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The Utility-Connected Home: A Primer

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NRECA
America's Electric Cooperatives

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The Utility-Connected Home: A Primer

Introduction

Recent and continuing evolutions in control and communications technologies—including the building blocks underpinning the "Internet of Things" (IoT) and smart grid systems—have given rise to an ever-expanding array of innovative applications and opportunities. Of particular interest for consumers and utilities is the notion of the "Connected Home." A connected home, often known as a "Smart Home," is a premise enabled by communications and automation to allow devices to work with one another as well as external entities.

The combination of applications that are centered on utility-related use cases, together with utility access (or, even, partnership), combine to deliver value to the end-use member and the co-op itself.

Capabilities and applications that make up a smart home can be grouped into a variety of categories, including entertainment, security, automation, and health. Different premises may incorporate these capabilities in a variety of combinations for a variety of purposes, all designed to improve the life experiences of the homeowner.

For co-op members, a smart home is characterized by communications, devices, and applications that enable control over energy consumption within the home. The value of smart homes employing energy management capabilities extends beyond the homeowners to their cooperatives and wider grid operators, developers, and commercial interests.

A closer examination of these technologies, their value proposition, and the transformative promise they offer are the focus of this paper. This paper will not examine the value of providing such services as a function of being a co-op member; that value will vary from co-op to co-op and as various entities sell such services to consumers in local markets.

'Utility-Connected Home' Definition

A connected home not only encompasses a technology platform; it is a purpose-driven affair. While the technology employed in the establishment of a connected home is powerful and interesting, it is the value delivered to stakeholders that is the essence of why the investment is worth the cost. The combination of applications that are centered on utility-related use cases, together with utility access (or, even, partnership), combine to deliver value to the end-use member and the co-op itself.

A close parallel to the connected home may be found in the relationships a co-op has with its commercial and industrial (C&I) customers. In these cases, C&I members engage in close collaboration with the co-op to leverage communications, monitoring, and control systems to manage energy demand and oversee efficiency. A connected home functions in much the same way, only on a mass-market scale with a common technology platform.

It is important for a co-op to understand its member segments and their needs and desires.

The idea is more than just installing some isolated, interesting gadgets to save time or a little money.

Not all co-op members will be ideally suited—with respect to interest or ability—to take advantage of a connected home platform. A classical market adoption curve may be inferred for the likelihood of achieving significant customer participation. While a modest percentage of members will be ready to embrace connected home programs and devices in much the same way that comparable new technology offerings are adopted, there is a roughly equal percentage that will likely be resistant to accepting such offerings from their co-ops.

In order to engage a meaningful share of members, factors such as income level, home ownership, technology acceptance, broadband access, affinity for "green" solutions, and retail services preferences all play a part in the decision making of a given customer group. The concept of clustering, or a herd mentality, may also influence adoption rates within a geographical area or other defined community.

For example, a progressive, tech-savvy urban or suburban customer population may be more inclined to adopt connected home programs in meaningful percentages when compared to a more rural, geographically isolated, less technology-oriented customer group. It is important for a co-op to understand its member segments and their needs and desires.

The chief definition of a utility-connected home is the interconnection of communications, monitoring, and controlling devices regulating a home's gas and electric energy systems. These devices allow for automated control of energy use though the monitoring and management of specific appliances and features in the home, such as water heaters, HVAC, water pumps, lighting, and electric-vehicle charging systems. Provided with enhanced awareness of their energy usage overall, members can make better energy use decisions.

For all utilities, the value is in developing consumer energy awareness and the potential for improved partnerships in lowering energy costs while enhancing customer satisfaction. At the very least, the expectation is that enhanced awareness will empower members with additional information when making energy decisions. This could simply be a byproduct of an energy consumer recognizing where her hard-earned dollars are being spent.

In more advanced cases, a utility can assume an active role in the connected-home relationship, whether via rate programs, integration with smart grid systems, or, perhaps, direct control over devices at the member's premises. Managed loads at the homes of residential members may include water heaters and HVAC systems, or more flexible options such as pool pumps and electric-vehicle charging systems that lend themselves to management with less member inconvenience.

In the fullest sense, the integration of the technological, systemic, behavioral, environmental, and economic opportunities under the heading of a utility-connected home represent a substantial and compelling case for both the member and the co-op to partner. The utility-connected home helps to align interests among stakeholders via information and automation.

The idea is more than just installing some isolated, interesting gadgets to save time or a little money. For the individual member, a utility-connected home provides a means to manage costs meaningfully with added lifestyle convenience. For the co-op, the connected home offers the promise of extending the value of the smart grid directly to members and supporting behavioral change with policy, economic, operational, and environmental benefit.

This has the potential to reshape the transactional nature of the energy-delivery-and-consumption relationship between consumers and utilities. Moving away from the monthly standard of measurement, billing, and payment, significant research and testing is underway to explore how an interactive model between the utility and the customer in a building management context (which is the nature of the utility-connected home) will allow for exchanges that make energy use a transaction between utilities and customers, based on temporal, physical, and economic factors.

As a general reference framework for utility-connected homes, an understanding of typical use cases is helpful; see Table 1.

TABLE 1: Utility-Connected Home Typical Use Cases and Their Benefits.

