Home Area Networks: A Preferred Choice for Energy Efficiency

Rising energy prices, increasingly sophisticated conservation options and gains in customer confidence are driving the adoption of home energy management technologies and electric vehicle charging.

Executive Summary

According to reports, global investment in smart home management will surpass $4 billion in 2016, fueled by government stimulus, faster wireless networks and cloud platforms. Utility customers now no longer just consume energy but are willing to participate in energy conservation and contribute through energy generation. For a utility, every kWh saved is a kWh earned.

The current scenario has enabled energy service providers and retailers to offer cloud-based smart services and solutions for home energy management.

This paper seeks to address the challenges that the energy industry faces in leveraging investments in advanced meter infrastructure. It proposes engaging residential customers in achieving end-user energy efficiency.

The Geopolitical Imperative

The “Green Button Initiative,” an industry response to a White House call to provide utility customers with energy usage data to help them minimize wastage and shrink bills, has prompted large investments in home area network (HAN) development. Adding to the urgency is the fact that the U.S. Environmental Protection Agency has proposed strict greenhouse emissions rules for all new power stations, effectively barring the building of any new coal-fired plants. Nuclear power generation has proliferation and environmental risks. The aftermath of the 2011 tsunami made this abundantly clear. With the given rise in political pressure, utilities worldwide would look to their own customers to help tackle the ever-increasing demand for energy.

Energy Demand and Utilities’ Response

According to the Electric Power Research Institute, electricity consumption in residential, commercial and industrial establishments in the U.S. is set to increase at a rate of 1.07% annually, with consumption increasing by 26% till 2030. Whereas the Annual Energy Outlook 2012 (AEO2012) Reference Case forecasts a realistic potential reduction of 22%, to 0.83% in this growth rate, by the creation of a favorable environment through government sponsorship as well as market-driven trends toward energy efficiency.

While utilities search for newer and cleaner ways of energy generation, however, their programs and policies for energy demand reduction lag behind. This can be partly attributed to utilities’
fears about their bottom line, which in turn is due to their lack of understanding of appropriate technologies to achieve demand reduction. Successful demand reduction can be realized with automated demand side management (DSM), which uses analytical frameworks to analyze HAN device data, end-user load profile characterization and environmental impact, and thereafter integrate this data into utility resource planning.

The U.S. Federal Energy Regulatory Commission’s report on national demand response potential suggests that the residential class of customers, which is awash in energy choices and replete with high tech options, provides the most “untapped potential for demand response.” With 70% anticipated participation, demand response programs represent roughly 45% of the potential impact on end-user energy efficiency.¹ The caveat here is the lack of a viable business plan for generating revenue and profit from smart appliances.

Business Case Modeling for HAN Energy Management

Automated Demand Response

Automated demand response (ADR) programs for HAN-enabled appliances present a utility with viable opportunities for flattening peak load demand to a manageable scale through peak shaving. Peak shaving could be achieved by programming end-user devices to reflect daily demand patterns.

This leads to some obvious questions:
- How profitable is pursuing residential energy efficiency through ADR?
- How much are customers willing to invest in HAN-enabled smart appliances?
- How should baselines be estimated for residential customers without jeopardizing their comfort or safety?
- How should rewards be determined for consumers without compromising grid operators’ profitability?
- How should energy reduction coefficients for demand reduction management be calculated?

Impediments to end-user demand control can be resolved through a systematic and streamlined approach towards ADR programs. It would comprise steps such as the following:
- Segregate consumers into heterogeneous groups based on factors such as weather conditions, appliance classes, etc. and designate a baseline load shape for each group.
- Analyze demand patterns combining historic and real-time demand data.
- Design and deploy an accurate prediction model for dispatchable and non-dispatchable ADR programs.
- Quantify statistically the impact of ADR through an appropriate measurement and veri-

Results of ADR Implementation from a Listed Utility

Source: http://www.pge.com/mybusiness/energysavingsrebates/demandresponse/adrp/
Figure 1
Dynamic Pricing Philosophy

Would you mind a dynamic tariff?
No risk, no reward

Potential Reward
(Discount from Flat Rate)

Less Risk,
Lower Reward

More Risk,
Higher Reward

Flat Rate

Inclining Block Rate

Seasonal Rate

Super Peak TOU

CPP

VPP

RTP

Increasing Reward

Increasing Risk

Risk
(Variance in Price)

Source: http://www.menloenergy.com/?p=349
Figure 2

Dynamic Pricing and Curated Consumption
Consumers find it easier to comprehend price information rather than kilowatts/hour. Thus price management systems must translate peak electric system conditions, providing objective information on scarcity of electricity to customers, so as to engage them in energy management.

