-2031)

The twenty-year long-term view shows what we have done to-date and directionally indicates our long-range Smart Grid plans, subject to revision as our near-term plans adjust and/or are implemented. This view is used to guide the Smart Grid activities in a strategically focused direction. Although this direction will evolve over time, it is generally stable and aligned with long-term views of the industry and the expected State energy policies in Hawai'i.

Figure 8 below depicts our long-term Smart Grid view as divided into two major sections: (1) a "Base Stage," in which the basic capabilities and foundational infrastructure are assessed, implemented, operated and monitored; and (2) an "Enhancement Stage," in which additional capabilities that have yet to be fully commercialized are layered on top of the base in order to complete the implementation of a modern power grid that realizes our Smart Grid vision.

Figure 8 – Our Smart Grid Overall 20-Year Long Term View



Our Smart Grid journey formally began in 2008, with the submission of an initial AMI only application. At that time, we determined that we could not afford to be an early adopter and therefore, were delayed until the 2012-2013 timeframe to develop our initial roadmap and strategic partnership with SSNI, and subsequently carried out the Initial Phase and preparation for the SGF Project application. Outside of the Initial Phase demonstration, our power grid today does have some base capabilities for limited connectivity, information creation and operational control. These capabilities are mostly traditional and provide basic information for traditional dispatchable resources.

Our Smart Grid plan has been to build upon this traditional basis and improves on it by introducing and expanding smart capabilities beyond transmission and distribution substations, into service locations (e.g., smart meters). From 2012 through 2015, we improved our understanding and knowledge about our Smart Grid and are further building upon the Smart Grid learnings and experiences collected in the early discovery, evaluation, planning and assessment phase. We have also completed our Initial Phase and are now well into the Application phase. The year 2016 marks the start of the next phase within the Base Stage, and with support from our customers, policy makers and stakeholders, we are now looking to implement the Near-Term Smart Grid Related Projects phase in which the foundation will be established.

In achieving the Base Stage, our Smart Grid will be instrumented and interconnected from the transmission through distribution networks and to the service location levels. With the base in place, we can then focus on enhancing power grid capabilities and leveraging the developing technology advancements in storage and DER management. The collection and analysis of "big data" now enabled, collected and analyzed will allow for greater predictive intelligence, autonomous operations and independent systems in the future.[23]

The Enhancement Stage ushers in a future that is still being formulated. IEEE paints the picture of a progression of technologies that will allow for fully autonomous systems that will not only support real-time interactions but also provide predictive capabilities.[24] We acknowledge that there is still a lot of work to be done to fully flush out this portion of our Smart Grid roadmap. Nonetheless, it is provided to guide our overall broad Smart Grid strategic level decision making.

B. Near-Term Smart Grid Related Projects View (2016-2021)

The near term view of six years (2016 through 2021) provides a working construct of interdependent Smart Grid-related projects that connects the dots between the Companies' various plans, strategies and dockets currently before the Commission. This view is organized utilizing the key strategic themes, the associated solutions, their planned corresponding Commission applications, and target years of implementation. These are reflected on the near-term roadmap based on interconnected planning assumptions that not only provide the basis for scope and timing, but also for its inter-dependencies. For example, it is not possible to offer RTP without the Meter Data Management System ("MDMS") solution that is connected to an installed base of smart meters. Details of the various projects are not presented in this roadmap, but rather have or will be provided in the associated applications for Commission approval of the respective projects, as listed below:

Smart Grid Foundation Project contains requests for approval of the base Smart Grid technologies needed to implement foundational capabilities that include the AMI solution (i.e., smart meters, the multi-directional communications network, the CFS and the MDMS), enhance DR capabilities to replace end-of-life one-way water heater direct load control ("DLC") to smart devices, implement the Volt-VAR Optimization solution that will enable conservation voltage reduction ("CVR"), back office supporting capabilities for integrating, warehousing and analyzing data, and the propose a non-standard meter tariff.

DR Aggregator Contracts represents the request for approval of firm provider contract(s) resulting from negotiations expected to take place in the first half of 2016. These negotiations will focus on the shortlisted vendors selected pursuant to request for proposals #061715-02, "Provision of Grid Services Utilizing Demand-Side Resources," issued in May, 2015.

DR Program Portfolio (Docket No. 2015-0412) contains the request for approval of Demand Response Program Portfolio tariff structure, reporting schedule and cost recovery of program costs through the Demand-Side Management (DSM) Surcharge. The December 2015 filing is considered preliminary at this stage due to the need to sync up the planning assumptions

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[23] "Big Data" is a term coined in 2001 by MetaGroup (now known as Gartner) to depict data sets so large or complex that traditional data processing is no longer adequate to capture, store, search, analyze, share and visualize.
[24] The IEEE Grid Vision 2050 Roadmap describes the IEEE Power and Energy Society's vision of the power system infrastructure into the year 2050 and provides for discussion a roadmap of the associated power and energy technologies.

with the updates of the Power Supply Integrated Plans ("PSIPs") on April 1, 2016. Therefore, this docket update will be scheduled for after mid-2016 to include final program riders, sample contracts and implementation plan including demonstration projects.

