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Zapped by Smart Meters?

By Ken Wacks

Smart meters are an integral part of electric smart grids. The public press has been reporting stories about smart meters such as health issues and potential privacy compromises. Some smart grid committees that I introduced in previous *iHomes & Buildings* articles are investigating these issues. The good news is that these problems either do not exist or are readily manageable. In this article, I provide some background about the objectives and challenges of installing smart meters.

What is a smart meter?

An electric meter measures the electrical energy delivered to a home, apartment, or business. Technically, it integrates the power flowing into the premises over a specified time interval. Traditionally, this time interval has been a month.

The most important function of an electric meter is metrology: the accurate measurement of energy (in kilowatt-hours, kWh) and for some meters the peak power flow (kilowatts, kW) during a specified time, typically 15 minutes. Nearly all residential customers in North America are billed based on kWh consumed.

Some customers have a "demand charge" for kW to discouraging using a lot of energy-consuming appliances simultaneously. High demands for power may occur in factories and office buildings where demand charges are common. In some European and developing countries, demand charges are imposed because the distribution grid cannot accommodate high peak demands for power. The kW and kWh values are displayed on a register with mechanical dials and a pointer to show the demand or a digital display.

Smart meter communications

In the 1980s utilities started to deploy meters that could be read remotely in order to reduce the labor costs for reading meter manually. The meters for remote reading were new designs or add-ons to mechanical meters that included a radio transmitter. Some early designs for automatic meter reading (AMR) used telephone lines to report the consumption, but most AMR is radio-based. A common ARM scheme uses short-range radios that are read from a drive-by van. When the van enters a neighborhood, a radio signal from the van causes nearby meters to wake up and start sending the present reading repeatedly for a few minutes.

Some utilities install collection radios on utility poles to create a fixed-position network. The data from utility-pole receivers may be relayed to utility-substation radios where they are delivered to a utility operations center via telephone lines. This hierarchical data collection scheme, as illustrated in Figure 1, is an example of a neighborhood area network (NAN) for data communications. Many of these networks use low-power transmitters that do not require licenses (less than one Watt). Some include mesh network capabilities that provide increased reliability by allowing messages to be relayed among collection nodes.

A different approach for AMR communications, shown in Figure 2, uses licensed transmitting stations that gather meter data from a wide area. The benefit over an unlicensed network is the higher radio power that increases meter coverage and may reach meters inside buildings and in basements.

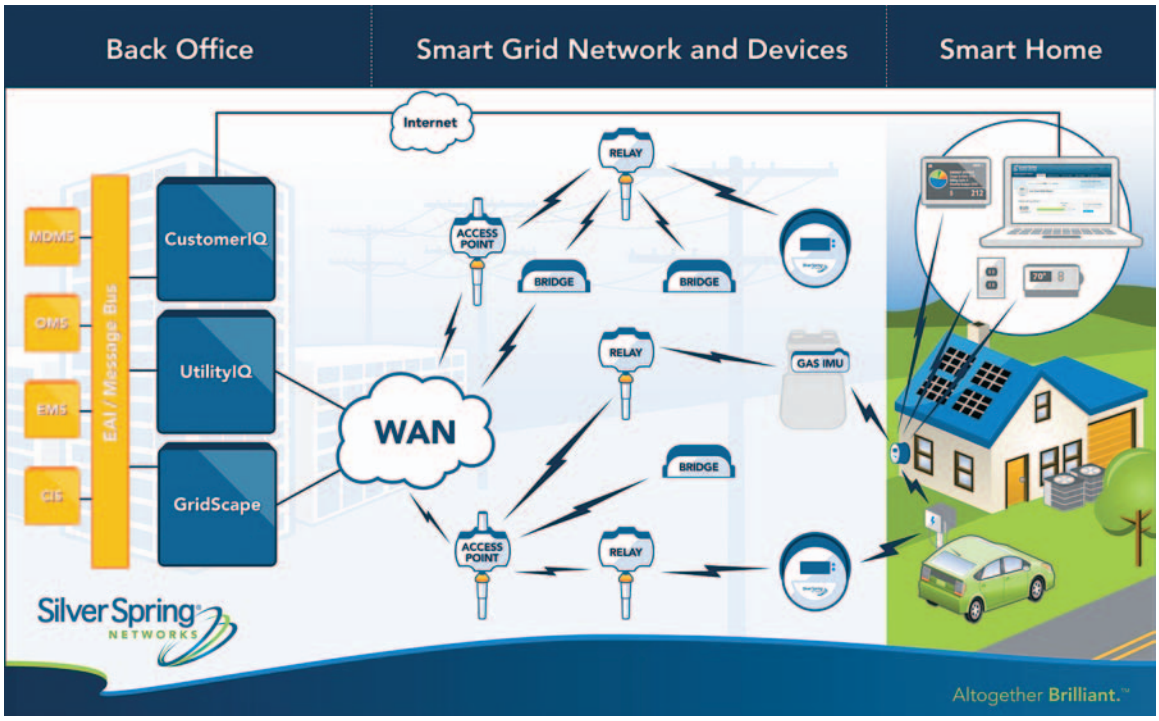

Figure 1 - Mesh Network for Meter Data Communications (Courtesy of Silver Spring Networks)

Radio communications interference

The Home-to-Grid Domain Expert Working Group (H2G DEWG) that I co-chair with an engineer from the U.S. National Institute of Standards and Technology (NIST) has reviewed reports about smart meters affecting household appliances. The public press in "Silicon Valley" California reported that some smart meters interfered with AM radios, portable telephones, and baby-room monitors. The Electromagnetic Compatibility (EMC) Society of the IEEE (Institute of Electrical and Electronic Engineers) advised us that there are federal regulations on unintended radio emissions from consumer electronics. However, there are no regulations in the United States on product immunity to radio signals from other devices and licensed radios. (Some other countries do require immunity protection be built into consumer electronics.)

