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TUTORIAL 5144

Environmental Benefits of Smart Meters

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Abstract: Today, consumers and utility companies can agree that smart meters provide benefits such as time-of-use billing, accurate measurement, and elimination of a meter reader's monthly visit. But do smart meters provide tangible benefits for the environment? Not all agree on this. This article discusses how a smart meter helps a utility to monitor energy usage. That monitoring data then allows the utility to work with consumers to reduce energy usage and integrate various sources of renewable energy. When that happens, the environment wins.

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An Awakening

"I don't understand the environmental benefits of the smart grid," my cousin Chris said after I told him about my involvement in the smart grid effort at Maxim. "I think it is just a ploy by the utilities to raise rates," he added.

Ordinarily, I would have interrupted him with comments about intelligent management of energy and resources, but my cousin worked for the northern California utility for 15 years. He was not speaking from an uninformed standpoint, so I listened further. "Electricity flows like water," he continued. "It flows from the source to all points of consumption. Installing a smart meter does not save energy, it just counts when you are consuming it." These are all valid points.

Here I was, convinced that smart meters were a good thing, something that could benefit both the economy and the environment, something that brought a better technical solution to an old problem. But in fact, I did not really know how the smart grid could reduce energy consumption. I decided to take a closer look.

It turns out that smart meters offer tremendous *potential* environmental benefits. Peak load reduction and distributed generation are two critical functions made possible by the superior control and communications of an appropriately engineered smart grid and willing consumers. These functions help to reduce energy consumption, especially at critical times. They also help to effectively integrate various renewable energy sources such as solar panels and windmills. Furthermore, initial data from early adopters demonstrate the success of smart meters. These benefits have prompted significant investment into smart meters as a path toward reduction of consumption and adoption of renewables. One thing, however, remains clear: a well-engineered smart grid will not effectively benefit the environment without one critical participant, you, the smart consumer.

What Is the Smart Grid?

To some, the smart grid simply means new electricity, gas, and water meters on their properties. To others, smart grid is an insidious, radio frequency emitter attached to the meter outside their building. To still others, smart grid is a new network that will connect all things consuming electricity.

Many people have said that if Thomas Edison were to return to the earth now, he would easily recognize the aging electricity grid. Operating at relatively slim margins over the past 75 years, utilities have had little impetus to upgrade the existing infrastructure. Furthermore, consumers are used to a system in which they blindly consume and then pay at the end of the month or longer.

The smart grid is, indeed, a new network. As a new network, it is overlaid on top of the existing power infrastructure. Energy is measured at points of generation, distribution, and consumption. Those measurements are then communicated within the network. This communication, to the utility and consumers, allows quick, smart decisions to be made about the status of the grid. In the same way that smartphones give us faster access to information, the smart grid gives us and the utilities faster access to energy information. Imagine if the energy consumption of every major piece of equipment was measured, fed back into a state-of-the-art computer, managed by the utility, and provided for review by consumers! That level of knowledge definitely opens up opportunities for identifying those who waste energy and for encouraging conservation.

Smart electricity meters track (i.e., "meter") household or business energy consumption and communicate that data, usually at 15-minute intervals, back to the utility. This task is called "energy metering" and it takes place inside the meter itself. Energy metering needs to be very accurate and reliable, so utilities know the correct consumption amounts and so consumers do not get over billed. Semiconductors perform most modern metering. One such device is Maxim's 71M6541D, which accurately meters electricity in a typical household meter.

The process of communicating the consumption data back to the utility is also done by semiconductors. These devices will either use the powerline as the "wire" for communication, or they will communicate wirelessly. Powerline communication (PLC) has the benefits of low-RF emissions and it is effective for meters where RF penetration is difficult, such as in basements. The MAX2991 and MAX2992 make a complete chipset for robust PLC from meters to the utility.

