
Industrial Revolution

Every home makes compromises among different and often competing goals: comfort, convenience, durability, energy consumption, maintenance, construction costs, appearance, strength, community acceptance, and resale value. Often, consumers and developers making the tradeoffs among these goals do so with incomplete information, increasing the risks and slowing the adoption of innovative products and processes. This slow diffusion negatively affects productivity, quality, performance, and value. This department of Cityscape presents, in graphic form, a few promising technological improvements to the U.S. housing stock. If you have an idea for a future department feature, please send your diagram or photograph, along with a few, well-chosen words, to elizabeth.a.cocke@hud.gov.

Smart-Grid Technologies in Housing

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The material in this article is part of a report completed by the authors and commissioned by ELECTRI International, the research foundation of the National Electrical Contractors Association. The report, "Smart Grid: Installation and Construction Management Aspects for Electrical Contractors," is available at <http://www.electri.org/research/smart-grid-installation-and-construction-management-aspects-electrical-contractors>.

Abstract

The implementation of smart grid has led to a number of technologies for the housing industry. Two of these technologies, Advanced Metering Infrastructure and Home Area Networks, have a direct effect on the operations of a home. These technologies have influenced many new products and applications for homes; examples include smart meters, car-charging stations, smart thermostats, renewable-energy installations, and smart appliances.

The Status Quo

The electrical consumption in a typical American home is growing steadily, mainly because of the adoption of consumer electronic equipment. The U.S. Energy Information Administration forecasts a 30-percent increase in demand for electricity by the year 2030 compared with current demand rates (EIA, 2010). For example, if every home in the United States adopted the use of a digital photo frame, five 250-MW power plants will have to be built to accommodate the demand on the grid (EPRI, 2009).

This increase in electricity demand is making the electric grid more liable to power outages and load variations. The government, utility companies, and several stakeholders have proposed modernizing the electrical grid to make it efficient to meet predicted power demands. This modernized grid is generally termed the *smart grid*. A smart grid can be described as the integration of the electrical grid and the information technology and communication systems so as to be able to monitor and manage the generation, storage, transmission, distribution, and consumption of electricity (Austin Energy, 2010).

As part of the smart-grid upgrades, a number of technologies have emerged. The five major smart-grid technologies responsible for successfully implementing a smart grid follow.

1. Energy storage devices.
2. Advanced superconducting transmission cables.
3. Smart Substations and Smart Transformers.
4. Advanced Metering Infrastructure (AMI).
5. Home Area Networks (HANs).

Two of these technologies, AMI and HANs, have a direct effect on the operations of a home or building, but all the other smart-grid technologies have some level of indirect effect on the housing or communities. An example of the indirect effect is the location and zoning considerations for new transmission lines.

The following sections describe the two smart-grid technologies directly related to housing. These technologies have influenced many new products and applications for homes; for example, smart meters, car-charging stations, smart thermostats, renewable-energy installations, and smart appliances.