The H2G DEWG wrote a report for the Smart Grid Interoperability Panel (SGIP) entitled *EMC Considerations in Home-to-Grid Devices*. We stated in the introduction:

"For Home-to-Grid devices to function properly and to coexist with other electrical and electronic systems in the home, they must be designed with due consideration for electromagnetic emissions from the grid or home and for immunity to various electromagnetic phenomena near the grid or in the home. They must also take into consideration the devices that are already present in the home to minimize interference to those products. Finally, EMC considerations must take the view that the home and the smart grid are a system since some issues such as surges caused by sources external to the home like lightning strikes, cannot be remedied at the end device."

The likely cause of the interference reported in the press was smart meter radio signals sending data to the NAN using an unlicensed spectrum shared with some consumer electronics. The meter maker did not violate any radio regulations, but failed to accommodate the lack of immunity in some consumer products. The H2G DEWG recommended that premises devices critical to smart grid services, such as demand response, be tested to voluntary immunity standards like those applied to information technology equipment.

Health issues from smart meter radios

We are awash in radio waves. Radio waves are part of the electromagnetic spectrum that also includes infrared (heat), light, and x-rays. Sources include radio and TV stations, computers with Wi-Fi, cell phones, Bluetooth headsets, etc. Furthermore, motors or electronics carrying alternating current or digital signals generate some level of radio signals as do most heavenly bodies. In August 2000, *IEEE Spectrum* magazine reported that when a cell phone is held next to the ear, half of the transmitted power is radiated into the brain. However, they could not conclude whether this was deleterious to health.

Figure 2 - Licensed Spectrum Network for Meter Data Communications (Courtesy of Sensus)

We cannot avoid radio signals. So far, there is no scientific evidence or public health statistics showing that radio signal exposure in urban settings impacts health. If further analysis reveals a problem, smart meters would be a minimal contribution to the problem of dangerous radio waves.

Data gathering and privacy

ARM has evolved into AMI, advanced metering infrastructure, as utilities recognized the value of communication networks for ARM and the data collected. The communications network could be used to deliver control message, pricing data, and event notices for demand response programs. The meter data could provide information beyond consumption for billing, such as:

- Outage indication
- Distribution grid problems
- Meter tampering

The Electric Power Research Institute demonstrated that if the time intervals between meter reads were reduced, information about appliance power consumption could be gleaned. This method is called *non-intrusive appliance load monitoring*, as I explained in my article "The Smart Grid Impact on Homes" from the Autumn 2011 issue of *iHomes & Buildings*.

Appliance consumer data could be useful in educating customers where energy might be conserved. I remember my parents exhorting me to turn the light off whenever I left a room empty. Now I know that what matters more are the settings of the thermostat, water heater temperature, clothes dryer, etc.

Data that monitors appliance energy consumption could also reveal home occupancy, daily activities, and the energy efficiency of appliances. Such data could be mined to determine where to market energy conservation tools or appliance sales. Such data could also be used to "case the joint" for a break-in. An unnamed U.S. law enforcement agency was reported to be looking forward to using utility records as part of dossiers on citizens. A divorce proceeding subpoenaed utility records gathered from a smart meter to determine when a philandering spouse was really home.

A German investigation demonstrated the ability to determine which TV program was being viewed based on detailed electricity consumption data. Some European countries are specifically forbidding the accumulation of meter data as an invasion of privacy.

The Department of Energy and Climate Change in the United Kingdom ruled that utilities are allowed to read smart meters monthly. More frequent meter readings require consumer permission. Utilities may accumulate

half-hour reads, but cannot use these data for marketing, and customers have the right to opt-out from frequent meter reads. Such frequent meter reading is allowed for improving system operation provided the data are aggregated to prevent the identification of specific household consumption.

Dealing with smart meter challenges

Most of the smart meter stories in the public press focus on assertions of health risks. Frankly, medical, dental, and airport x-rays pose relatively much higher risks.

The practical challenges with smart meters are choosing radio frequencies that avoid clashes with poorly designed consumer electronics. Utilities cannot stop consumers from buying products that meet existing radio frequency (RF) regulations. However, utilities should be prepared to deal with the consequences of installing meters that share RF bands with consumer products not designed with immunity protection.

The privacy issues are the easiest for utilities to manage. Simply collect the minimum data needed for billing, demand response programs, and reliable grid operation. Data should be aggregated in space and time, anonymized, or obliterated as soon as practical.

Customers should be given more choices than accepting a smart meter that is read every few minutes or paying an up-front fee plus a monthly penalty for keeping a dumb meter (as proposed by some utilities).

Utilities should take a lesson from more than a century of mass-market retailing: give the customer choices. If this is too daunting for utilities, they might cede the customer services end of their business to consumer companies.

Dr. Kenneth Wacks has been a pioneer in establishing the home systems industry. He advises manufacturers and utilities worldwide on business opportunities, network alternatives, and product development in home and building systems. In 2008, the United States Department of Energy appointed him to the GridWise Architecture Council. For further information, please contact Dr. Wacks at 781.662.6211; kenn@alum.mit.edu; www.kenwacks.com.