The smart grid will reach beyond the meter and into businesses and home. Data centers, factories, and appliances all become "smart" when equipped with measurement and, sometimes, communication devices. Measuring the amount of energy consumed and relaying that information back to a utility or home network is called energy measurement. Renewable energy generation also relies on energy measurement. An example is measurement of the energy produced by the solar panels on a structure. Effective energy measurement must also be accurate and reliable. The 78M6612, a single-phase, dual-outlet power and energy measurement IC, provides high accuracy energy measurement for a variety of applications.

Peak Load Reduction and Distributed Generation

From a utility standpoint, smart meters (a portion of the smart grid) offer the opportunity for peak load reduction. Managing energy consumption during a period of peak energy demand represents a real challenge for utilities.

Figure 1 shows energy consumption on a warm summer day in the central United States. Imagine a hot summer weekday. Prior to getting up at 7:00am, your energy consumption is very low. After rising, you turn on the TV, the coffee pot, and some lights. The electricity grid experiences an increased load from you and everyone else doing the same things. Soon you turn on your work computer and the air-conditioning units in your office come on. In manufacturing facilities, the motors spin up. Equipment operating during the day requires constant air conditioning because it generates extra heat. After the work day, as people arrive home and turn on their air-conditioning units and appliances, energy demand continues to rise. Consumption generally peaks in the early evening and falls as temperatures and human activity drop off.

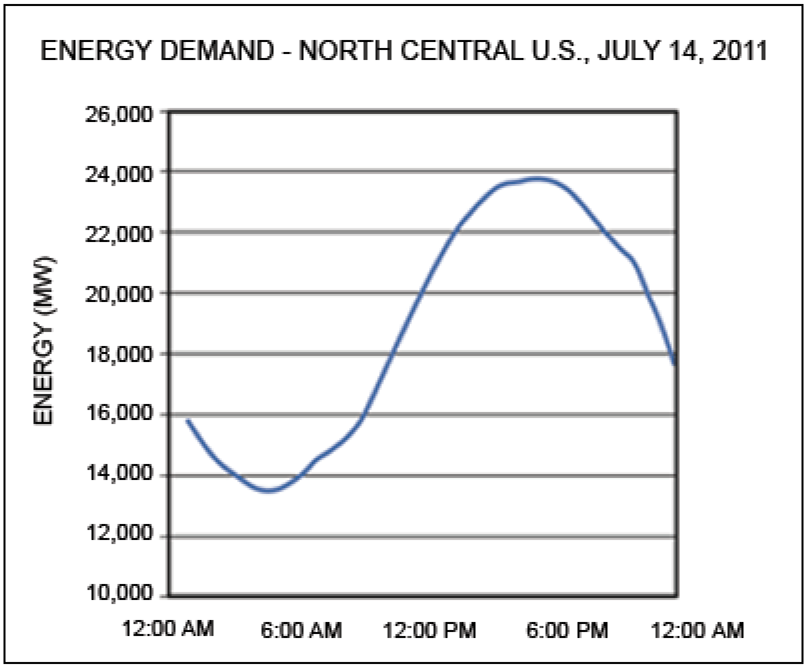

Figure 1. Actual energy demand data for the north central United States on July 14, 2011. Data provided by the Electric Reliability Council of Texas (ERCOT® organization) at www.ercot.com/gridinfo/. In the winter, electricity demand does not peak as high because many heating units use natural gas.

How does the utility manage this fluctuating energy demand? The critical thing to remember is that utilities have very few options for power storage. There are no large-scale batteries that store the amount of energy required by a city or large utility service area. A utility must have enough energy-producing facilities to meet peak demand quickly, and with enough margin to avoid brownouts. A typical utility will supply their base load of energy with a combination of hydroelectric and coal-fired power plants. Both of these are excellent, consistent sources of electricity, but power production from a hydroelectric source responds too slowly to meet demand changes in real time. Petroleum and natural gas turbines do respond quickly and therefore augment the energy supply to meet the peak and variable demands through the day. Solar installations also provide daytime energy on sunny days.

This is how utilities have managed and supplied energy for decades. Now consider the smart grid.

Imagine the same hot day and a complete implementation of accurate smart meters with robust communication capability. As demand increases during the morning, smart meters are transmitting real-time usage data to the parent utility at 15-minute intervals. Any points of high consumption are quickly identified.

