California Utility Technology Readiness Roadmap for Customer Energy Management

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ABSTRACT

To guide the development of a smarter, more robust, and more efficient electricity infrastructure, California's three investor-owned utilities (SCE, PG&E, and SDG&E) and SMUD in collaboration with EPRI developed a vision of the California Smart Grid of Year 2020 [1]. The envisioned smart grid would enable achievement of California's energy and environmental policy goals to reduce greenhouse gas emissions (GHG), expand the use of renewable generation, maintain or improve grid reliability, enable the electrification of transportation, implement demand response, and increase penetration of distributed energy resources. The smart grid would link electricity with communications and automated control systems to create a highly automated, responsive, and resilient power delivery system. These expanded capabilities will enable optimizing service and empowering customers to make informed energy decisions.

The paper presents a technology readiness roadmap for customer energy management that defines a logical progression or pathway for achieving energy smart communities through advancement in home and building energy management. The progression of capabilities outlined in the roadmap is discussed in terms of envisioned applications for customer energy management, critical enablers for advancing through stages of technology readiness, and associated beneficial impacts achievable at each stage. The paper also identifies the types of energy policies and values to society and customers that are supported at each stage of technology readiness. The paper concludes with remarks on further research and industry collaboration needed for clarity and direction along the pathway to building energy smart communities.

Vision towards Energy Smart Communities

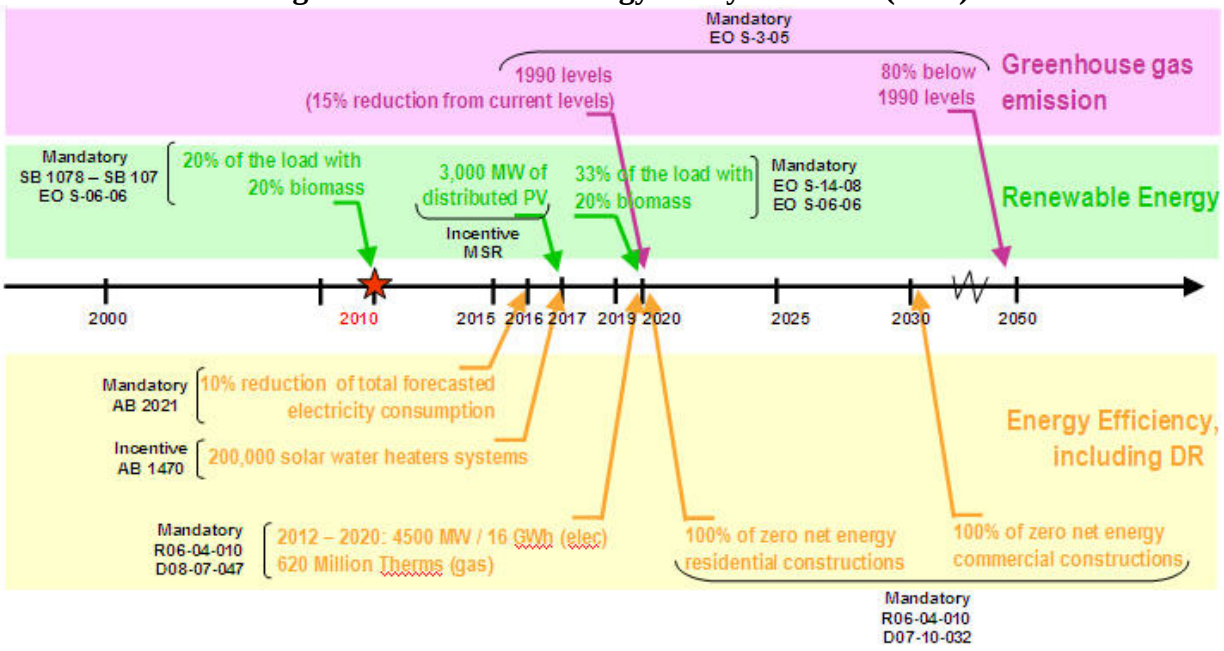
State energy policy goals and targets, as summarized in Figure 1, provide major drivers for the California Smart Grid, including customer energy management. Buildings account for 40% of the nation's energy consumption, 70% of electricity consumption, and nearly half of all greenhouse gases annually [2]. In California, buildings accounted for 80%[1] of the state's total electricity consumption in 2005 [6]. Energy Smart Communities are the future of building construction and they will play a vital role as electric utilities face growing operational and environmental challenges in the future. In particular, California's energy policy towards zero net

[1] The statistic is based on the total electricity consumption of the commercial and residential sectors.

energy home construction by 2020 (see Figure 1) will compel a movement towards these communities. These communities will leverage advancements in customer energy management.