Use Case Example	Value to Home Dweller	Value to Utility
Climate Control	Reduced Energy Costs, Energy Use, and Cost Visibility	Demand Response (DR), Energy Efficiency (EE)
Load Control	Reduced Energy Costs	DR, EE, Grid Security
PEV Charging Control	Reduced Energy Costs, Energy Use, and Cost Visibility	DR, EE, Grid Security
Timely Usage Information	Energy Use and Cost Visibility	EE
Timely Cost Information	Energy Use and Cost Visibility	EE
Cost-Based Behavioral Modification	Reduced Energy Costs, Energy Use, and Cost Visibility	DR, EE

Connected Home Technology Platform

An examination of the associated features, capabilities, and trade-offs currently underpinning the technology platform associated with the utility-connected home must consider the concept of a Home Energy Management System (HEMS) in combination with the related communications technologies that provide connectivity both between the premises and the utility and within the home itself. **Figure 1** provides a conceptual view of a HEMS system incorporated with the required communications layer in a fully integrated smart home, as envisioned by a leading research effort on the subject.[1]

COMMUNICATIONS

The communications layer within a home is typically referred to as a home area network (HAN), but mixing of terms has often led to confusion of this concept with home automation network, also sharing the same abbreviation. Recently, the concept of a customer premises network (CPN) has become a common term to define the critical element of communications supporting message exchange among smart meters, energy management systems, load controllers, smart appliances, and electric vehicles in a home or building.[2] A variety of wired and wireless networking technologies is available and new protocols are being considered. Give some attention to these technical features—alongside CPN requirements (in light of market adoption rates)—when selecting utility-connected home components to recommend.

Utility-connected home CPN environments are characterized by devices that require neither low latency

1 Karlin, Beth, et al. "**Characterization and Potential of Home Energy Management (HEM) Technology**." Pacific Gas and Electric Company. January 20, 2015.

2 Kuzlu, Murat, M. Pipattanasomporn, and Saifur Rahman. "**Review of Communication Technologies for Smart Homes/Building Applications**." *2015 IEEE Innovative Smart Grid Technologies – Asia* (ISGT ASIA). November 2015.

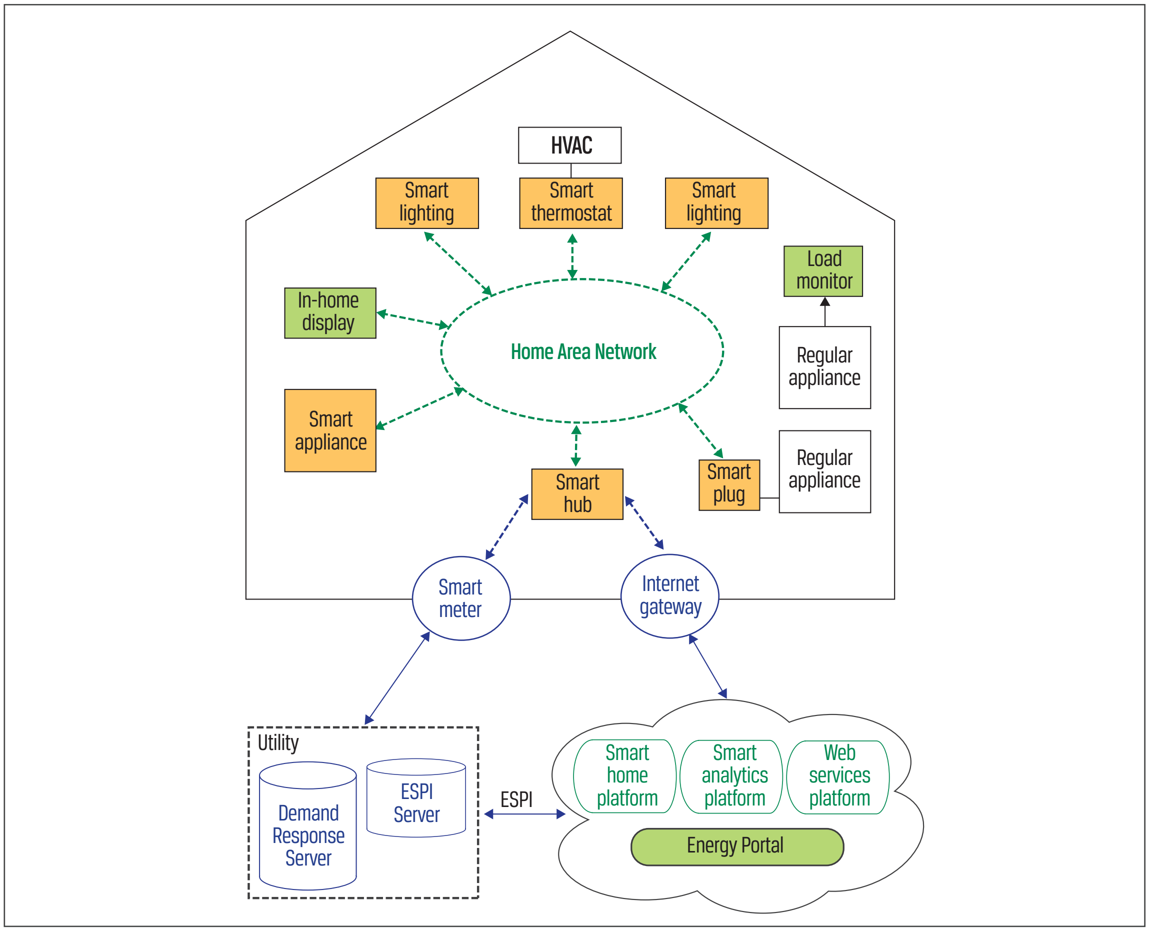

FIGURE 1: Conceptual View of a HEMS System and Communications in a Fully Integrated Smart Home.

nor high bandwidth. Most current HEMS applications involve data payloads of only 100–500 bytes at sampling frequencies that are configurable, but typically not less than 1 minute in granularity. Furthermore, latency requirements are in terms of seconds, on average, though reliability is required to be 98% or greater. These needs can be met by a wide variety of communications protocols and technologies. **Table 2** summarizes wired and wireless communications technologies for CPN applications.[3]

The technical specifics about the design and function of these networking protocols are beyond the scope of this paper; however, chief considerations for selection of networking standards and the HEMS devices should be driven by performance requirements, market adoption, device support for interoperability considerations, and flexibility. To this last point, the choice between wired and wireless network media is typically driven by locational flexibility in the case of a CPN, as data rates in the wireless technologies are more than adequate for HEMS applications.

