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Smart thermostats: are we ready?

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VIEWPOINT

Smart thermostats: are we ready?

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Abstract

Purpose – The purpose of this paper is to determine the important product features that are to be included in smart grid devices. This will help the decision makers to prioritize the product feature implementations.

Design/methodology/approach – This paper provides a quantitative approach to determine the important product features. Data used in the model have been gathered by conducting a survey among 22 potential customers who have been living in residential areas.

Findings – Although customers understand that a feature to respond to price signals could benefit them, they overwhelmingly prefer cost benefit that an energy demand system would provide.

Originality/value – At a time when many are rushing in to implement technologies such as demand side management and any smart devices that go with them, this paper shows that customers may have different preferences than those implementing the technologies.

Keywords Demand management, Energy conservation, Energy technology, Analytical hierarchy process, United States of America

Paper type Research paper

Introduction

The demand of energy in the USA continues to grow. The *Annual Energy Outlook 2008* (AEO, 2008), a report by the Energy Information Administration, projects a steady demand growth of 0.7 percent per annum through 2030 (US DOE, 2004). This projected growth in demand has spurned several initiatives aimed at forestalling potential shortages and outages caused by supply-demand mismatches. One such initiative is demand side management (DSM). With DSM, the focus is on influencing the energy consumption patterns of end-users especially during peak demand times when energy supply systems are strained. Moreover, the modern society has become more sensitive to the individual's impact on the environment. More energy consumers are aware today of the need to conserve energy. Per capita energy consumption has remained fairly constant but is projected to drop due to consumer's adoption of high technology. DSM provides an opportunity to meet the needs of today's energy-hungry yet environmentally aware society.

Background

Forecasting electricity loads had reached a comfortable state of performance in the years preceding the recent waves of industry restructuring (Bunn and Such, 2000). Adaptive time-series techniques based upon ARIMA, Kalman filtering, or spectral methods were sufficiently accurate in the short-term for operational purposes, achieving errors of 1-2 percent (Bunn and Farmer, 1985). The technology is now providing the opportunity for consumers to respond to fluctuation in price by lowering their energy consumption during this time. Using this strategy power companies now

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have the capability to even out the demand for power generation with simple economics rather than building physical power plants. Kirschen states, most consumers, with the possible exception of the largest ones, do not have the financial incentive and the expertise required to contribute effectively to such a complex and time-consuming task (Kirschen, 2003). Recent experience in California made painfully clear, that introducing competition on the supply side while shielding the demand from liberalized prices seriously distorts the market (Caves *et al.*, 2000).

A typical platform enables the customers to reduce electricity usage at small commercial sites and residences. The ability to manage energy usage more effectively saves businesses and homeowners' money. Some provide the web site to the users enabling them to control the temperature with internet. The users are able to use cell phone to control the temperature of home as well. Internet-based solutions provide the user-friendly setup, control and reliability that are critical to end-user acceptance, while delivering the security and extensibility that the customers require. Typical system moderates heating and A/C temperature settings through the use of an intelligent thermostat that can be controlled from the web interface (Powermand, 2008).

The residents use these devices to get cost savings and comfort within the facilities. However, to obtain the advantage, they need to learn how to use it as a skill. What they need is not only the benefit to save energy, but also the convenience as much as possible the product can provide. They would rather to have one device to control all the device of the home site than to have separate devices for different controls. So they hope that the product can integrate more features such as fire control, security control, irrigation control, gas leaking control, etc. In short, they need a gateway for them to control all the home facilities. it might be a web site or telephone service for them (Gehring, 2002). Residents also need more remote means to control devices in their homes. Besides, the web site, they also need to have more connectivity options like PC, telephone, SMS, etc. to access their system. The users hope that the device can be more intelligent in operation of home devices. For example, the users hope that the energy consumption can be as low as possible when there is no one in the house.

The aggregators, electricity generation and distribution businesses all want to get the information about what is the energy consumed by each house at a given time, especially at peak demand time. That enable them to accurate forecast the energy needed down to the substation level as well as make them charge at different prices during different time. The information which the system will provide is the input for the Energy Businesses' information system. In order to cooperate with the other parts of the IS, the incoming data must be integrated into the system of energy businesses. A data transfer interface is needed to do this.

The smart thermostat technology model has opened up new fronts in the relationship between energy producers, distributors, and consumers. Now, there is potential for interactive or "live" response to changes on all sides. Consumers have an opportunity to monitor and adjust their consumption. Energy distributors such as energy utilities and aggregators can now use energy data from smart thermostats and advanced metering systems to predict energy patterns, buy energy at better rates and deliver savings to their customers. In 2006, one such utility, PJM interconnection which serves 13 states and the District of Columbia, realized 2,046 MW resulting in payments of $650 million to customers who curtailed their energy usage as part of demand response programs (PJM, 2008).

Many other technology stakeholders are also aligning themselves strategically by forming alliances that share ideas to promote innovation in the industry. The smart energy alliance is a group of technology companies including Capgemini, Cisco, GE Energy, HP, Intel, and Oracle. Smart Energy has a goal of implementing Supervisory Control and Data Acquisition systems that give customers more power to manage their energy consumption, given the eventuality of smart metering and smart thermostat technology (Smart Energy Alliance, 2008). Another example of this is The NewEnergy Alliance which brings together the technologies, manufacturers, engineers, and service providers across the energy, IT, and building systems industries. The group's members are involved in developing and implementing complementary solutions and technologies to deliver sustainable energy goals for every type of building and customer. A key goal of the alliance is to help empower and create immediate revenue opportunities for members who wish to directly participate in demand response with their products, services, and technologies. Another goal for such alliances is to develop and strengthen industry wide standards for home automation. Currently, there are several different communication protocols used by different manufacturers which could lead to interoperability issues.