The smart grid enables customers to actively support the reliable, sustainable and economic delivery and use of power by providing feedback to help customers manage the timing and quantity of their energy usage. Additionally, the smart grid will help enable third-parties, including utilities, to manage energy usage on behalf of customers; and allow customers to adopt environmentally-friendly technologies like plug-in electric vehicles (PEVs) and solar photovoltaics (PV) without sacrificing grid reliability.

Figure 1. California Energy Policy Elements (2010)



Source: EPRI [1]

Beneficial Impacts of Customer Energy Management

Customer energy management capabilities supported by the smart grid will result in tangible efficiency improvements in terms of both energy (kWh) and power demand (kW) reductions, maintained and/or enhanced service reliability, safety, environmental improvement, energy independence/ national security and sustainable economic prosperity. The introduction of customer energy management systems in residential, commercial and industrial sectors will stimulate local economies leading to job creation in manufacturing, retail and services as these systems are built, installed and maintained. A reliable electric charging mechanism in customer premises will accelerate the adoption of electric vehicles leading to more energy independence and national security.

Demand response (DR) refers to a dynamic adjustment in electricity consumption coordinated with power grid or market needs. DR can be provided by a number of different resource types (e.g., flexible end-use loads, distributed generation, storage, plug-in electric vehicles, and in some cases renewable resources). Contributions to demand response, which can

be automated through customer energy management systems and incented by time-of-use and dynamic electricity rates, will better match demand to power system or market conditions, thereby leading to lower cost of electricity to rate payers and greater sustainable economic prosperity. Besides adjusting consumption, customers will also be able to provide services back into the grid (e.g., producing electricity via roof-top solar systems, shifting times of electricity consumption using on-premise battery systems, and using inverters to provide voltage support back into the grid). Such advances can be attained in a sustainable fashion, provided markets are appropriately developed for such services and pricing of electric services is aligned with value.

Pathway to Advances in Customer Energy Management

Stages of Technology Readiness

The technology readiness roadmap in Table 1 shows a progression of advancing capabilities in customer premises for customer energy management. The capabilities are grouped into four distinct stages associated with a particular time horizon (short, medium, or long-term). The time horizon (indicated in the second column) represents the soonest infrastructure and technologies are expected to be commercially available to enable widespread adoption of the capabilities and customer applications associated with each stage. As such, the time horizons for each stage indicate the soonest these stages can be reached in the manner described, although supporting activities for each stage may occur simultaneously or continue beyond the time horizons indicated.

Table 1. Technology Readiness Roadmap for Customer Energy Management

Stage	Time Horizon	Applications / Capabilities	Key Enablers
Customer Situation Awareness	Short	• Value-added web tools to understand energy usage (day-after/historical basis); third party access • Near real-time view of energy usage and marginal retail price of energy (via HAN)	• Customer awareness and engagement • Smart metering implementation • Home area network (HAN) implementation • Standards development • Customer privacy issues addressed • Retail product availability
Energy Usage Automation	Short	• First generation devices for automatic trade-off of energy cost, comfort, environmental impact • Remote control capabilities (e.g., via Web) • Residential applications: HVAC, EV charging, household appliances, and other large loads • Commercial applications also include lighting, refrigeration, and other unique loads	• Customer awareness and engagement • Clear customer value proposition • Standards development • Tariffs and incentives in place • Proven reliability and robustness of HAN • Retail product availability
Customer Energy Optimization	Medium	• Advanced automation, control, and optimization • Energy management applications for DG and storage, facilitating zero-net energy constructions (residential and commercial)	• Tariffs and incentives in place • Standards development • Proven reliability and robustness of HAN • Customer awareness and engagement • Integrated DSM systems, including energy storage (commercially viable)
Energy Smart Communities	Long	• Zero net energy constructions (residential & commercial) • Micro-transactions and markets • Community supply source optimization	• Customer awareness and engagement • Energy Storage • Proven reliability and robustness • Smart Grid Implementation

Based on Source: EPRI [1]

Key Enablers for Stage Advancement

The key enablers (listed in the last column) in Table 1 identify critical advances needed to reach each stage of technology readiness. Key enablers for the applications listed include technical enablers (e.g., advanced metering for customer energy usage awareness), regulatory enablers (e.g., tariff or rate development that will incent DR and/or investment in enabling technologies) and customer acceptance (e.g., customer privacy issues, awareness, and engagement).