3 *Ibid.*

TABLE 2: Wired and Wireless Communications Technologies for Customer Premises Networks.

Technology	Standard/Protocol	Max. Theoretical Data Rate	Typical Coverage Range	Market Adoption
Wired Communication Technologies				
Ethernet	IEEE 802.3	10 Mbps–100 Gbps	Up to 100 m	Extremely High
ITU-T G.hn	ITU-T G.hn	1 Gbps	N/A	Low
PLC	X10	120 bps	Up to 300 m	Medium
	Insteon	13 kbps	Up to 3,000 m	Medium
	IEEE P1901, HomePlug AV	200 Mbps	Up to 300 m	Medium
	IEEE P1901, HomePlug GP	10 Mbps	Up to 300 m	Medium
	CE Bus	10 kbps	Up to 3,000 m	Low
	LonWorks	1.25 Mbps	Up to 3,000 m	Low
Serial	RS-232	1 Mbps	Up to 15 m	High
	RS-422	10 Mbps	Up to 1,200 m	Low
	RS-485	10 Mbps	Up to 1,200 m	High
HomePNA	HomePNA	240 Mbps	Up to 300 m	Low
MoCA	MoCA	800 Mbps	Up to 60 m	Low
Wireless Communication Technologies				
Wi-Fi	IEEE 802.11	2 Mbps	Up to 100 m	Extremely High
	IEEE 802.11a	54 Mbps	Up to 50 m	Extremely High
	IEEE 802.11b	11 Mbps	Up to 100 m	Extremely High
	IEEE 802.11g	54 Mbps	Up to 100 m	Extremely High
	IEEE 802.11n	600 Mbps	Up to 250 m	Extremely High
ZigBee	802.15.4, ZigBee	250 kbps	Up to 100 m	High
	IEEE 802.15.4, ZigBee Pro	250 kbps	Up to 1,600 m	High
Z-Wave	Z-Wave	40 kbps	Up to 30 m	Medium
Bluetooth	IEEE 802.15.1	721 kpbs	Up to 100 m	High
6LoWPAN	IEEE 802.15.4	250 kbps	Up to 100 m	High
IEEE 802.15.3a	IEEE 802.15.3	1.3 Gbps	Up to 10 m	Medium
EnOcean	EnOcean	125 kbps	Up to 30 m	Medium
Wave2M	Wave2M	100 kbps	Up to 1,000 m	Low
RFID	RFID	4 Mbps	Up to 200 m	Medium
ONE-NET	ONE-NET	38.4 kbps	Up to 100 m	Low

The possibility exists to implement functions that allow the user or utility to manage load actively.

Selecting a wired technology would be physically limiting on the placement of devices in a home. While the range of network technology options appears significant, the easiest approach—and one that will help ensure connectivity and interoperability—is to leverage Wi-Fi for IP-based communications between HEMS components, with connectivity to the Internet and the utility through a home gateway and service provider interface.

Co-ops have a number of network technologies to consider for interaction with the CPN and HEMS. Generally, the requirement is for Internet connectivity to gain access to on-premises systems. Smart meter networks were originally promised to deliver CPN or HAN connectivity, generally through a built-in ZigBee interface under the meter glass.

However, these solutions have proven cumbersome to administer and not well-suited to the intended use and design of Smart Meter networks, which are typically designed to meet the demands of delivering meter data rather than the more ubiquitous networked applications. As long as Internet service is in place, the CPN can be accessed by the utility to serve the connected home using Internet protocol (IP) and Internet of things (IoT) based principles. This is a significant barrier for many co-op territories that lack adequate Internet access.

HEMS TECHNOLOGIES

HEMS technologies are comprised of three categories of products or applications as outlined below[4] with their constituent functional elements:

- **User Interfaces**
  - Energy Portals
  - Load Monitors
  - In-Home Displays (IHD)
- **Intelligent Devices**
  - Smart Appliances
  - Smart Thermostats
  - Smart Lighting
  - Smart Plugs
  - Smart Hubs
  - Smart EV Chargers
- **Software Platforms**
  - Smart Home Systems
  - Data Analytics
  - Web Services

The ability to select and configure elements as desired means that there is no single definition of a HEMS. Each utility and customer can define a solution that best fits their needs.

The primary function of user interfaces in a HEMS is to engage the home dwellers by providing information to help them make better-informed decisions about energy usage. Intelligent user interfaces will be able to provide more than details about consumption and load; the possibility exists to implement functions that allow the user or utility to manage load actively.

Intelligent devices enable specific control over energy-consuming appliances within the home. Some of these devices—such as smart refrigerators and washing machines—are programmed with functions that provide inherent energy management capabilities. Others, such as plug-based load controllers, provide information and some control leverage over the devices that are connected to them. Ultimately, the programming in these units is oriented around altering the energy consumption of the device based on inputs from other intelligent control systems such as smart hubs or energy management systems. Some devices are designed with the capability to self-manage their energy consumption.

[4] Karlin. *Op. cit.*

Almost all definitions of a HEMS platform encompass the ability for home dwellers to interact with the energy delivery system or grid and, consequently, the utility.

The true value for utilities exists in the software platforms that communicate data between users, the utility, and the hardware on the premises. Smart home platforms are intended to provide a comprehensively managed home energy system. Analytics—the interpretation of meaningful patterns in data—are typically hosted in the cloud and provided by utilities or third parties. The intention with analytics is to sort through a large amount of utility and premises data for automated action or useful information for home dwellers. Web services allow for utility and third-party control over devices on premises as a programmatic interface.