Armed with this energy usage data, utilities are beginning to practice time-of-use billing. Under this program, users are charged much higher rates for electricity during peak demand periods. Motivated either by a desire to conserve or lower their bills, consumers, businesses, and even data centers can elect to give the utility, or a third party, limited control of their electrical systems. Then as temperatures rise, the utilities will remotely adjust the thermostat on air-conditioning units. This will save energy, while only slightly raising the temperature in a home or office. The end user will experience minor, automated disruptions in service.

At midday, the utility will have immediate feedback on the quantity and location of renewable energy (i.e., power generated by wind or solar systems) that is being generated. Described as points of distributed generation, these energy sources provide meaningful power to the grid and can be delivered to the closest point of consumption. By using distributed generation, the utility will activate fewer supplemental generators, which use fuels that are less environmentally friendly than renewable energy. Better data and control mechanisms also let the utility operate with a smaller margin above the actual load. In the future if loads increase even further, electric vehicles plugged into charging stations can automatically be switched to become sources of energy back to the utility.

By the end of the day, this smart grid has reduced the peak load during the highest demand. It saved energy and reduced the amount of needed energy-producing capacity. Because of its inherent flexibility, this smart grid can even operate at a higher capacity during nonpeak periods to charge electric vehicles used as energy sources earlier in the day and to allow consumers to run their air-conditioning units longer. Ideally, this evening power will come from cleaner base-generation sources like hydroelectric dams or other forms of renewable energy.

In the end, consumers and utilities can agree that reducing the peak load and using distributed power generation from renewable sources will reduce on our reliance on environmentally harmful sources.

Real-World Results

At this point, some may say that all this sounds good, but wait until we see if it can work smoothly...everyday...and everywhere. The benefits of the smart grid certainly sound nice when consumers and the utility are working together to conserve energy, but has any of this really been *proven* in the real world?

The first major smart-meter rollout occurred from 2001 to 2006 in Italy. Enel, an Italian utility company, drove the rollout to reduce cost. Now nearly 85% of Italian customers have smart meters. That actually translates to about 40 million meters. Enel estimates that customers are saving $750 million annually from the installations. Time-of-use pricing and customer awareness are the critical cost-saving mechanisms. Some customers report savings of up to 50% on their bills. Reduction of truck rolls for meter reading and maintenance are credited with some of the cost savings.[1]

Peer pressure has also been shown to alter customer behavior in a positive way. In 2009, a Minnesota cooperative utility, Connexus Energy, was faced with legislative mandates requiring them to reduce consumption by 1.5% annually. Efforts to reduce the demand, such as with renewable generation and more efficient distribution, would only meet a portion of the required reduction. The situation was clear: Connexus Energy needed its customers to reduce consumption. The Connexus Energy® cooperative partnered with a consulting firm to implement a creative new billing and educational program. They mailed 40,000 residential customers a report that compared their consumption first with their nearest 100 neighbors of similar sized houses, and then with the top 20 percent "energy savers" among all neighbors. To provide a true comparison, Connexus Energy also created a control group of 40,000 customers who were not receiving the monthly usage information. Over the course of 2009, the peer pressure worked. Consumers reduced energy consumption by 2% and saved $20 to $30 annually. The cumulative savings was over $1 million. Afterward, 98.7% of program participants opted to continue the program.[2]

The U.S. government is now aggressively funding smart grid programs with $4.5 billion as part of the American Recovery and Reinvestment Act of 2009. Goals include development of energy efficiency, peak demand reduction, and integration of distributed renewable energy.[3]

Additional programs funding smart meter rollouts exist worldwide in a variety of countries.

What It All Means

Data indicate that the smart grid truly can provide environmental benefits through demand reduction, renewable integration, and conservation. One thing is clear, however: these benefits cannot be achieved without a well-engineered grid and consumer education and involvement. No amount of machine control can raise awareness and change habits. Smart meters, solar panels, and electric vehicles are simply the tools of the trade. The success of the smart grid comes down to you and me, the smart consumers.

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