Demand Response Management System ("DRMS") Project (Docket No. 2015-0411) contains the request for approval to defer certain computer software development costs for the DRMS, to accumulate an allowance for funds used for construction during the deferral period, to amortize the deferred costs, and to recover deferred, amortized costs through the Renewable Energy Infrastructure Program Surcharge.

EV Time-of-Use rate schedules (Transmittal No. 15-08 and Docket No. 2015-0342) contained requests to approve modifications to existing EV time-of-use ("TOU") rates and schedules, and to approve new proposed rates and schedules. The Commission has issued Decision and Order No. 33165 and Decision and Order No. 33279 in which extension and transition of EV TOU rates and schedules were approved but conditioned on adjudicating these EV rates and schedules together with the overall TOU rate design in DER Phase 2 (discussed below).

DER Time-of-Use rate schedules (pursuant to Order No. 33258) contained the request for approval of DER TOU (includes EV) rates and schedules that are complementary to the DR Program Portfolio. These are included in the DR Program Portfolio as a rate within the Capacity Service Tariff. The currently proposed TOU design at the high level is for three fixed time periods, established based on marginal generation costs, and will be recomputed annually. This is subject to change pending the on-going discussions and collaboration with stakeholders.

Real-Time Pricing Tariff will contain the request for approval of the proposed RTP rates and associated schedules that leverage the use of the granular data that the AMI solution provides. This is one of the future DR programs as outlined in the recent DR Program Portfolio as discussed above.

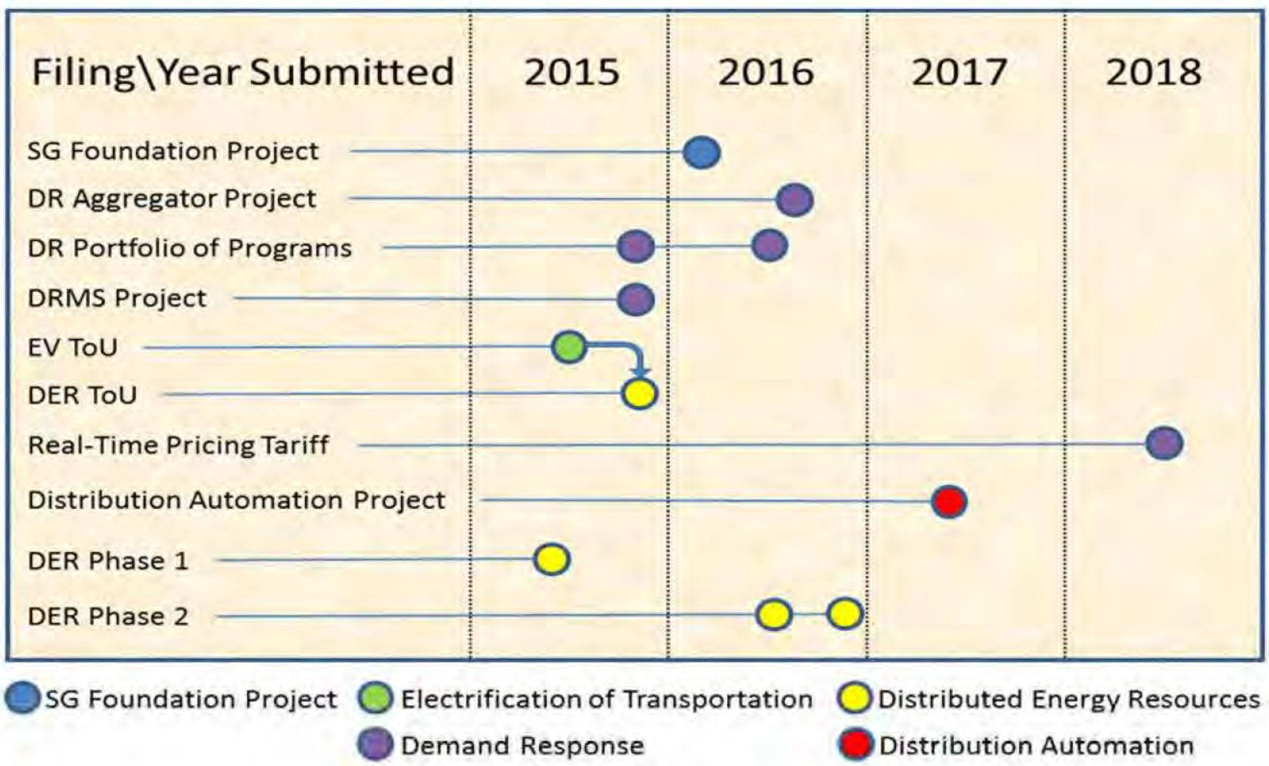
Distribution Automation Project will contain the request for approval of distribution smart field devices, communications, and the associated Advanced Distribution Management System ("ADMS") that will be used to enhance our outage management capabilities and provide incremental Smart Grid management functions that will increase power grid stability, reliability and resiliency.

DER Phase 1 (Docket No. 2014-0192) responded to the Commission's request to institute a proceeding to investigate DER. Based on that investigation, Decision and Order No. 33258 approved revised interconnection standards to streamline and improve the Companies' interconnection process, closed the Companies' net energy metering (NEM) program to new participants, and approved new options for customers to interconnect DER to the Companies' power grids (self-supply and grid-supply options).