Examples of each of these solution types are numerous and continuously changing. Vendors are entering (and exiting) the marketplace for each HEMS technology. Standards are evolving and new protocols are also under development. Collaboration opportunities make for continually shifting alliances. For utility leaders, a detailed, timely industry survey will be required before finalizing architectural, programmatic, or procurement decisions pertaining to a utility-connected home strategy.

As a part of any strategic decision, a careful assessment of market adoption must also be undertaken. It is not clear that home dwellers are fully embracing the value/promise of these technologies, further complicating the settling of standards and brand leadership.

Almost all definitions of a HEMS platform encompass the ability for home dwellers to interact with the energy delivery system or grid and, consequently, the utility. The primary purpose of the HEMS solution is to provide monitoring and control functions, as described in Figure 2.[5]

This framework provides a model by which utilities can clarify their strategic intention in employing the technology. Is there an interest in simply signaling consumers about their energy use so they can modify it or not, or is there a desire to organize a program to spur a specific action on the consumer's part based on a price or load condition? Does the utility wish to take direct control of one or more load contributing devices in the home, such as an air conditioner, in order to mitigate demand? Or is there automation that can be scheduled according to program rules or a condition-based algorithm? These considerations and program design goals will tell the utility what the HEMS technology needs to accomplish. Clearly defining the level of automation, customer collaboration, market uptake, and dependence on human behavior are integral concerns for utility programs making use of a connected home model.

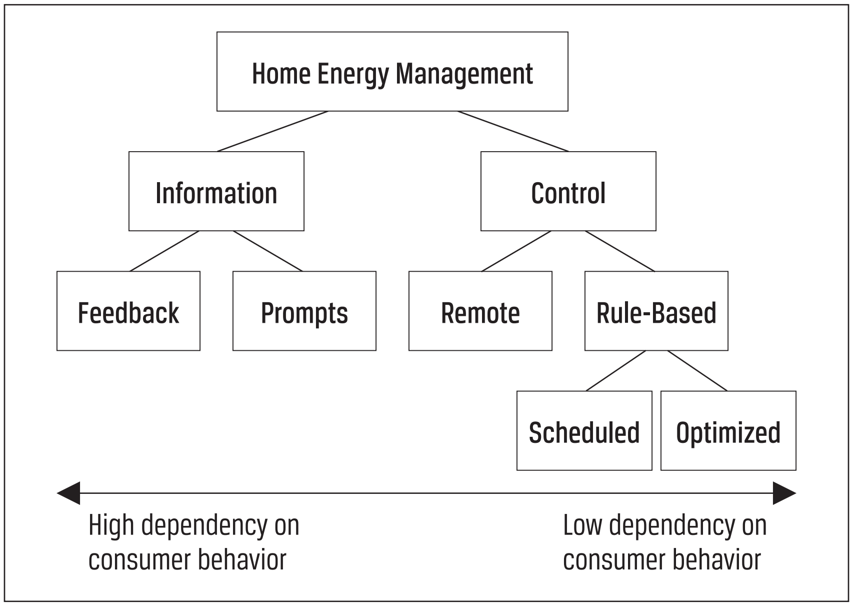

FIGURE 2: Monitoring and Control Functions of Home Energy Management Systems.

[5] *Ibid.*

The utility-connected home presents a unique context within which to leverage data as part of an intimate customer relationship.

The proliferation of consumer-facing products in the marketplace also make it increasingly likely that members will select and install their own products based on needs they identify. For co-ops to capitalize on this trend, their plans will need to contemplate a 'bring your own device' (BYOD) policy and design. Thermostats, plug load controllers, pool pump controllers, and EV charging systems are all fair game. Technical compatibility, standards, and customer communications become primary concerns so that a co-op can inform members about available choices and then incorporate these possibilities into the design of its technology plan. This is not an easy task. But it is one of the critical components of a successful program.

Various electric utility industry consortia and agencies are engaged in developing standards and compatible products aimed at providing dependable interoperability for customers and utilities in order to ease the technical engagement process for BYOD devices. The **Open Automated Demand Response Alliance (OpenADR)** is one such example. Its goal is to standardize communications between power sellers, utilities, and consumers using open development principles in order to enable demand response. Using a standards-based approach, OpenADR has achieved significant industry acceptance and is partnered with the U.S. Department of Energy (DOE), Federal Energy Regulatory Commission, and the National Association of Regulatory Utility Commissioners. A strong roster of product vendors is engaged in enabling BYOD programs using this standards-based effort.

Another program to consider is **VOLTTRON**, sponsored by DOE. Per its website, "VOLTTRON™ is an open-source, secure, extensible, and modular technology that supports a wide range of applications, such as managing end-use loads, increasing building efficiency, integration of distributed variable renewable energy, accessing storage, or improving electric vehicle charging." This is another example of concerted efforts to develop standards and technology to enable interoperability for specific utility outcomes. NRECA and a group of cooperatives are participating in a field demonstration of the VOLTTRON system with Pacific Northwest National Lab.

DATA AND ANALYTICS

As Smart Grid and IoT-based solutions continue to proliferate at utilities, the resulting cascade of data—in increasing volumes, velocities, and varieties—poses significant challenges in terms of data curation, analysis, and business value. While this is generally true in many utility business and operational models, the utility-connected home presents a unique context within which to leverage data as part of an intimate customer relationship.