Generally, technology and operational factors collectively determine what can be technically enabled within the broad realm of possibilities; whereas regulatory policy, customer acceptance, and commercial viability determine more probable outcomes. Standards drive consistency and support commercial viability. For example, advanced metering is a technology enabler for customer energy awareness and other advanced customer applications. The state public utility commission (PUC) had approved each of the three investor-owned utilities' advanced metering infrastructure (AMI) deployment plans in 2006-2008, after having reviewed business cases demonstrating the commercial viability of the respective plans. Utility efforts had also led to publication of technical requirements and open standards for Home Area Networks (e.g., OpenHAN, Smart Energy Profile) that advanced meters would interface with, towards standardization of capabilities prior to AMI deployment. Nevertheless, lack of full customer acceptance for advanced meter installations, an issue which emerged during meter deployment, has compelled the three IOUs to offer customers a choice to opt-out of receiving a new meter. The resulting need for utilities to support both their traditional and new metering platforms, in

order to accommodate customer opt-outs, can begin to erode some of the overall technology benefits for lack of consistency.

Among the many elements that are necessary to support the realization of customer energy management benefits in California is the transition of the electricity industry's market structure to more accurately reflect cost causation principles. Today, much of the load served by utilities is at prices that are well below cost. This means that many customers, given today's pricing for electric service, are less likely to purchase and install energy management devices. Under current utility rate design in place in much of California, net zero energy homes rely on utility provided standby, reliability and power quality services to operate, but do not pay the costs incurred to provide these services. This is because existing utility rates have not unbundled the prices for providing these services from the traditional bundled energy rate. This situation is not sustainable and will eliminate any reasonable opportunity of achieving California's net zero energy vision unless this issue is addressed.

Stage advancement will also depend in large part on how well customers become empowered to take control of their own power usage. A key determinant will be the extent to which utilities can market customer programs in such a way that they are seen as additive by customers and increase customer satisfaction. Other key enablers include evolution of utility rate structures, market development, and retail product availability (e.g., DR-Ready end-use technologies and appliances).

Customer Applications and Capabilities

Capabilities and applications enabled at the customer premises include the following in support of customer energy management:

- Value-added web tools to help customers understand their energy usage during the course of a day, as well as on a day-after and historical basis (e.g., trend analysis, benchmarking)
- Near real-time view of energy usage and marginal retail price of energy
- Authorized third-parties have access to customer data in machine-readable format and can help customers manage their energy usage
- Customers have the ability to obtain and install devices that automatically trade-off energy cost, comfort, and environmental impact based on user preferences; devices also provide remote control capabilities (via Web)
- Residential applications to primarily target HVAC, EV charging, household appliances, and other large loads
- Commercial applications to also include lighting, refrigeration, and other unique loads
- Advanced automation, control, and optimization applications to further help customers easily manage their energy usage and production
- Energy management applications to include distributed generation and storage, facilitating zero-net energy residential and commercial construction
- Zero net energy residential and commercial built environment construction
- Micro-transactions and market development supporting such things as vehicle-to-grid ancillary services
- Community supply source optimization

Benefits

The smart grid will create opportunities for the smart customer of the future to impact energy cost, adjust usage, reduce carbon footprint, and install and effectively utilize DG as well as behind-the-meter technologies [3]. Utility activities to improve customer situational awareness, energy usage automation and optimization provide building blocks towards achieving a vision of the smart customer and ultimately the vision of smart communities. Customer energy situational awareness, automation, and optimization will support beneficial impacts like meeting customer need, enhanced service innovation, reduced GHG emissions, and reduced peak demand. In addition, energy smart communities are anticipated to further the reduction of power losses and provide for microgrid operation.