DER Phase 2 is expected to address the following issues: (1) Hosting Capacity Analysis (circuit-level and system-level); (2) Opportunities to enhance the value of DER to the power grid (focused on integration and aggregation of various forms of DER); (3) The Companies' Integrated Interconnection Queue and further revisions to applicable interconnection standards to enable advanced DER capabilities and improve the interconnection process; (4) Establishment of communications protocols between utilities and DER; (5) Activation timeline and implementation process for advanced inverter functions; and (6) DER rate design and program structures. The current target is to complete DER Phase 2 processing by the end of 2016.

The anticipated timing for the various Smart Grid-related project applications is shown in Figure 9, below. Figure 9 also provides the base color coding legend for the subsequent Figures 10 through 14, which show the solutions contained within each docket by year grouped by strategic theme.

Figure 9 – Near-Term Smart Grid Related PUC Filings (subject to change)



The following sections outline how each of the filings and the associated solutions support the Smart Grid strategic themes by year. Each section has a corresponding figure that depicts the overall solutions within each strategic theme. Each bar within the respective figures represents the implementation of a particular solution. Each solution within its bar can have multiple progressive releases before final completion. In many cases, benefits are realized before the final completion of each solution.

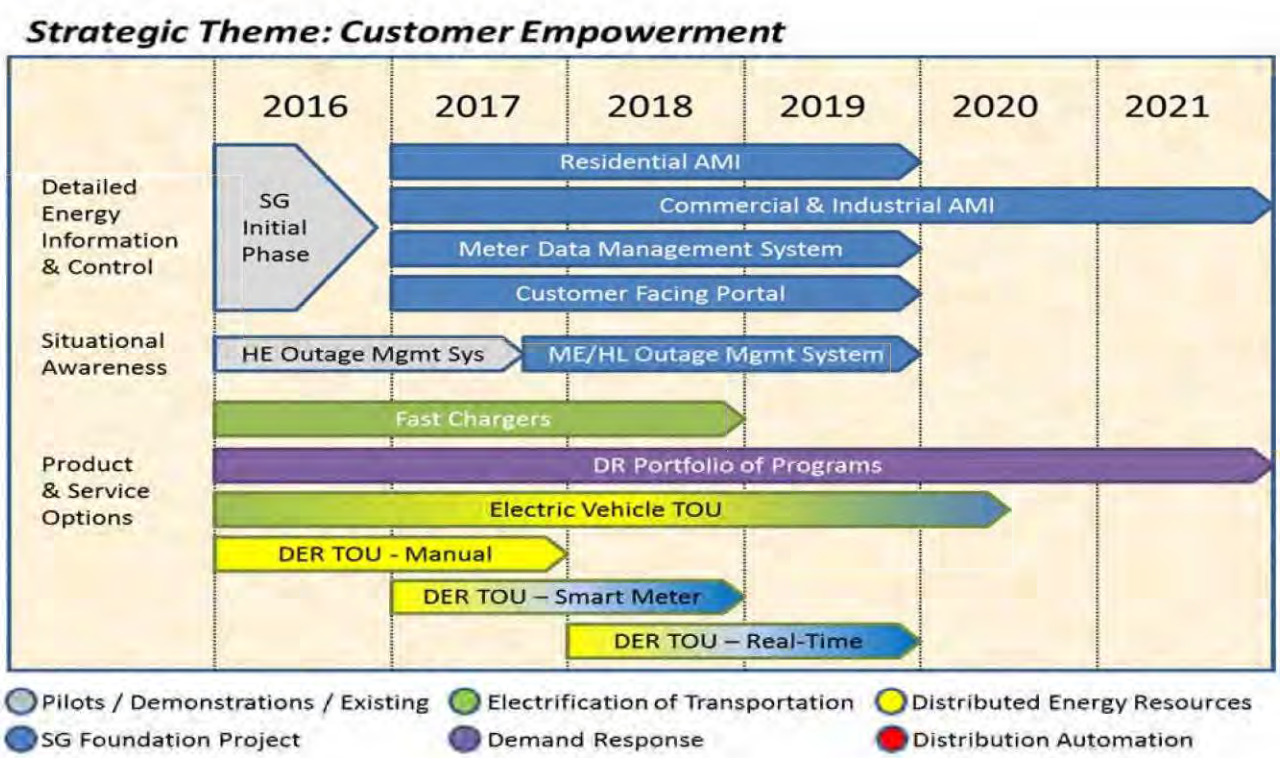
1. <u>Customer Empowerment</u>

Figure 10 below depicts the primary functions encapsulated under the Smart Grid customer empowerment strategic theme. It is in this timeframe that customers will gain access to their energy usage at a more granular level via their online or mobile one-stop customer experience portal. Customers will have access to new customer options and be able to compare products and services (e.g., new DR programs and options for further integration of EV options), in a unified customer experience. During power disturbances, customers will have greater visibility and situational awareness of outage occurrences and estimated restoration times. Additionally, traditional fixed-period TOU capabilities will be enhanced to more RTP programs once AMI is deployed.

There are three stages of TOU capabilities: (1) Manual TOU – which requires truck rolls to replace the existing meter with a TOU enabled meter, and to read the meter manually; (2) Smart Meter-enabled TOU – which utilizes the installed smart meter and communications network to remotely collect the TOU fix period energy use data; and (3) RTP – which utilizes the smart meter, smart communications network, and in addition, leverages the MDMS to dynamically and remotely configure, calculate and verify compliance to a RTP program.