A number of data resources converge around the utility-connected home, including data related to smart meters, customer rates and billing, customer program participation, utility program rules, utility operational data (load curves), weather, and more. These data resources must be aggregated and analyzed for both utility use and delivery to customers and their HEMS endpoints as signals for either information or automation. Broader data analytics strategies are a significant topic in their own right, but, for the utility-connected home, the focus is on software and hardware that deliver data warehousing, analysis, visual displays, and communications via media such as web or mobile interfaces in a cloud-based platform. Most utilities are entering the analytics discussion carefully at this time and there are commercially available solutions in the market today that are targeting home dwellers directly, thereby alleviating the need for utilities to go it alone.

Utility motivation might be better described as utility value.

The ability to shed load during times of peak demand is often critical to system stability, resource efficiency, and cost reduction.

The best solutions will take on the burden of processing the data for the utility and delivering information, tuned with behavioral science, to interfaces in mobile, web, or HEMS environments so that utility program goals such as DR and EE can be achieved. A number of solutions are in the marketplace that use cloud-based algorithms to optimize DR and performance monitoring on behalf of utilities for the benefit of customers. Some of these solutions can adjust settings on devices (such as thermostats) based on rules and conditions in order to help the home dweller to save money. A comprehensive utility-connected home strategy must incorporate the data analytics requirements that support the business objectives of the utility.

Co-op Motivation

Utility motivation might be better described as utility value. Looking past member interests to invest in a co-op-connected home technology, the co-op itself must see value in the effort.

For most utilities—investor-owned, municipal, and cooperative—investments required to engage in a connected home strategy are not trivial. Some co-ops may have some of the technology building blocks necessary from prior investment. Certain co-ops may possess the organizational capacity and expertise necessary to address the programmatic and technical needs. Others may need to consider additional investments in technology or human capital to meet the desired objectives. In some cases, these needs may be met by engaging partners to address requirements. Nevertheless, a careful examination of available technologies, competencies, and capacities is necessary to develop a clear strategy for connected homes and to define the actions and investments necessary to meet desired goals.

To properly explore the co-op motivation, it is best to start with the end in mind. Most utility-connected home programs are undertaken to meet specific business or operational objectives. The following are several of the most common goals or benefits identified for a utility-connected home strategy:

- Demand reduction
- Voltage control
- Frequency regulation
- Energy efficiency

DEMAND REDUCTION

Demand reduction (or demand response) is often one of the primary goals of consumer-facing utility programs and, consequently, a utility-connected home program. The ability to shed load during times of peak demand is often critical to system stability, resource efficiency, and cost reduction. The HEMS solution provides an opportunity to send signals to home dwellers to take a specified action. Most DR programs involve voluntary participation on the customer's part with a specific action, such as turning off A/C or other high-demand household systems. This would involve the information provision function of the HEMS, or some other service such as web or mobile interfaces, and previously arranged customer behavior.

There is an administrative cost to this program in terms of customer engagement and commitment management. Conversely, the scope of response can be relatively easily predicted as customer participation is known in advance. The degree of automation required is generally limited to notification only, with actual response measured on a system-wide basis or, perhaps, at the individual smart meter but only in terms of actual demand reduction overall.

Other DR programs may be conceived with a dependency on automated signaling and response. Technology now allows for utilities to send demand reduction signals to a fleet of homes—or individual dwellings—with compatible HEMS whose residents have committed to participate in DR events via the automated limitation of use of specified devices, such as A/C. On the surface, this may not seem much different than options such as remote A/C switch programs that some co-ops have employed for years. But the opportunity to provide information to members, engage in confirmed, *two-way communications* with the HEMS control on member premises, and operate in a granular, informed manner, is a superior option.

The program effort is likely to be similar in terms of communications, technical setup, and event execution. However, results can be managed and monitored much more effectively and, by using automation, dependence on human behavior is eliminated or reduced. The utility-connected home provides for verifiable and measurable response, by premises, with specific load reduction performance confirmation. The ability to manage DR on an area-specific basis, with locational opportunities in terms of system performance and economics, becomes a realistic possibility. By integrating premises-based controls through the HEMS, a DR program has the potential to become a tunable, non-wired alternative to additional distribution system investments.

Enticing members to use more-efficient appliances is one challenge, but altering member behavior is quite another.

ENERGY EFFICIENCY

Energy efficiency (EE) programs have been employed by co-ops for years with the goal of reducing overall electric consumption by members. The effectiveness of traditional programs can be difficult to measure and track. Typically, most utilities take the approach of portfolio estimation in an attempt to account for the effectiveness of various programs. Simply replacing a refrigerator with a more efficient unit is estimated to deliver a certain EE benefit.

Meter data can help to validate reduced consumption at a home overall, but actually tracking benefits at the premises or aggregate level becomes an exercise in estimation. A utility-connected home with a HEMS solution provides for the incorporation of smart appliances that can modulate their own use of energy and provide feedback to the home user about energy costs and usage timing to help balance demand and operate more efficiently.

Enticing members to use more-efficient appliances is one challenge, but altering member behavior is quite another. In order to help members to respond to information about energy consumption and costs, the utility-connected home can allow co-ops to communicate with and signal consumers about peak cost periods based on their consumption, rate structure, and demanding weather and grid conditions.

Energy efficiency programs can be designed with behavioral assumptions in mind and tuned to meet actual performance, with specific effectiveness measures for individual homes. Consumer demographic analysis can be applied to program design in order to ensure that individual consumer needs and concerns are taken into consideration, both in terms of how signals are delivered and how effectiveness is measured. The goals of reducing energy consumption or shifting periods of activity based on customer action can now be more accurately defined and managed.

Further EE gains can be achieved using full automation. For those members using plug in electric vehicle (PEV) chargers at their homes, the ability of the co-op to engage the charging system directly offers the opportunity to shift significant load and reduce overall charging requirements. These systems lend themselves to automated utility control as the consumer expectations provide for degrees of freedom in the timing and performance of the system.

Recent studies have suggested that PEVs can participate in frequency regulation.