Utility Activities Supporting Stage Advancement

Customer Situational Awareness - Capabilities

California utilities have been actively working toward improving customer situational awareness via enabling Home Area Network (HAN) capabilities for many years. Each investor-owned utility has filed a Home Area Network Implementation Plan with the California Public

Utilities Commission (CPUC) describing their respective efforts in some detail[2]. Capabilities being enabled under this first stage of customer energy management include:

1. To deliver customer benefits and value leveraging the Smart Meter infrastructure,
2. To give customers choice, control, and convenience regarding their energy usage;
3. To provide rates that empower customers with choice;
4. To protect the security and privacy of customers' data;
5. To target and coordinate technology efforts related to the HAN platform enabling the expansion of the market for customer products and services; and
6. To enable customers to actively participate in demand response programs and rates while maintaining or improving their overall satisfaction levels.

Customer Situational Awareness – Sample Activities

California utilities are conducting on-going work in fielding HAN pilots and although each are in various stages in this effort, each will leverage the Zigbee Smart Energy Profile (SEP) standard. For example, San Diego Gas and Electric (SDG&E) is conducting multiple HAN pilots utilizing a hybrid architecture that includes both a smart meter and an internet connected (broadband) gateway at the customer premise including upwards of 700 customers. Looking ahead in this space, SDG&E has stated:

"SDG&E is considering many factors in planning for its future involvement in the HAN space. SDG&E does not see the value in simply rolling out devices for its own sake. SDG&E's desire is to see how the market can function with various offerings from the utility as well as other vendors, where the cost effectiveness is concentrated, and where the customer experience and engagement can be optimized… While there are certainly many promising scenarios, there are also many uncertainties around those factors." [4]

Similar goals are being strived for by other utilities in the state. Beneficial impacts include improved customer situational awareness to meet customer need, enhanced service innovation, reduced GHG emissions, and reduced peak demand. In an ecosystem of service providers which include utilities and other energy service providers, customers will be empowered with more choice on how and when they use electricity, with the benefit of improved information and enabling technology capabilities.

Energy Usage Automation - Capabilities

Energy Usage Automation builds on the platform developed in the Customer Situational Awareness stage. Customer Situational Awareness is focused on energy usage information flowing to displays and being used in analyses to help motivate customer behavior change. This behavior change will also be impacted with the evolution of utility rate structures. Energy Usage Automation builds off of this capability by enabling customers to automate and manage their energy use through products and services that have been emerging over the past several years, such as internet-connected home energy management (HEM) devices and HAN devices that connect and communicate with smart meters. These products and services fall into two primary categories which are not mutually exclusive. The products in both categories build off of

[2] These plans were filed in response to ordering paragraph eleven (11) of decision (D.) 11-07-056.

capabilities from a well-developed home automation market (e.g., lighting controls with occupancy sensing). These technologies support capabilities for energy usage automation – the ability to send and receive control signals, manage premise data, create control settings, and communicate with energy applications – so that customers can balance between cost, comfort and environmental impact.

Energy Usage Automation – Sample Activities

Automated demand response. California utilities have demonstrated automated demand response through a number of different applications. These include building energy system automation in commercial and industrial facilities, plug-in electric vehicle smart charging (e.g., off-peak charging), and smart appliances that can modulate operations based on dynamic signals in support of grid needs (e.g., air conditioner cycling).

In PG&E's case, these efforts have resulted in well over 80 MW of automated demand response capability under PG&E Critical Peak Pricing, Demand Bidding Program, Peak Choice, and Capacity Bidding programs. PG&E has also demonstrated applying automated demand response for the provision of Ancillary Services (AS) to the wholesale markets, by leveraging automation-based communication infrastructure to provide internet-based price and reliability signals that are linked to facility energy management control systems. The price and reliability signals trigger pre-programmed energy management and curtailment strategies configured by the customers for responding during an event in an automated manner. Both price and reliability signals can be used to automate response to dynamic pricing as well as interruptible and demand-bidding program options.

In SDG&E's case, during the summer of 2011, 3,000 customers were involved in a 'Reduce Your Use' day pilot. As part of the pilot, day-ahead notifications were provided for customers who opted in to that service. For all pilot participants bill credits were calculated and issued based on event day savings below the individual's average during the 11am-6pm period. (A credit of $.75/kWh was used if customers did not have any automated enabling technologies – such as air conditioning cycling devices or programmable communicating thermostats – and a credit of $1.25/kWh if the customer did have enabling technology). This program is to be extended to all SDG&E residential customers in Summer 2012.