While the manual TOU capability is available to customers today, enrollment in the manual TOU program is strictly based upon assumptions that a TOU customer's energy use behaviors (e.g., energy use during specific times of the day) are better suited for TOU rates. However, with Smart Grid, customers will be able to use their actual energy usage data to more accurately select the appropriate rate plan that fits their lifestyle and makes the most economic sense. The Smart Meter-enabled TOU capabilities will also increase operational efficiencies through the ability to switch a customer on or off of the TOU rate plan remotely, eliminating the need to send a person out to manually swap out the meter and switch services. Such remote capabilities will provide a more sustainable solution than our option today through easier access for customers and enhanced efficiencies in service.

Figure 10 – Customer Empowerment Near-Term Roadmap

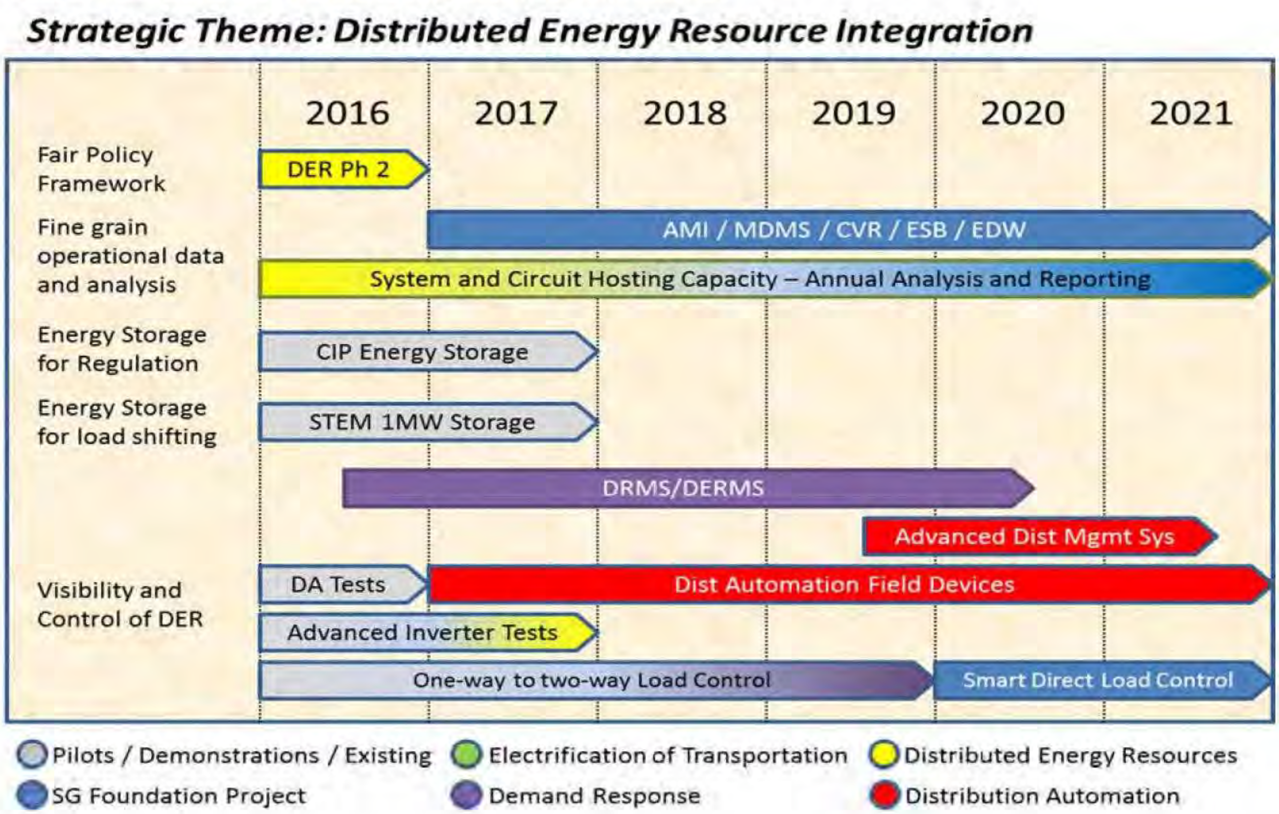


2. Distributed Energy Resources Integration

Figure 11 below depicts the primary functions encapsulated under the DER Integration strategic theme. Since a large portion of the capabilities in this space are still emerging, we have included a number of pilot/demonstration items (shown in gray) that are designed to test the proposed functions and capabilities. This includes visibility and controllability of smart devices located behind the meter and energy storage systems. There is also a planned lag in time for which an expected amount of DA smart field devices are installed before the "master control" ADMS is implemented.

This is possible because smart field devices have autonomous functions as well as limited central controllability. However, once the number of smart devices is at scale, the central system is then needed and its costs can be leveraged over a large population of smart devices. We have also included on the roadmap the assumption that the proposed DRMS is in fact a DER management system that will become fully integrated into the overall system once all the various components evolve and mature over time.[25] This approach is more cost-effective as we will be able to grow with a single solution, versus needing to procure and maintain two separate solutions.