Co-ops may also be motivated to use a connected home strategy as a means to improving member relationships.

This freedom contrasts significantly with A/C control automation where comfort settings are usually quite noticeable to customers and are likely to affect participation rates. A PEV can be set to charge more efficiently at times of the day when the distribution system can most tolerate the demand, while also reducing overall cost. An additional benefit of automated control over PEV charging by the utility is the opportunity to engage the PEV battery as a source of energy for the grid to either serve demand or meet grid security requirements for frequency and voltage stabilization.

GRID SECURITY

Premises-based solar photovoltaic (PV) and energy storage provide the opportunity for frequency regulation and voltage control in a utility-connected home scenario, along with the PEV battery. In fact, recent studies have suggested that PEVs can participate in frequency regulation.[6] With rapid smart grid technology development, the customer can actively participate in demand-side management (DSM) with the communication of information between the distribution co-op and the smart devices in real-time.

Controllable load management not only has the advantage of peak shaving, load balance, frequency regulation, and voltage stability, but is also effective at providing fast balancing services to the renewable energy grid in the distributed power system.[7] These premises-based systems present challenges with small loads and smaller, distributed energy sources, but the technical potential exists and can be enabled in utility-connected home implementation using a combination of technologies.

MEMBER RELATIONSHIPS

Co-ops may also be motivated to use a connected home strategy as a means to improving member relationships. The likelihood of members employing HEMS solutions independent of co-op participation is expected to increase. Members will purchase devices and systems based on their needs, over time, as capabilities and consumer-facing value continue to improve. In fact, the market is evolving rapidly.

Along with these premises-based tools, companies are offering services and products to manage energy and control home-based systems outside of co-op input. This circumstance sets up a competitive challenge to co-ops, which can have the effect of further distancing the member from co-op value-added services or, perhaps, substituting the utility in a substantial manner in the customer relationship.

As deployment of DR and storage technologies grow, the risks of grid defection and a future where utilities sell less of their primary product (energy), the need to hold members close and engage them meaningfully in this evolution becomes more pronounced. It could become a key component of being a consumer-centric utility. Although the likelihood of individual residential premises defection is currently unlikely, some co-ops are concerned about understanding and improving member relationships with targeted services.

[6] Wu, Chenye, Hamed Mohsenian-Rad, Jianwei Huang, and Juri Jatskevich. "**PEV-Based Combined Frequency and Voltage Regulation for Smart Grid**." *2012 IEEE PES Innovative Smart Grid Technologies (ISGT)*. January 2012.

[7] Shen, Jingshuang, Chuanwen Jiang, and Bosong Li. "**Controllable Load Management Approaches in Smart Grids**." *Energies*, vol. 8, no. 10, Oct. 2015, pp. 11187–11202.

A part of developing a utility-connected home strategy must address necessary technology-specific skills.

KEY BENEFITS

The co-op motivation to engage in a connected home strategy can typically be characterized in terms of the following benefits:

- Operational improvement and stabilization
- Energy efficiency and demand reduction
- Member engagement improvements and partnership
- Integrated customer, system, and program management

The Transformative Utility Impact

In order to understand the value of connected homes to a utility, it is important to consider what is required in terms of investment. For reference, a utility considering connected homes would generally require the following:

- A comprehensive utility-connected home strategic plan
- Existing competency in program and technology management
- A network of partnerships with expertise and service providers
- A reference technical architecture[8] incorporating both utility and end-user technologies
- Programs with specific goals defined to make best use of customer HEMS platforms
- A basic foundation of smart grid capabilities, such as smart meters and related communications

For many but the most well-resourced (typically largest) utilities, many of these needs will be beyond their current reach in technological, capital, and competency terms. This will require a searching, realistic assessment of internal capabilities in light of connected-home strategic objectives, followed by outreach to secure the needed assistance and solutions. Many cooperatives may look to partner with neighboring co-ops or their G&T network to launch such programs.

The transformative impact of implementing a utility-connected home strategy extends well beyond the implementation effort. Utilities should expect to modify components in the following areas as a result of implementing a connected-home strategy:

- Technology and technology management
- Policy
- Process
- Workforce
- Culture

TECHNOLOGY PLANNING

The technology challenge for co-ops will extend beyond the capital investment and procurement of the solutions themselves. The technology skills required must align with smart grid systems, analytics, and HEMS interaction requirements, potentially exceeding the existing capabilities of many utilities. Many utilities—particularly those that are consumer-owned and less resource-rich—are built to operate quite well and manage core technology infrastructure. However, when challenged with transformational technology opportunities and advanced system management requirements, existing skillsets may not be adequate. A part of developing a utility-connected home strategy must address necessary technology-specific skills.

Beyond implementation and administration, technology planning will also become an important practice for a co-op to cultivate culturally. The planning culture is not confined exclusively to the needs of the connected home, but it is a vital practice to

8 "Reference technical architecture" provides a template structure and common vocabulary to map the relationships among program elements to ensure the consistency and applicability of technology use and information exchange within an organization or program.

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implement for a utility overall. It should be noted that, in many examples, significant business benefit and technological improvements have been realized through the adoption of diligent planning.

Sound technology planning is typified by the following best practices:

- Business-driven functional and project needs are identified within a regular planning cycle.
- Technology is viewed as an enabler and capability consultant of the business, not a driver of the business.
- Technology planning priorities are identified in support of utility and business functional priorities.
- Technology maintenance is considered alongside business functional needs.
- Projects and investments are properly planned, funded, and staffed as a part of a formal governance and approval process.
- Information Technology (IT) and Operational Technology (OT) are managed as a portfolio of benefits and costs to identify the highest priorities for funding.
- A roadmap of technology projects is planned and managed.
- A stakeholder-oriented, team-based approach is used to engage leadership and staff across the organization in setting priorities and budgets for technology.
- Stakeholder steering committees are used to govern planning and implementation of projects.
- A process exists to allow for unanticipated business or technical needs to be met in-between planning cycles.
- Projects are planned and led with an understanding of business value, technology, workflow, and change management.
- The technology plan is defined, managed, and measured on a regular basis.