Is Dynamic Pricing the One-stop Shop for DSM?
Dynamic pricing deployment involves challenges such as the following:

• Availability of usage data that is sufficiently granular and frequent for flexible rate deployment.
• Consumer sentiment about the complex dynamic pricing being predatory and unfair and designed to benefit only high-end homes.

• Accruing cost overhead of newer devices and absence of accepted standards for interoperability.

How can these problems be addressed?
• Leverage advanced communication such as Wi-Fi, 4G-LTE, etc. to stream real-time usage data from smart meters.
• Educate consumers by deploying IHDs and energy dashboards, and eradicate misconceptions about price neutrality and the extent of usage curtailment by using statistically accurate yet easy-to-decipher reports, messages and alerts.
• Exhibit sensitivity towards particular customer segments such as low-income groups, the elderly, the infirm, children and small businesses to help allay concerns about dynamic pricing being unfair. Create forward contracts and baseline rebates and encourage risk-free trials.
• Provide bill protection by ensuring that bills are not higher than otherwise applicable tariffs but rather are reduced.

Distributed Generation and Impact from Electric Vehicle Charging
With the advent of deregulation, distributed energy generation can no longer be overlooked in distribution systems. Bloomberg’s energy
A finance report on the U.S. mentions a massive 57% increase in its renewable energy outlay, to $51 billion. Falling technology costs and strengthening policy support in favor of renewable energy create a favorable environment for benefitting from the advantages of distribution generation.

A major advantage of the advent of smart grids and smart appliances is their ability to sense, collect and analyze disaggregated data. Therefore dynamic peak load shaving can be achieved by intelligently shifting residential users to their localized power backup facilities during peak demand.

Growth of Electric Vehicles

The stability of energy grids worldwide has been affected by plug-in electric vehicles. U.S. government agencies predict that more than one million electric vehicles will be in service by 2015. The U.S. Department of Energy recently announced an $8.5 million grant to support public planning of EV infrastructure through joint public and private ventures.

A settlement between the California Public Utilities Commission (CPUC) and NRG Energy Inc. will result in the establishment of roughly 200 charging stations and over 10,000 charging units in 1,000 locations across California.

To mitigate the risk from uncontrolled EV charging, utilities should focus on applications that help integrate the charging infrastructure into their resource planning.

Problematic Scenarios for EV and Renewable Energy Integration

- EV early adopters with even a level 2 charger could exceed the emergency loading characteristics in most transformers today in a matter of minutes.
- Disparate EV charging could be uncontrollable and undetectable. Simultaneous charging at off-peak hours could cause shifts in demand peaks and may lead to vulnerability in the power distribution system.
- High variability and complex signaling make renewable energy integration difficult.
- Power quality and harmonic distortion can throw a systematic grid off balance.

Dealing with the Impact of EV Charging

Utilities can subsidize electric charging equipment, thereby reserving the rights to provision them as HAN devices – thus making remote monitoring and management possible.

Utilities should provision separate meters for EV charging so that the advanced metering infrastructure (AMI) data from these meters can be collected and analyzed for accurate identification and customer profile segregation. This will help in prediction of EV penetration and charging behavior.

Finally, focused solutions such as EV charging impact visualization, ADR and direct load control can be leveraged through HAN and wide area network applications.

Conclusion

Growing energy prices and consumers’ desire for energy monitoring and control will attract investments into HAN technology and in-home displays. Commoditization of LAN/WAN technologies coupled with maturity and standardization of protocols will foster growth and ease of deployment in HAN-based energy management systems. Utilities and energy service providers should target this growth opportunistically and should align their offerings to capitalize on the emerging HAN marketplace. Simply put, execution of ADR, DSM and dynamic pricing combined with the versatility and flexibility of HAN technology will not only increase trust among customers but also engage them in energy-saving endeavors.
Footnotes


8 CPUC settlement. http://docs.cpuc.ca.gov/PUBLISHED/NEWS_RELEASE/165145.htm

About the Author

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