Figure 11 – Distributed Energy Resource Integration Near-Term Roadmap



[25] See Exhibit C to the Companies' DRMS Project application in Docket No. 2015-0411 for further details on the selected Siemen's solution, which is in essence a DER management system.

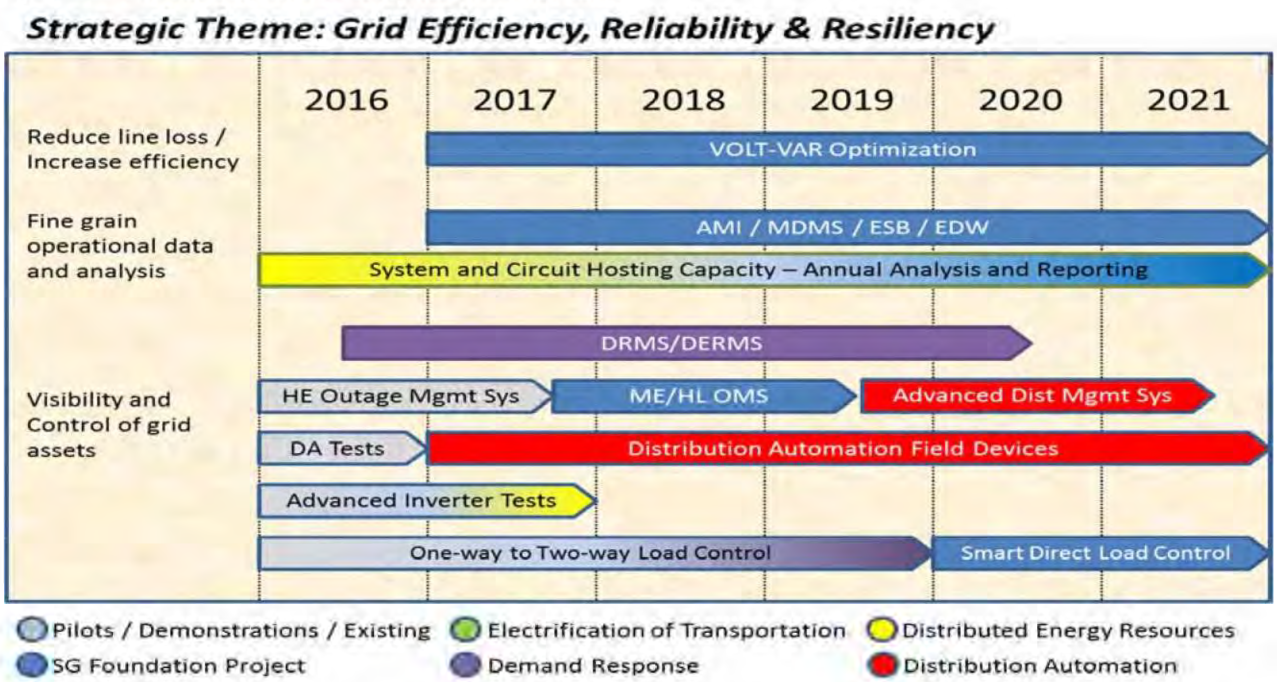
3. Grid Efficiency, Reliability and Resiliency

Figure 12 below depicts the primary functions encapsulated under the Smart Grid efficiency, reliability and resiliency strategic theme. In this case, Volt/VAR Optimization (VVO) relies on the AMI smart meter and communications infrastructure in order to deliver CVR capabilities. Additionally, with the implementation of AMI, incremental operational information such as voltage and temperature from the service location level will be collected into the Enterprise Data Warehouse ("EDW") via the Enterprise Service Bus ("ESB") and will enhance our ability to effectively and efficiently share and analyze data in real-time or near-real-time. This will further enhance our modelling and visualization capabilities and will be especially helpful in cross-functional analytics such as system and circuit hosting analyses.

This roadmap also represents the functional maturation required to move from an OMS to a fully matured ADMS system that will centrally manage in aggregate all distribution resources. It is important to expand automated outage capabilities first in order to implement the foundational reliability capabilities associated with reducing outage durations. This is why the ADMS system implementation follows after the implementations of the MDMS, DRMS/ DERMS and OMS are completed – and once enough distribution smart field devices have been implemented.

There are items on this roadmap that are still in test phases (e.g., advanced inverters, in-line power regulators). Once proven, these items will ultimately feed into the formalization of solutions that will then be implemented. Existing capabilities will also evolve into the more mature Smart Grid two-way information and controls (e.g., DLC). An item that is currently not on the roadmap but will be added once evaluated, is the use of energy storage at the distribution level in response to providing greater power grid stability.