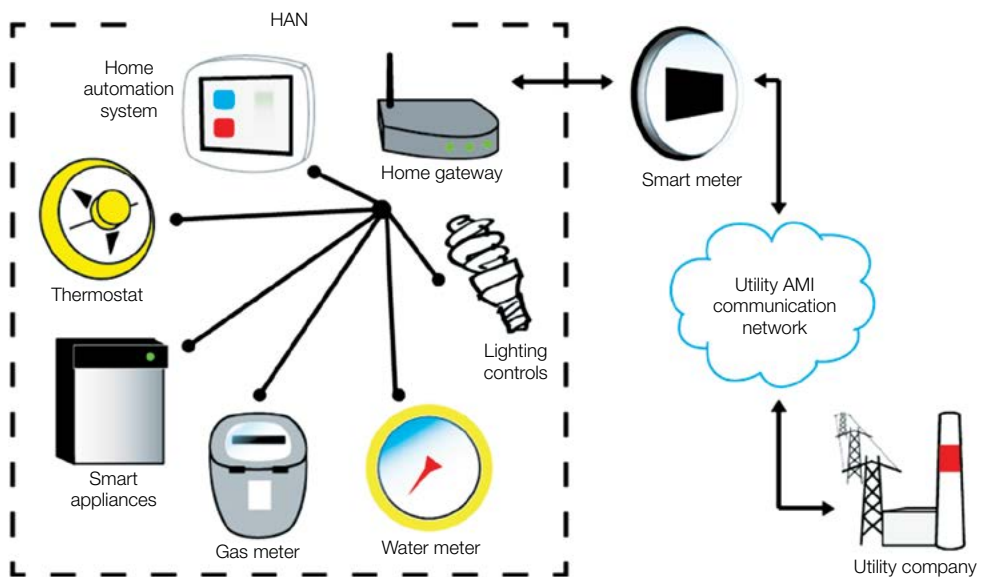
Advanced Metering Infrastructure

AMI represents fully integrated, two-way communication technologies that will make the grid a dynamic interactive system for power and real-time data exchange (NETL, 2007; Roncero, 2008). A variety of communication technologies is used in today's grid, but most of these technologies lack full high-speed communication integration. To be most effective, the integrated communication protocol will have to achieve universality, integrity, ease of use, cost effectiveness, standards, openness, and security (NETL, 2007). Although no universal standards exist for AMI and demand response, several committees and trade groups are currently collaborating to determine standards for integrated communications systems.

AMI is an integration of several technologies; it consists of three main components (exhibit 1): (1) a smart meter at the customers' location, (2) a communications network between the utility company and the smart meter, and (3) the HAN to connect the house with the smart meter. These components provide the infrastructure to establish the communication between the house and the utility company. This communication can enable consumer-demand response through consumer-level decisions on power supply prices. Utilities can also receive consumer usage data in real time that can enable the utilities to manage electricity demand and supply effectively (EPRI, 2007; Hart, 2008).

Exhibit 1

AMI Including Smart Meter and Link With HAN



AMI = Advanced Metering Infrastructure. HAN = Home Area Network.

A smart meter is the latest version of electric meter installed at the customers' premises. According to Van Gerwen, Jaarsma, and Wilhite (2006), the meter is deemed "smart" because it enables utility companies to perform three main functions: (1) track the electricity used, (2) remotely control appliances on the HAN, and, therefore, (3) remotely control electricity consumption. This control is especially important in the event of demand exceeding supply, which may threaten the disruption of service.

Smart meters are similar in size and installation features to the existing electric meters. The only visible difference between the two is the digital panel as opposed to the dials and needles (exhibit 2). Therefore, the smart meters can easily be installed by popping out the existing electric meters and popping in the smart meters in the same socket (exhibit 3).

Smart-meter installations are growing at a fast pace nationwide. The Institute for Electrical Efficiency (IEE) found that, as of May 2012, 36 million smart meters have been installed compared with 13 million meters installed as of December 2009. IEE has also projected that approximately 65 million smart meters will be deployed by December 2015 (IEE, 2012).

Exhibit 2

Smart Meter (left) and Older Electromechanical Meter (right)



Exhibit 3

Installation of Smart Meters



Home Area Networks

The HAN forms an inhome network of smart appliances, water heater, air-conditioner, cable box, and so on, via a home gateway to link to the smart meter, as shown in exhibit 1 (NETL, 2008). It can also link residential renewable energy-generating sources; a home charging battery to store excess generated energy; an inverter; a programmable communicating thermostat (smart thermostat); various equipment and appliances, including lighting and security systems; and a plugin hybrid or electric vehicle charging station. HANs are commercially available and use existing communication technologies such as WiFi and Bluetooth (EPRI, 2005; Sharma, 2008).

The HAN makes it easy to implement home automation systems and, therefore, makes it possible for the consumer to respond to price signals in the event of dynamic electricity pricing. For example, customers can schedule the dishwasher or the clothes washer to operate at the time of lowest pricing.

Smart appliances are fitted with the grid-friendly appliance controller that can sense grid conditions by monitoring the frequency of the system and can provide automatic demand response in times of disruption. If the imbalance between supply and demand goes unchecked, it can lead to many grid-related problems, even a blackout. In such an event, smart appliances will turn off automatically for a few minutes or even a few seconds to allow for the grid to stabilize. For another example, the utility would be able to adjust the cooling temperature of homes in a neighborhood for a few minutes to manage the peak demand and avoid disruption (PNNL, 2009).

Benefits

AMI technologies will allow for consumer-demand response through consumer-level decisions on power-supply prices. In addition, with fully operational HAN systems, utility companies will receive consumer usage data in real time for managing supply and demand effectively. This access to real-time data will enable the utility company to have a more efficient planning protocol for its generation, transmission, and distribution assets.

Availability

All the technologies described in this article are commercially available. The References section that follows provides additional information for the technologies described.

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