Home Area Network rollout. Utilities throughout California are looking at implementing Home Area Network (HAN) capabilities. PG&E will enable a SmartMeter based HAN platform that is responsive to the needs of customers and energy markets, providing near real time electricity usage data, as part of a larger ecosystem of enabling technologies that support customer driven energy management programs. In an initial phase, PG&E is installing and supporting up to 500 in-home displays for residential customers. During the next phase, PG&E is expanding the number of customers up to 5,000 and providing customers with a list of up to five PG&E approved devices (e.g., supportive of Smart Energy Profile) that they can buy through retail channels and self-register their HAN device through an online portal. PG&E is enabling the HAN platform by providing device registration and metering information for up to five approved HAN devices. The device manufacturers can also innovate on the information provided from the SmartMeter to provide for a range of customer experiences and benefits (e.g. information,

monitoring, analytics, automation, etc). In SDG&E's case, the HAN pilots mentioned above are in progress.

Smart thermostat pilot. PG&E is in the initial stages of launching an internet and smart phone connected thermostat pilot, which will enable customers to balance heating and cooling cost with comfort. The pilot will quantify energy savings, as well as measure customer engagement with behavior-based enabling technologies.

Customer Energy Optimization - Capabilities

Primed by the smart grid (including the evolution of utility rate structures), customers who choose to actively engage in demand-side opportunities will have the information and capabilities necessary to allow them to optimize their energy usage and save money on their energy bills. They will be provided an abundance of program and technology options to improve their energy efficiency and increase energy savings. These options range from manual reactions, as a result of better and timelier information being provided related to usage and cost, to automated actions from elaborate energy management systems at customer premises incorporating automated demand response, energy efficiency, distributed generation, and energy storage. As stated in the California Air Resources Board's (CARB's) Climate Change Scoping Plan pursuant to Assembly Bill (AB) 32, "thinking about climate change and our carbon footprint will naturally become part of how individuals make decisions about travel, work, and recreation."[3] Bolstered by the smart grid, utilities will give customers the information, technology, and capabilities they need to use energy more optimally and efficiently.

Through price-responsive DR, customers may benefit directly by choosing to participate and receive financial incentives for doing so. Further, many customers may elect to participate in utility programs in an effort to take actions that support a healthier environment.

Customer Energy Optimization – Sample Activities

California utilities continue to work on better engaging customers, thus educating them on how much energy they are using, when they are using it and the cost of that energy. SCE, for example, is engaged in specific EE and DR program engagement activities that will prepare customers to conscientiously raise their awareness, and most importantly, behave differently with regards to their energy; motivate and incent them to take action by enrolling in special rates and programs; and keep them engaged by helping them to optimize the benefits of participation. While SCE promotes integrated customer energy management as appropriate, it also leverages associated funding (from SmartConnect, Energy Efficiency, Demand Response, California Solar Initiative, the Generate Rate Case, among other sources) to give its diverse customer base targeted information about relevant energy management and dynamic pricing programs.

In particular, SCE is giving customers access to new programs, alerts and technology solutions that will help customers optimize their energy use by responding to events and changing their energy consumption behavior. Activities like Edison's Participating Load Pilot and Proxy Demand Response Pilot demonstrated application of air conditioning cycling to provide non-spinning reserve services, thereby optimizing an end-use in support of wholesale

[3] Assembly Bill 32 Scoping Plan, California Air Resources Board, p. 99.

markets. Of specific interest is SCE's program initiative to integrate EE, DR, and renewable generation programs into a seamless offering for customers through marketing, awareness, program development, and end-use technologies incentives. This initiative is both rooted in SCE's development of best practices as well as California state energy policy, and is identified as Integrated Demand Side Management (IDSM).

Energy Smart Communities - Capabilities

California's Energy Smart Communities future includes thermostats, appliances, and electronic devices that will communicate with the customer's electric meter to allowing them to receive price or event day signals. All customers will be able to view their energy usage on a laptop, smart pad or smart phone at any time, from anywhere along with associated energy pricing based on two or three period time-of-use rates or perhaps even more granular periods. Builders will combine these new smart technologies with energy efficiency, solar panels and storage to create Energy Smart Communities. The electricity markets will have evolved to more accurately reflect cost causation and to include new market mechanisms. Furthermore, community-level production of electricity will be enabled by aggregating the output from solar panels, distributed generation, and storage technologies.