Along with smart grid technology and data analytics, connected homes further elevate the need to plan and manage technology effectively. Technology and HEMS-device standard policies should be developed to help guide the cooperative and its members in incorporating premises effectively into the connected-home program.

POLICY AND PROCESS

Policy requirements will be specifically associated with a connected home. Some of those policies may be compelling reasons to adopt a utility-connected home strategy, such as external drivers influencing greenhouse gas mitigation, renewable power supply integration, or customer empowerment. More and more regions in the country are moving progressively to adopt policies that will influence how utilities plan resources, generate and deliver power, and engage customers.

In terms of policy objectives that are under utility control, examples include how technology is leveraged to drive customer behavior, rate and billing policies, program-related policies covering incentives, information security and privacy policies, and technology governance policies to control BYOD interoperability and connectivity. As a part of governing externally facing practices and standards, and to enforce critical internal-process adherence, policy definition and enforcement will require careful assessment and planning in concert with business process and technology.

Transforming the way your co-op currently conducts business is key to obtaining the required value from any technology implementation or strategy. As a part of executing a connected-home strategy, utilities must consider how the process might evolve during cross-functional

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The customer-centric aspect of a connected-home strategy may demand a cultural shift, depending on how the co-op is perceived and the historical performance of member-engagement functions.

business shifts and the use of new technologies inside and outside of the utility. These impacts should be anticipated in the following areas, at a minimum:

- Customer service
- Billing
- Grid operations and communications
- Distribution system planning
- Resource planning
- Energy efficiency programs
- Consumer communications and marketing
- IT/OT technology administration

Best practices indicate that a careful process impact study must be followed up by current process mapping and a cross-functional process change assessment. Ideally, the results will include a repository of standardized process documents with specific details pertaining to technology intersection and member interface. This process analysis will help inform the cooperative about changes, identify skill gaps, and support training and other transition requirements, much like any complex technology implementation.

At the intersection of technology, policy, process, and expertise is privacy and security. As a point of emphasis, it is vital for co-ops that are reaching out directly into member premises and engaging with new technologies and information to have a clear understanding of information privacy and security concerns. Subject matter expertise, either within the cooperative or procured for the co-op, must be employed to develop policies and procedures governing business processes, customer engagement, technical security, and ongoing testing.

WORKFORCE AND CULTURE

Workforce transition requirements are very much dependent upon the core competencies already in house at the cooperative. Skills requirements, as noted in this paper, are going to evolve, in particular in the functional areas listed prior. This is not likely to require a significant hiring plan, but, as a part of the utility-connected home strategy, a workforce assessment should be undertaken to determine where key gaps exist or where known transitions are likely to occur. Long-term skills can be identified along with transitional skillset needs, then a rational, cost-effective approach can be devised, including the hiring of temporary expertise to fulfill unique roles or requirements.

Culturally, the impact of a connected-home strategy may result in minimal change. It depends upon the baseline cultural makeup of the cooperative and strength of influence exercised by leadership. The customer-centric aspect of a connected-home strategy may demand a shift, depending on how the co-op is perceived and the historical performance of member-engagement functions. Because the success of the strategy will depend upon member engagement and perception, trust must be established and maintained. A misaligned culture will make this a harder task and the results may be painfully evident externally. The execution of programs designed to take advantage of a connected home will have a bearing on market adoption, which will then affect the results that can be achieved.

As a less tangible and measurable aspect of the utility transformation, a cultural assessment—including all levels of the organization—should be undertaken. Experts skilled in cultural evaluation and change can be obtained to plan, orchestrate, and support the necessary shifts. It is important to recognize that cultural transformation is a slow process and one that is hard to recognize other than over the course of time.

The more dwellings that adopt the HEMS platform with utility integration, the better the expected savings and results from the programs.

The number of smart thermostats in North American and European homes is projected to increase 64% annually by 2019.

Member Programs and Adoption

Member programs using HEMS and the connected home can provide incredible value for co-ops. Alignment of program goals to strategic objectives is a critical step, followed by the alignment of HEMS implementation and execution with program design. This is the crux of how the savings potential of the connected home will be realized. Ultimately, the adoption rate of the utility-aligned HEMS platform is key, so the rate of that adoption must be both maximized and well-understood in order to properly tune DR and EE programs for results.

As discussed elsewhere in this paper, successful use of technology and program design is dependent on both automated responses and the spectrum of human behavior. The levers at the co-op's disposal are contained within the program rules and incentives. Solid program adoption depends upon incentives, usually aligned with price signals that compel the desired response on the part of the member participant. Even where these rules are codified and automated in a HEMS system, customer commitment is still required for adoption and program goal realization. The design of specific DR and EE programs is highly utility-specific, but these goals should be carefully considered in the requirements specifying the HEMS platform.

Communications used for customer-facing programs is an important success factor as well. Careful marketing based upon clear customer segmentation and goal alignment with customer-facing programs should support HEMS adoption and customer participation, thereby maximizing expected results. Customer participation is, after all, voluntary at every level in this strategy. Market analysis and professional communications support in planning, selling, and delivering customer programs is key.

This leaves the co-op in the position of maximizing HEMS adoption as a means to achieving the best value possible from the customer programs and the connected-home strategy. The more dwellings that adopt the HEMS platform with utility integration, the better the expected savings and results from the programs.

