Distributed Generation: Cleaner, Cheaper, Stronger

Energy Smart Technologies in the Evolving Power System

Overview

Distributed energy resources allow electricity to be generated closer to where it is used, protecting businesses and institutions from unexpected outages caused by natural disasters and other disruptions. The U.S. national laboratories as well as public-private partnerships provide financial resources and access to research facilities to foster innovations to modernize the power sector from a 100-year-old centralized system to one that incorporates disparate clean technologies such as microgrids, batteries, and energy smart tools. These investments and the resulting new products and capabilities decrease costs, improve grid reliability, reduce emissions, and offer consumers more options.

Energy smart technologies are products and services that increase the connection and dialogue between electricity producers and end users. They are the heart of a smart grid—a combination of parts plus a process for using information and communication technologies to integrate the components of each electric system—and are contributing to one of the first major foundational changes to the U.S. power system since its inception a century ago.[1] The growth of this market presents a critical opportunity for generators and end users across a vast array of industries to develop new products and improve efficiency and resiliency in the evolving grid.

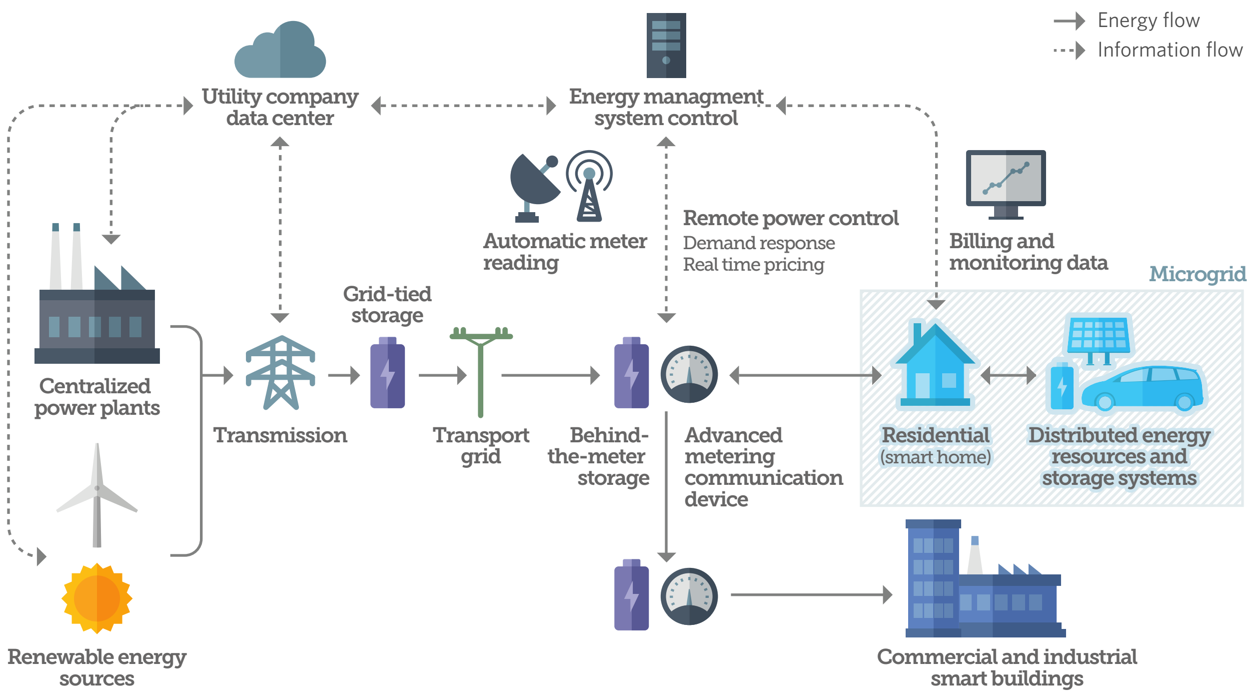
Smart innovations increase dialogue between producers and users

Energy smart products and devices can be deployed in the residential, commercial, institutional, and industrial sectors. By increasing the analytic data available to grid operators and energy users, smart technologies create an information bridge linking generation, transmission, and distribution with consumers.[2] For example, digital technologies that enable two-way communications are helping to better match the generation of power with demand. These capabilities allow grid managers and end users to make more informed decisions about how and when to use energy based on grid requirements and price signals. And the additional information helps utilities manage their increasingly diverse generation portfolios.