Energy Smart Communities – Sample Activities

Net zero energy community and other smart communities development. SMUD's 2500 R Street project is the first net zero energy community in Sacramento's midtown district. In this project, net zero energy means that over the course of a year, each unit will generate as much energy as it consumes. The combined effort of community partners—Pacific Housing, Sunverge and SMUD—has produced a major achievement in modern, efficient housing. The homes at 2500 R Street are net zero energy, zero carbon, zero emissions, LEED®-certified residences. They satisfy the desire of homeowners not only to save money on energy, but also the need to achieve energy independence and actively address the problem of climate change. Key project design features include:

- 34 single family detached homes sized between approximately 1300 to 1700 square feet
- Solar integrated system, smart appliances, and smart thermostats
- Energy efficiency 40% above Title 24 requirements
- Sited along light rail line and includes community EV central charging station

The homes at 2500 R Street incorporate technology that can enable solar energy to be far more practical and reliable than before. The solar integration system optimizes the value of solar power by leveraging the practical advantages of distributed generation and storage. Through intelligent and cost-effective energy management, the system captures solar energy and stores it using lithium ion batteries, for use when it's needed most, thereby shifting electrical loads, flattening peak electricity demand and maximizing return on renewable energy investments.

These homes also satisfy SMUD's goal of providing a benchmark in determining whether combined energy storage, renewable intermittent distributed generation, and demand response can be controlled and aggregated to provide multiple grid management resources. It will test

whether these resources can be simultaneously used on the customer side to manage electricity use and minimize costs. It will also allow SMUD to implement, evaluate, and advance these technologies as part of its broader Smart-Sacramento® initiative.

As part of this initiative, SMUD is using this project to evaluate the possibility of scale benefits such as spinning and non-spinning reserve capacity, renewable resource firming, regulation support, voltage support and renewable energy time shifting. Demand response use case scenarios and time-of-use rates will also be incorporated into the analysis of this project.

The homes are a prime example of what can be achieved through strategic collaboration, technological know-how and thoughtfully applied green building disciplines. With an innovative grid-tied model that aligns the goals of residential consumers and electricity utilities, this system will allow customers to have more control over their energy usage, operators to optimize the use of the grid assets, and communities to reduce their carbon footprint.

Application of PV, storage and MicroGrids. To demonstrate the impacts of adding distributed energy storage to a residential community with high penetration of PV, SMUD has implemented a significant battery storage project at the Anatolia subdivision. Each home in Anatolia has a PV system ranging in size from approximately 2 to 4 kW. This project is being used to evaluate the impacts of adding community and residential energy storage in order to build a strategy for integrating energy storage with PV throughout SMUD's service territory. The Anatolia project will allow SMUD to monitor PV output, energy storage and customer loads. The resources can be controlled at an aggregate level, or more granularly at the substation, feeder, or individual residence level. While energy storage is seen as a potential solution for "firming" the variable output of PV, there has been a gap in experimental data to show how effective storage might be for overcoming these problems. This project will provide the data necessary for determining the firming potential of PV.

In SDG&E's case, a micro-grid demonstration pilot project is in development in the desert community of Borrego Springs. Jointly funded along with the Department of Energy and the California Energy Commission, this project will use smart grid technologies to integrate and manage distributed resources like solar and storage as well as include testing of an 'islanding' capability and in-home technologies to test a price driven load management system.

Additional benefits of energy smart communities. Energy Smart Communities can provide numerous benefits to end-use customers as well as the utility. The upgrades and tools available in Energy Smart Communities will empower customers with individual control over energy use and monthly bills. The communities will allow customers to reduce their utility costs, purchase cleaner generation, and increase reliability. In addition to these individual customer benefits, the entire community will be able to benefit from the integration of renewables, mitigation or reduction in the price of electricity and the reduced need for additional fossil generation, which leads to reductions in carbon dioxide and other pollutants. In addition to these customer benefits, these communities, along with microgrids and other distributed generation, will assist grid operators in optimizing the use of the grid assets and avoiding excess capital expenditures, which will result in avoided costs to customers.