Available studies assessing HEMS adoption propensity and actual adoption rates are somewhat dated at this point. Quite a lot of market research dollars are pouring into studies of connected-home technology in general for product and general adoption propensity. Generally, momentum in the connected-home market is gaining ground with a roughly 30% compound annual growth rate (CAGR) overall. This does not refer specifically to the utility-connected market.

Some utility-specific insights are available. In October 2015, Deutsche Telekom released a study of the multibillion-dollar smart-home market that called out impressive numbers: The number of smart thermostats in North American and European homes increased by 105% in 2014 to a total of 3.2 million units, according to Berg Insight, and is projected to increase at a compound annual growth rate of 64.2% by 2019. Navigant Research predicts global revenue from home energy management to grow from €533 million ($568 million) in 2014 to €2.18 billion ($2.32 billion) in 2023. Deutsche Telekom believes the smart home market will really take off when companies focus on customers' primary needs, which includes home energy efficiency.

The smart home system market is competitive. Consumers can find whole ecosystems of tech products for their homes in systems such as Apple's HomeKit or Belkin's WeMo.[9] Like many other technology trends, there are indicative demographic trends to be understood. Applying available insights or gathering direct study data may support the development of effective marketing strategies.

Strategies to engage consumers in taking up this technology—and, specifically, technology that meets a utility's needs—must include early definition of the programmatic requirements, clarity around HEMS requirements (preferably standards-based), clear communications to customers about the benefits and technology options, and ongoing marketing. The goal is to end up with a clearly described population of HEMS-enabled members, with compatible and connected systems, who are interested in participating in the cooperative's programs. Provide as much definition and clarity as possible—in easily accessible formats—to help users see the benefits and understand what to buy.

Factors motivating the adoption of HEMS technology are noted in Table 3.[10]

TABLE 3: Factors Motivating the Adoption of HEMS Technology.

HEMS or Related Technology	Motivation Factors in Persuasion Stage
Home Energy Audit (adopters)	• Save energy • Reduce costs • Increase efficiency • Improve comfort • Solve particular problems • Issues of health and safety
Smart Grid Technologies	• Useful to society and the environment
Smart Home Devices (intending adopters)	• Interoperability • Easy • Control • Safety • Convenient
Smart Home (adopters)	• Novelty • Cost savings • Reduction in electricity use • Being green
Smart Home (mostly nonadopters)	• Safety: Home security, hazard protection (floods, fire, etc.) • Information: Home monitoring • Convenience • Feel more tech savvy • Financial: Monthly fee, cost of equipment, savings on energy bills, insurance discount • Ease of use
Automation (mostly nonadopters)	• Lighting • Temperature
Load monitor (adopters)	• Curiosity • Gathering information • Attributing blame to appliances/devices
Feedback (recruited users)	• Financial savings • Environmental concern
Smart home and advanced telemedical technologies (mostly non-adopters, older adults)	• Emergency help • Prevention and detection of falls • Monitoring physiological parameters • User-friendliness • Lack of human response

Barriers

Barriers to a utility-connected home are noted throughout this paper and summarized here. It is important to understand each in the context of a specific utility plan and to develop rational, effective approaches to overcome or address each one. This is an emerging field of engagement for utilities and risks must be detailed and mitigated in much the same way as any other initiative.

These barriers and risks include:

- Interoperability in the HEMS environment
- Data privacy and security
- Consumer engagement
- Utility technology management maturity
- Third-party providers
- Data analytics maturity

[9] Dobush, Grace. "**How Smart Homes Help Energy Efficiency**." Blog. Consumer Technology Association. Dec. 9, 2015.
[10] Karlin. *Op. cit.*

Engaging other entities in the promotion and installation of the utility standard HEMS solution can only help to drive adoption rates higher.

Community Partners

A number of stakeholders and partners will be interested in the opportunity to support a utility-connected home program. Engaging these stakeholders as a part of defining the strategic plan and as a part of its execution will result in a more effective program with stronger adoption and enhanced technical capability.

Each utility must consider a stakeholder analysis carefully. The following are important representative examples:

- Municipalities
- Developers
- Network Operators

Municipalities, in particular for consumer-owned utilities, are important stakeholders. These entities may provide additional strategic input for inclusion in smart city initiatives. Additionally, municipalities may be advancing communications capabilities that can support a utility-connected home, such as fiber optics to the premises or municipal wireless network access. Other municipal departments may be able to complement the utility-connected home strategy with additional smart home features and technology which can help to spur adoption.

Developers can be engaged to provide HEMS technologies as a part of building new dwellings in the cooperative service area. Engaging other entities in the promotion and installation of the utility standard HEMS solution can only help to drive adoption rates higher. Strengthened relationships with entities like developers who are a part of elevating living standards regionally can be a fruitful approach to meeting utility objectives. Co-ops should be aware that developers may be partial to a particular solution alternative, such as a brand of thermostat, and will be reluctant to change their preferred vendor.

Network operators, likewise, are engaged in developing a variety of solutions across numerous industries. Their primary interest is in driving up IoT device proliferation using their networks for data transmittal and connectivity. Providers such as Verizon are actively supporting solution innovation and communication integration with products qualified for direct access to LTE networks. This alleviates some of the potential for impaired adoption of HEMS resulting from Internet connectivity limitations. Reaching out to regional network operators may provide avenues to technology requirements refinement and, ultimately, aid in defining a HEMS solution with optimized characteristics for adoption in a utility's service area.

Resources and Information

The following resources may be helpful in exploring a utility-connected home strategy further:

- U.S. Department of Energy
- Pacific Northwest National Laboratory
- National Renewable Energy Laboratory
- Institute of Electrical and Electronics Engineers
- Electric Power Research Institute
- Open ADR Alliance
- Utilities such as PG&E and Duke Energy, among others

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