Figure 1

Digital Products and Processes Integrate Electrical Grid Components

Sample system design and interconnection



Source: LG CNS

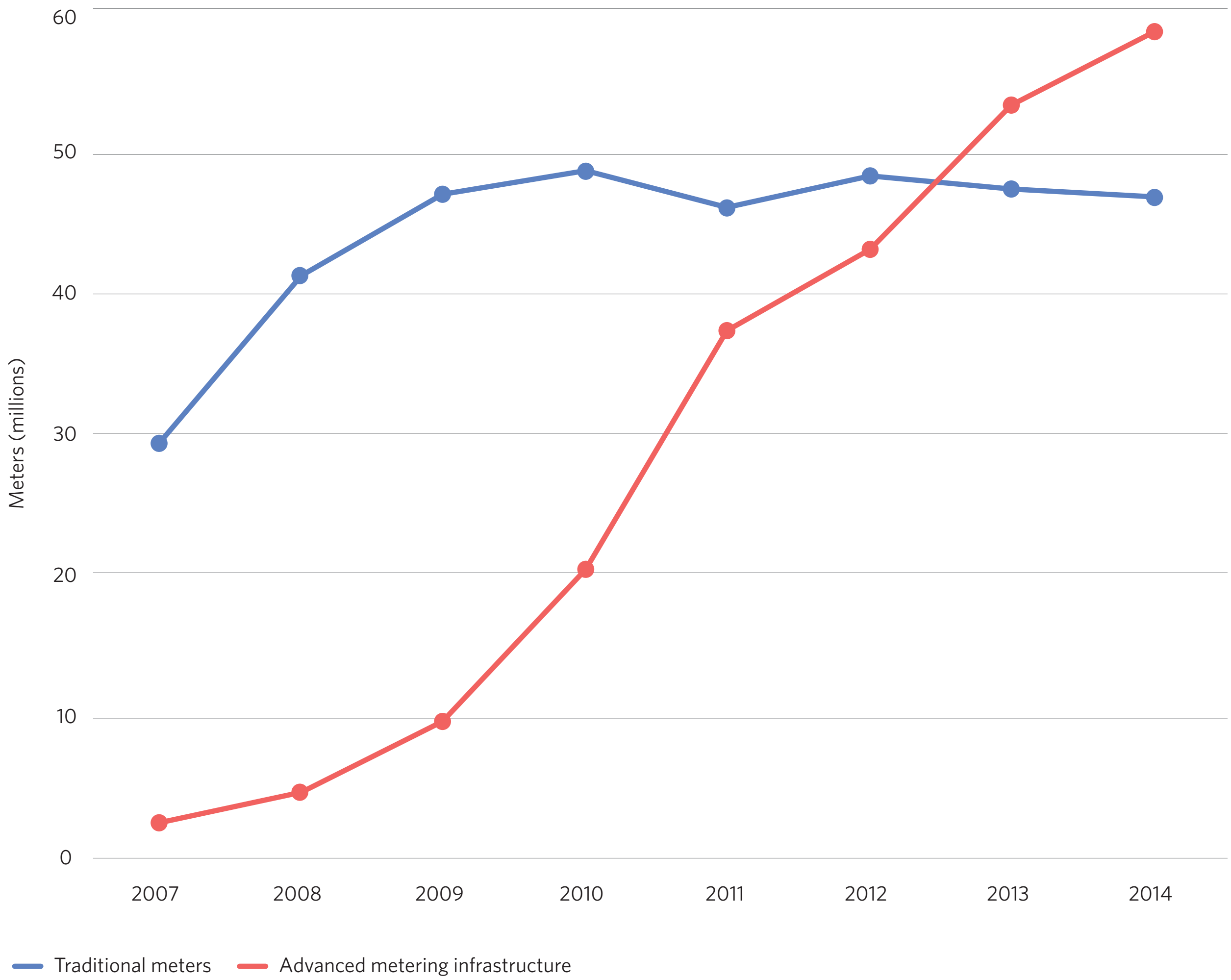
Other new products are making the grid more interconnected and responsive. These include advanced metering infrastructure, automated feeder switches, voltage regulators, and other innovative controls that enable grid stability and resilience. Similarly, smart meters allow utilities and consumers to communicate digitally and make more informed decisions about energy demand, production, and use. Such sharing of data is emblematic of these emerging capabilities. Since 2007, deployment of these meters has grown rapidly, surpassing traditional automated installations for the first time, with over 51.9 million meters in 2013.[3]