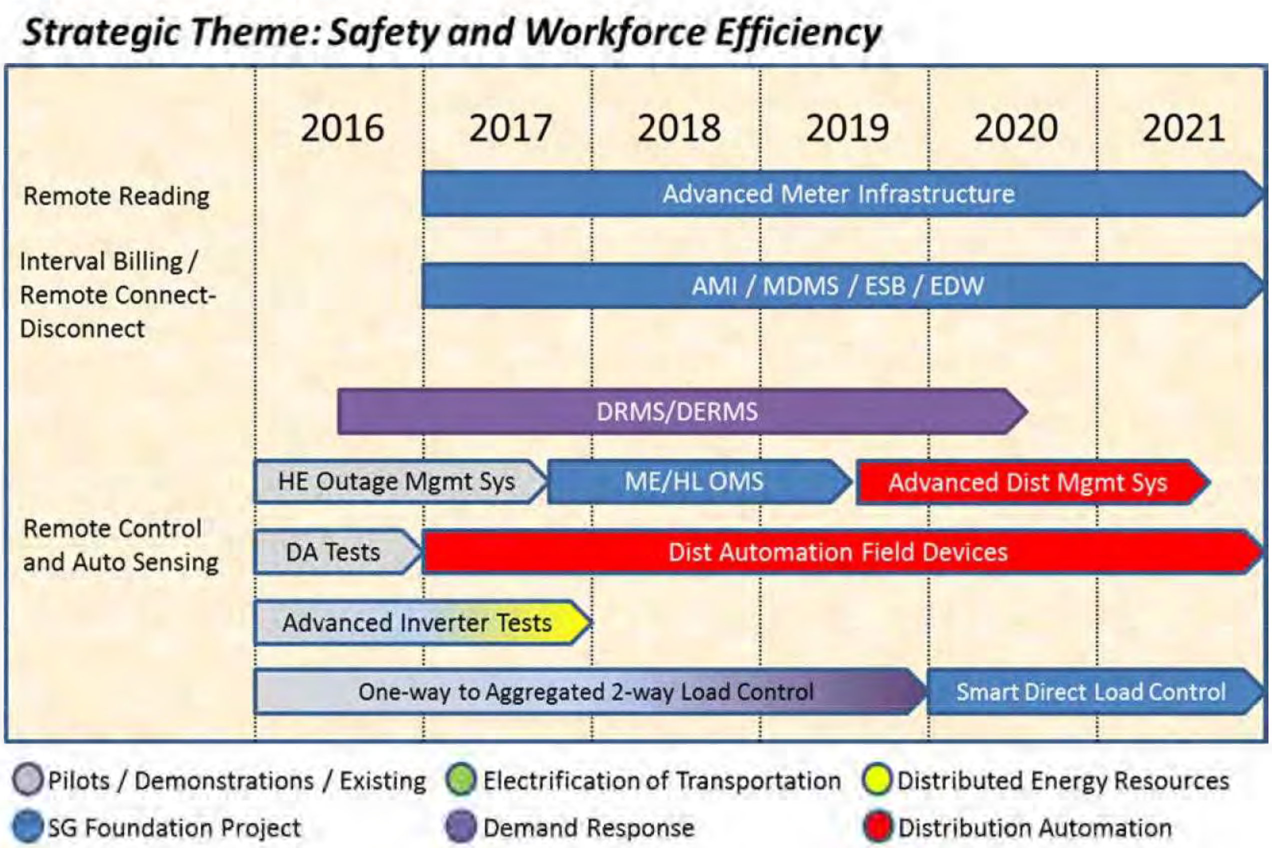
Figure 12 – Grid Efficiency and Resiliency Near-Term Roadmap



4. Safety and Workforce Efficiency

Figure 13 below depicts the primary functions encapsulated under the Smart Grid safety and workforce efficiency strategic theme. This component of the roadmap shows when the expected capabilities that improve safety and workforce efficiency will be delivered by the associated solutions. Specifically, we expect that with AMI and the MDMS, ESB and EDW, we will attain the ability to remotely read all meters and therefore, be able to reduce the number of existing meter reading positions (although some may still be retained due to the need to manually read non-AMI meters for customers who chose not to have a smart meter installed or are located in geographic areas that do not support electronic communications). Each of the capabilities represented under this strategic theme allows us to increase efficiency and productivity, while maintaining the safety of our workforce. The increase in smart devices that are capable of autonomous actions will reduce the time to action (e.g., no need to roll a truck to change a switch setting) and central monitoring capabilities will further enhance our system operations capabilities to process complex amounts of data quickly in order to mitigate grid issues. As we begin deploying these new technologies, we will implement a training program for our affected workforce so that the value and benefit of the technologies and more efficient work processes can be fully realized.