There are various different smart thermostat options available to consumers in the market. They offer a variety of technology features such as electricity controls, water controls, in home display interfaces, phone interface, web interfaces, fire monitors, appliance control, gas leak monitors, among others.

With such a wide array of technology options and providers all competing for market share and industry recognition it can be challenging to determine the best way forward for the company.

It is important to note that there are a few off the shelf programmable thermostats that currently retail at about $100 such as the Rite temp 6000 series which offer additional features like fan and humidity control. The technology curve for these products tends to trend up slowly by integrating additional features with minimal or no increase in price. There are also some technologies in the building automation industry that offer a complete suite of control options including thermostat control and may have characteristics of disruptive technologies for the thermostat market.

Even though the market for smart thermostat has steadily grown, there are some barriers that exist to the widespread adoption of the technology. Several different reports have made an attempt to identify and address these barriers. One such report is the Residential Energy Conservation report done by request from the Technology Assessment Board at the Office of Technology Assessment (OTA, 1979). The report cites ease of use and cost, particularly life cycle cost as large barriers to the widespread adoption of smart thermostats. Another barrier identified in the report is that many consumers lack practical knowledge about how to accomplish conservation using existing technology options. This represents barrier to the diffusion of innovations. This effect is compounded further when the introduction to a new idea or innovation is involved. Innovations and new ideas often involve uncertainty and a lot of misinformation or no information.

Customer preferences

According to the technology acceptance model perceived usefulness and ease of use are important determinants for customers to adopt a technology (Venkatesh and Davis, 2000).

In our study, we regarded "savings" and "additional features" as sub parts of "perceived usefulness" as these are the competitive advantages that smart grid appliance developers focus on. We regarded "ease of use" itself as a determinant in the model.

We thought "cost" to be an important factor in deciding adoption of a technology or a product. In the literature many researchers included this variable in their studies (Kargin *et al.*, 2009).

From several meetings with industry experts, we have come up with two major determinants that are important in smart grid technology field. These are "service reliability" and "additional features". Service reliability is considered to be important because many of the smart grid appliances use online communication which makes their systems vulnerable to cyber attacks and hacking issues. At this point, it becomes very important to protect the system from attacks by the outsiders. Connection availability is considered to be important because of potential discontinuities in communication. At this point ability to communicate in multiple ways becomes important so as to provide continuing service. We have included several communication ways by reviewing existing products in the market. These are internet, SMS, mobile phone, and telephone connections (TSC_Systems_Eng., 2008). To gain a deeper understanding in additional features we have reviewed existing product features in the field and come up with several features. These are integration with water control, integration with home appliances, light control, fire control, phone control, fire control, security control, mode control, gas leakage control, PC control, and in home display control (TSC_Systems_Eng., 2008). As part of the research methodology, we a survey which consists of eight questions prepared for potential customers. We got 22 responses from people who live in residential areas and are interested in owning an energy saving system. The details of the evaluation criteria and their importance as assessed through our analyses are presented in Table I.

As it can be seen the customers are more interested in cost and resulting savings. Rest of the criteria have less importance as shown in Table I. These results provide an interesting baseline for those who are targeting to develop devices for smartgrid like architectures. Although it is a limited study, it indicates that customers may have different preferences than what the utilities think they have.

Conclusions and future work

Many interesting results were derived from our analysis of the survey data. The small sample size of participants was a limitation. A larger sample size, with better defined questions, using the analysis we developed, could help improve the results. It is very important to be able to predict customer desirability trend when there is potential for market to have a new feature emerging or an emerging product with existing features. In the future studies our focus customer group survey could be revised by adding or omitting some of the features which are to be analyzed and conducted to focus customer group again. By this way it would be possible to observe how the weights of customer desire moves between determinants. This knowledge would help managers to give decisions about product features. Organizations could save capital by not investing every emerging R&D projects but could save a lot by investing capital on the features which are to provide competitive advantage.

Items	Relative weights (%)	Overall weights (%)
Installation cost	28	7.3
Maintenance cost	38	9.9
Product cost	34	8.8
Cost		26
Energy efficiency	56	12.9
Demand response saving	44	10.1
Savings		23
Interface		
Web site	30	1.8
Cell phone	30	1.8
Special device	15	0.9
PC	25	1.5
		6.0
Interface	35	6.0
Personalization	32	5.4
Ease of installation	33	5.6
Ease of use		17
Connection availability		
Internet	28	2.1
SMS	23	1.7
Mobile phone	26	2.0
Telephone	23	1.7
Sum		7.5
Connection availability	50	7.5
Security	50	7.5
Reliability		15
Integration with water control	11	2.0
Light control	10	1.9
Phone control	5	0.9
PC control	7	1.4
In home display	11	2.1
Integration with appliances	10	1.9
Integration with renewables	9	1.8
Fire control	7	1.4
Security control	12	2.2
Mode control	6	1.2
Gas leakage control	12	2.2
Features		19
Total		100

Table I.
Evaluation criteria and results

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