51.9 million smart meters deployed in 2013

Figure 2

Smart Meter Installations Have Surpassed Those of Traditional Meters

Changes in deployment of metering infrastructure, 2007-14



Source: U.S. Energy Information Administration

Energy users reap benefits of smart technologies

New smart devices are providing residential customers with a greater understanding of their energy use and, in turn, driving changes in individual behavior. For example, smart thermostats provide customers with data about what time of day their appliances are cycling on and off and how their energy use compares with that of their neighbors. The thermostats are also a source of tips for saving more power—for example, doing laundry at night when the price of electricity is lower. Some utilities are offering customers digital meters and incentives to temporarily reduce their homes' power use when the grid experiences high demand.

Figure 3

New Products and Devices Increase End-User Energy Management

Example of residential smart technology opportunities

Source: Austin Good

Many major businesses and sectors are targeting the emerging opportunity of the "connected home," including telecommunications firms such as Verizon and AT&T; information technology firms such as Google and Apple; solar energy firms such as Solar City; home security firms such as ADT; home improvement stores such as Lowe's and Home Depot; and an array of companies that provide individual or bundled services to consumers.

The availability of additional information is also changing the behavior of many industrial, commercial, and institutional energy users. Having access to real-time demand and price data helps end users make more informed decisions on energy use and consumption to optimize their resources. Large-scale power users who make electricity using distributed resources can decide whether to use the energy they generate or sell it back to the grid, taking advantage of real-time pricing. Further, as more improved technologies come online, smart grid devices will allow owners of energy storage equipment to capitalize on the power they are holding.

Energy Smart Technologies Come in Many Shapes and Sizes

A variety of available energy smart devices can provide consumers with real-time analysis and optimization of energy production and consumption. Among the leading products and processes are:

- **Smart meters and intelligent appliances.** Smart meters allow utilities and consumers to communicate digitally and are usually installed buildingwide. End users also can purchase new versions of commonly used devices—including household appliances, thermostats, irrigation and security systems, and heating and cooling systems—that can communicate with smart meters or central building operations and adapt energy use based on weather conditions and pre-established user preferences. Systems can be controlled remotely through Internet-connected products.
- **Grid automation.** Energy transmission with two-way digital communication allows utility operators to respond to data collected from grid components, such as smart meters and voltage sensors, and efficiently deploy power generation resources.
- **Intelligent demand management.** These technologies are capable of sensing system overloads and rerouting power generation to resolve potential disruptions.
- **Power asset integration.** These interconnected systems include all types of energy generation to take advantage of efficiency and storage technologies as well as renewable resources that may be intermittent, such as solar and wind, but are able to reduce demand peaks and contribute to load management.*

* Litos Strategic Communication, "The Smart Grid: An Introduction," U.S. Department of Energy, http://energy.gov/sites/prod/files/oeprod/DocumentsandMedia/DOE_SG_Book_Single_Pages%281%29.pdf; Smartgrid.gov, "What Is the Smart Grid?" https://www.smartgrid.gov/the_smart_grid/renewable_energy.html.

Research shows that energy smart technologies offer a safer, more affordable means of producing and transporting power. It also finds that, compared with traditional fuel sources, these technologies provide a cleaner approach to updating aging infrastructure across the country. An analysis of the economic benefits of smart grid systems by the National Energy Technology Laboratory found that improved operating efficiency could reduce operational maintenance and capital costs for delivery and electricity suppliers and that transmission and congestion losses could each decrease by 10 percent, saving consumers $2.5 billion and $2 billion a year, respectively.[4] A Rocky Mountain Institute report on residential energy smart technologies found that controlling the timing of just two common residential appliances—air conditioners and electric water heaters—could lower U.S. peak demand by 8 percent, lessening required infrastructure investments by 10 to 15 percent through 2030.[5]