Figure 13 – Safety and Workforce Efficiency Near-Term Roadmap

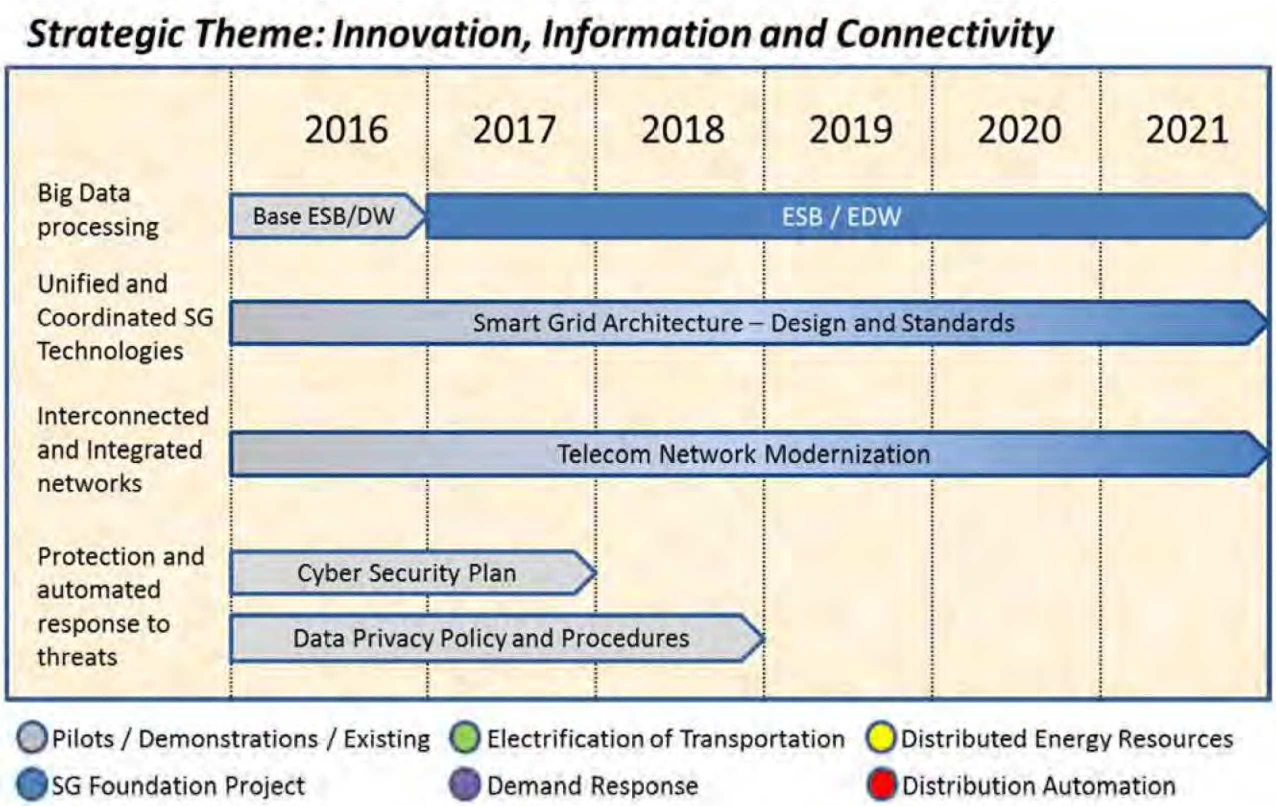


5. Innovation, Information and Connectivity

Figure 14 below depicts the primary functions encapsulated under the Smart Grid innovation, information and connectivity strategic theme. This portion of the roadmap shows capabilities that are key technical components as well as security and privacy policies and procedures that need to evolve over time in order to keep pace with the rapidly evolving nature of Smart Grid technologies. Since many of the technical solutions are still evolving (e.g., integration of advanced smart inverters), our technical capabilities need to be grounded in flexible frameworks that supports continuing innovation and change over time.

Many of the capabilities listed here (except for big data processing) already exist and only need to be improved and enhanced as we introduce newer technologies that change the way we serve our customers and manage the power grid. Our base ESB and data warehousing capabilities today only process a limited amount of data and support just a few applications for transaction interchange. With the implementation of Smart Grid, there are many incremental systems to be added to the overall environment and the data volume will exponentially increase. Once the major updates to the associated plans are in place, they will be revisited annually or as changes in assumptions occur. We do not expect these plans to remain static, as new capabilities are discovered and the plans will be updated in order to remain current and well maintained.

Figure 14 – Information and Connectivity Near-Term Roadmap



VII. CONCLUSION

By enabling more informed and timely energy decisions, Smart Grid is bringing enormous changes for the electric industry in general and the State of Hawai'i in particular. Our Smart Grid vision is to provide an intelligent and automated electric system that utilizes multi-directional communications and computing technology advancements to better meet customers' expectations, State energy policy objectives, communities' energy demands, and the Companies' overarching responsibility to provide safe, reliable and secure electric service. Our strategy for making this vision a reality is focused on delivering our Smart Grid strategic themes: (A) customer empowerment; (B) DER integration; (C) power grid efficiency and resiliency; (D) safety and workforce efficiency; and (E) innovation, information and connectivity.

Building a Smart Grid in Hawai'i will not be accomplished in a single project effort, but will evolve over time, growing and layering capabilities and functionality that increasingly deliver incremental value to customers. When taken in their entirety, the overall bundle of benefits and capabilities enabled by our Smart Grid initiatives supports a positive value proposition and business case, with a benefit-to-cost ratio of approximately 1.2, which will lower costs for the Companies and their customers in the long run. We look forward to working with the Commission, Consumer Advocate and other stakeholders on their ongoing, near- and longer-term initiatives to make Hawai'i's Smart Grid a leading model within the industry.

APPENDIX A – Definitions and Abbreviations

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

Advanced Analytics and Forecasting: Advanced Analytics and Forecasting allows for a tighter balance between energy supply and demand, thus saving energy. It provides more detailed, immediate information about how energy is being used within a customer location, which helps develop more dynamic demand forecasts.

Advanced Distribution Management System (ADMS): ADMS is a software platform that supports a full suite of distribution management by incorporating data, status and control capabilities delivered by OMS, DMS and SCADA systems. An ADMS can deliver optimization to system operators by integrating its own asset pool and those managed by an EMS upstream and the DERMS and/or MDMS downstream. The ADMS typically manages distribution system assets such as feeders, transformers, cap banks, switches, relays, DA, regulators, etc. It can also be coordinated with and leverage information and control of distributed assets on the customer side of the meter. ADMS functions include automated outage restoration, fault location, isolation and restoration; volt/volt-ampere reactive optimization; conservation through voltage reduction; and support for energy storage, micro-grids and electric vehicles that are directly tied into the distribution network.