Collaboration and Future Work Needed

Collaboration among energy stakeholders is critical to advance the California Smart Grid and support the state's energy policy goals. In many cases, technologies already exist; but the cost-effectiveness of their application for supporting energy smart uses needs demonstration and advancement [5]. For example, many types of energy storage technologies have been developed, but cost justification is lacking, especially when the majority of customers' electricity bills are based on energy consumption rates ($/kwh) that are lower than that deliverable from storage. Making more transparent the value of power and other reliability (kw) services the grid also supplies can enhance clarity needed to better cost-justify storage and other demand response enabling technologies that provide value beyond the energy component of electric service.

Standards drive consistency and support commercial viability of technologies, including the systems and products supporting customer energy management. Collaboration is needed in the area of standards development (e.g., communications standards, energy market design, operational processes and policies that better accommodate end-use resources). For example, weak markets with low demand for enabling technologies can be enhanced and strengthened by regional policies (e.g., building codes and appliance standards). In this way, economy of scale is enhanced through standards development, which in turn supports proliferation of products.

An important collaborative effort to enable mass market demand response is the designation of Demand Response Ready (DR-Ready) end uses (e.g., appliances, consumer electronics, etc.). EPRI is facilitating broad stakeholder discussions to designate the capabilities of end uses with grid-supportive functions built-in, towards eliminating the need for utility truck rolls to retrofit end-use equipment with necessary communications and controls to suport DR programs. Collaboration is needed between utilities, equipment manufacturers, governmental organizations, policy makers, and other stakeholders to clarify DR-Ready capabilities, beyond the minimum energy efficiency requirements defined under ENERGY STAR®.

Advancements in customer energy management will also depend in large part on how well customers are engaged and become empowered to take control of their own power usage – a prerequisite proceeding community-level smart energy applications. The extent utilities can offer customer programs that engage participation and incent behavior towards capturing value will be a critical determinant in realizing customer benefits and satisfaction. Collaborative investigation is needed to understand and devise alternative pricing/rate structures that are acceptable to customers, support scalable implementation, and enhance customer choice and service innovations.

Conclusion

Three key entities must "get smarter" and evolve if the state is to advance the smart grid and achieve California policy goals: the energy market, the customer, and the utility. This paper focuses on the customer energy management features that the smart grid will provide towards the enablement of Energy Smart Communities.

In the smart customer vision, customers have a clearer understanding than traditional utility customers about their energy usage, its impact on the electric system, and related energy costs. They have the knowledge and the means to be more of an active participant in the energy marketplace. Customers are empowered with more information and enabling technology to act

upon this information and improve energy efficiency. The smart grid will enable empowerment of customers, allowing them to become active participants in the electricity value chain, potentially reducing energy costs and supporting zero net energy applications.

Utilities and third parties are currently developing numerous products that will enhance, through automation and communication, the customer's ability to act on energy information. Innovations in this area include, but are not limited to, in-home displays and energy management systems, smart appliances, and automatic load control devices. Customers are further empowered to alter their energy usage and become active participants in the grid by engaging in dynamic pricing structures (e.g., time-varying) and incentives for participating in distributed generation, demand response, and conservation programs. Additionally, utility rate structures must evolve to reflect more accurately the principle of cost causation, as well as to provide incentives for customers to shift energy usage from peak periods. Energy markets must evolve to allow for accurate pricing to be promulgated and thereby incent such capabilities as vehicle-to-grid.

California's major utilities are each deploying enabling technologies like Advanced Metering Infrastructure ("AMI") ultimately for the benefit of the customer, the grid, and society as a whole, and to support state energy policy goals. AMI provides the backbone for sharing energy data with customers and enables flexibility in rate design. Development of communication standards such as Smart Energy Profile (SEP) will hasten home area network (HAN) capabilities and device development. Through standards adoption, third parties can enable a myriad of new products and services that can help enable the smart customer and ultimately achieve the vision of energy smart communities.

It is therefore imperative for customers to understand the benefits and the underlying reasons behind smart grid pursuits. Energy professionals in the building, automation, and efficient design industries can assist in securing California's smart energy future by developing a clear understanding of these relationships (between technology, programs, and policy), sharing the vision through direct dialogue with customers, and supporting critical standards development processes.

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