Overall, customer applications in residential and commercial building could have economic benefits worth $59 billion by 2019.[6]

Federal support promotes technology development

The Energy Independence and Security Act of 2007 identified modernization of the nation's electricity transmission and distribution system as vital for ensuring the reliability of its power supply. Since then, the federal government has supported a variety of research, education, and development efforts.[7]

Deployment of advanced metering infrastructure was one priority of the American Reinvestment and Recovery Act of 2009, which provided $3.4 billion in federal government grants for smart grid installation efforts.[8] These investments and associated private-sector initiatives spurred a near-fourfold increase in the number of smart meters installed in the United States from 2009 to 2014.[9] Federal government reports suggest that smart meters and other advanced controls are reducing participating utilities' costs by 13 percent to 77 percent and have the potential to lower peak electric demand by 30 percent or more.[10]

The U.S. Department of Energy's Office of Electricity Delivery & Energy Reliability runs Smartgrid.gov, an online public resource providing information on the technologies that make up a smart grid and their benefits.[11] DOE's Lawrence Berkeley National Laboratory provides technical assistance for research and policy support by developing best practices for design, measurement, verification, and implementation of smart grids and related products.[12]

The Advanced Research Projects Agency-Energy (ARPA-E), which helps commercialize cutting-edge energy technologies, invests in smart grid innovations: The agency has provided more than $37.5 million in funding to 32 completed projects and as of December 2015 is supporting 36 more with almost $29.5 million in grants.[13] In November 2015, it selected five projects focused on grid system performance—two housed at higher education institutions, two at private companies, and one at the Pacific Northwest National Laboratory in Richland, Washington—as 2015 funding recipients and awarded them a total of almost $15 million.[14]

Policies to advance energy smart technologies

For these benefits to be realized, however, policy changes are needed to address specific components of energy systems.[15] Energy smart technologies are often underutilized and undercompensated, considering the array of services and benefits they provide.[16] Traditional utility business models tend to provide a disincentive to customer efficiency by tying utility profits to the volume of power sales, although in some cases, advanced regulatory policies have been used to decouple utility profits from sales.[17] Load-driven electricity rates and residential demand charges are two regulatory changes that would begin to encourage technology deployment. Policymakers can also support energy smart technology adoption by providing regulatory guidance to states on best practices that clarify how, where, and when systems can be developed and can connect to the grid. This will ensure that all economic, environmental, and security benefits and services of these products are valued.[18]

Government-provided financial incentives that reduce upfront costs for interested parties can spur technology adoption and encourage development. Inclusion of products and processes that reduce power consumption in overall state renewable and efficient energy portfolios can also help drive growth and innovation.[19] Resource planning programs that require consideration of demand reduction as a means to avoid future capacity additions can also help maximize adoption and contribute to market growth in the sector.[20]

In April 2015, the Department of Energy released the Quadrennial Energy Review, examining modernization of the nation's energy infrastructure to promote economic competitiveness, energy security, and environmental responsibility with a focus on energy transmission, storage, and distribution.[21] The report identifies energy smart technologies as key infrastructure improvements that can mitigate environmental impacts and grid vulnerabilities, improve overall grid efficiency and resiliency, and reduce costs.[22] It also discussed the importance of open standard development—similar to the USB standard developed in the mid-1990s for evolving computers, printers, games, and mobile devices—to address the lack of interoperability between different technologies and the larger grid system.[23] The review recommended additional funding of up to $3.5 billion to support energy system modernization through development of smart grid technologies.[24]

Conclusion

As innovations in energy smart technologies enhance communication between producers and consumers, the role of these products in the power system will continue to evolve. National recognition of the economic and security benefits offered by smart products will be essential to support further deployment and market growth. Establishment of open standards will unify the technologies and drive interconnection. Continued financing of innovation will help to lower costs and increase market adoption, resulting in a cleaner, cheaper, and stronger grid. Although the U.S. Department of Energy has been a longtime sponsor of this type of groundbreaking research, the agency faces ongoing budget limitations. Continued congressional support and federal investment in energy smart technologies will be critical to maintaining the nation's leadership in clean energy.

Endnotes

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