Advanced Metering Infrastructure (AMI): The hardware and software, together with the telecommunications services, that enables: (1) automated meter reading, (2) the collection of meteorological data; and (2) the control of meters. AMI integrates advanced metering data and controls from the meter all the way through to back office systems.

Back Office: The internal business operations and systems of a company that are not visible to the general public.

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

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

Customer Payment Options (CPO): Combination of a broad array of payment technologies offered to customers; inclusive of credit and debit transactions utilizing the automated clearing house, and pre-payment and/or gift card solutions.

Customer Facing Solutions (CFS): Interactive web/mobile application platform that is viewable to the customer directly, and includes but is not limited to an energy portal, profile and preference management, billing options, and other web/mobile customer interactions. The CFS utilizes the MDMS and ADMS systems in order to convey energy usage, estimated bill, outage information, etc. to customers in near real-time.

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

Distributed Energy Resources (DER): Distributed energy resources include distributed generation, energy efficiency, demand response, electric vehicles, and distributed energy storage.[1]

Distributed Energy Resource Management System (DERMS): A software platform that enables status, command and control of a wide array of customer-sited, behind-the-meter, distributed energy resources and the programs that allow for the management of these resources (including Demand Response programs). This system employs a "system of systems" approach to facilitate the coordination across multiple head-end systems and direct end use communications and delivers grid services to system operators. To do so, the DERMS maintains current status on and optimizes the distributed asset pool, including those managed directly through DR programs, to allow an energy company to deliver a full spectrum of ancillary services through these resources. The solution also accurately measures and verifies the delivery of these services.

Demand Response (DR): Programs that reward customers for smart energy usage and save money during periods of peak demand through the voluntary curtailment of their consumption when demand is high or during periods when their continued use might jeopardize the stability of the electrical system. Fully automated DR can be initiated at a home or building by an external signal, which initiates pre-programmed shedding strategies. Facility staff at each site will pre-program the control systems to receive the signals. The energy company can provide payments as an incentive to participate in DR programs.

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

[1] Hawaii Public Utilities Commission, at 1 Docket No. 2014-0192, *Decision and Order* No. 33258.

Direct Load Control (DLC): A DR program that enables a system operator to interrupt a customer's load during the period of 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 energy, 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): A system comprised of control applications, communication networks and field devices, where the field devices are installed anywhere on the distribution system from inside a substation to the high side of the customer transformer, enabling remote control, monitoring, and automation to support the planning, engineering, construction, operation, and maintenance of the distribution system.

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

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.

Enterprise Data Warehouse (EDW): Central repository of integrated data from one or more disparate sources used in support of analysis, reporting, simulation, forecasting and machine learning.

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

Enterprise Service Bus (ESB): Software platform that supports and facilitates the use of service-oriented architecture to efficiently design and implement data communications, sharing and inter-operability between disparate software applications.

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.

Geographic Information System (GIS): A system designed to capture, integrate, store, edit, analyze, manage and display all types of spatial or geographical information.

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

IPv6 (Internet Protocol Version 6): The latest revision of the IP 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.

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

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

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

Meter Data Management System (MDMS): A system that performs the management and maintenance of smart meters, inclusive of its long-term data storage and management for the large quantity of data delivered by smart metering systems. The MDMS imports the meter data, then validates and processes it so it can be used for billing and analysis. It also manages and controls the meter configurations and statuses, and performs connects and disconnects through the smart meter head-end. It will also aggregate meter outage information for upstream systems like an OMS or ADMS to consume, while providing meter usage data to DRMS or DERMS for the verification of DR Program utilization.

Neighborhood Area Network (NAN): The Companies' last-mile, outdoor access network that connects smart meters and DA 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 allows private residential and commercial utility customers to effectively accrue solar generation credits by selling back excess energy. The NEW agreements enabled customers to interconnect their eligible, independently-owned and operated renewable energy generation system generating up to 100 kW to the Companies' power grid (according to Hawai'i State law, Hawai'i Revised Statutes (HRS) Sections 269-101–269-111). The executed agreement allows the NEM customer to connect their renewable generator to the power grid, allowing it to export surplus energy into the grid, and to receive credits at full retail value that can be used to offset energy purchases over a 12-month period. NEM was retired in October 2015, and replaced with two new programs, called Customer Self Supply and Customer Grid Supply.

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

Open Analytics Platform: A unified solution designed to address the demands of users, especially large data-driven companies, on the inadequacy of relational database management systems in providing contextual analyzed data out of all the stored information.

Outage Management System (OMS): A computer-aided system that allows an energy company to receive customer calls or indications from the SCADA system to manage and restore electrical outages. An OMS is generally integrated with a work order management system, and utilizes the ADMS for functional interoperability.

Real-Time Pricing (RTP): A DR program that provides pricing signals to encourage customers to use energy during times of the day where energy has a lower cost.

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).

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

Vol-Var Optimization (VVO): Techniques in which voltage on the power grid can be optimized in order to conserve energy (i.e. CVR) and/or to shed load via a DR capability.