

Smart grid - the evolution of energy management and conservation

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Today's electrical distribution system has changed little in 100 years - and is just as inefficient. The system, a major fossil fuel consumer and emitter of greenhouse gases, is not well suited to distributed, renewable solar and wind energy sources and does not have sufficient capacity to meet future demand. Environmentally friendly, 'smart grids' that depends heavily on clean, renewable, energy sources can not only supply energy, but interactively control and reduce the energy used by devices connected to it.



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Most of the world's electricity delivery system or 'grid' was built when energy was relatively inexpensive. While minor upgrades have been made to meet increasing demand, the grid still operates the way it did almost 100 years ago - energy flows over the grid from central power plants to consumers, and reliability is ensured by maintaining excess capacity.

The result is an inefficient and environmentally wasteful system that is a major consumer of fossil fuels and emitter of greenhouse gases and not well suited to distributed, renewable solar and wind energy sources. In addition, the grid may not have sufficient capacity to meet future demand.

Several trends have combined to increase awareness of these problems, including greater recognition of climate change, commitments to reduce carbon emissions, rising fuel costs, and technology innovation. In addition, recent

studies support a call for change: power generation causes 25.9 per cent of global carbon (CO₂) emissions¹ and CO₂ emissions from electricity use will grow faster than those from all other sectors through 2050².

Given this information, governments and regulators, utility companies, and technology firms are rethinking how the electricity grid should look. Utility companies and governments around the world are already launching efforts to increase distributed solar and wind power generation to increase the electrical supply without additional greenhouse gas emissions. There are plans to use plug-in hybrid electric vehicles (PHEVs) to generate and consume electric power intelligently, and sequester (scrub and store) the carbon from coal plant emissions. They are also looking to use demand management to improve energy efficiency and reduce overall electricity consumption, and monitor and control the

energy grid in near-real time to improve reliability and utilization, reduce blackouts, and postpone costly new upgrades.

For all of these efforts - solar and wind plants, PHEVs, active home-energy management, and grid monitoring - to work together in one integrated system, a new level of intelligence and communication will be required. For example:

- Rooftop solar panels need to notify backup power generators within seconds that approaching clouds will reduce output;
- The grid needs to notify PHEVs about the best time to recharge their batteries;
- Utility companies need to communicate with, and control, appliances such as refrigerators and air conditioners during periods of peak electricity demand;
- Factory operators must know the cost of electric power every few minutes to manage

¹ IPCC, 2007

² Stern Review on the Economics of Climate Change, 2006

their energy use economically; and

- Homeowners need to become smart buyers and consumers of electricity by knowing when to adjust thermostats to optimize energy costs.

Unfortunately, these activities cannot be achieved with the current energy grid. Today's electric infrastructure simply cannot coordinate and control all the systems that will be attached to it.

A new, more intelligent electric system, or 'smart grid', is required that combines information technology (IT) with renewable energy to significantly improve how electricity is generated, delivered, and consumed. A smart grid provides utility companies with near-real-time information to manage the entire electrical grid as an integrated system, actively sensing and responding to changes in power demand, supply, costs, and emissions - from rooftop solar panels on homes, to remote, unmanned wind farms, to energy-intensive factories.

A smart grid is a major advance; today, utility companies have only basic information about how the grid is operating, and much of that information arrives too late to prevent a major power failure or blackout.

Economic and environmental benefits of smart grids

A smart grid comprises three major components: demand management, distributed electricity generation and transmission and distribution grid management. A smart grid that incorporates these three elements allows for a wide array of more efficient, 'greener' systems to generate and consume electricity.

In fact, the potential economic and environmental benefits of a smart grid are significant. If widely deployed, this approach could reduce peak loads on utility grids by up to 15 per cent annually, which equals more than 100 gigawatts, or eliminates the need to build 100 large coal-fired power plants over the next 20 years in the United States alone. This could save up to US\$200 billion in capital expenditures on new plant and grid investments, and take the equivalent of 30 million autos off the road³. Similarly, governments are trying to revitalize economic growth by attracting industries that will produce and build the smart grid.

Demand management to reduce greenhouse gas emissions

Worldwide demand for electric energy is expected to rise 82 per cent by 2030⁴. Unless revolutionary new fuels are developed, this demand will be met primarily by building new coal, nuclear, and natural gas electricity-

generation plants. Not surprisingly, world CO₂ emissions are estimated to rise by 59 per cent by 2030 as a result⁵.

The smart grid can help offset the increase in CO₂ emissions by slowing the growth in demand for electricity. A smart grid will:

- Enable consumers to manage their own energy consumption through dashboards and electronic energy advisories. More accurate and timely information on electricity pricing will encourage consumers to adopt load-shedding and load-shifting solutions that actively monitor and control energy consumed by appliances;
- In deregulated markets, allow consumers to use information to shift dynamically between competing energy providers based on desired variables including energy cost, greenhouse gas emissions, and social goals. One possibility is an 'eBay for electricity' where continual electronic auctions match energy consumers with producers. Users could include utility companies, homeowners with rooftop solar panels, and governments with landfills that reclaim methane gas. This open market approach could accelerate profitability and speed further investments in renewable energy generation;
- Broadcast demand-response alerts to lower peak energy demand and reduce the need for utility companies to start reserve generators. Remote energy-management services and energy-control operations will also advise consumers, giving them the choice to control their homes remotely to reduce energy use; and
- Allow utility companies to increase their focus on 'Save-a-Watt' or 'Nega-Watt' programs instead of producing only power. These programs are effective because offsetting a watt of demand through energy efficiency can be more cost-effective and CO₂-efficient than generating an extra watt of electricity.

Distributed electricity generation

A smart grid will encourage home and building owners to invest in high-efficiency, low-emission micro-generation devices to meet their own needs, and to sell excess energy back to utility companies to offset peak demands on the electrical grid. This will reduce the need for new, large-scale power plants. Virtual power plants can also be created that include both distributed power production and energy-efficiency measures.

In addition, a smart grid will accelerate the introduction of PHEVs to act as temporary electricity storage devices, as well as provide incremental energy generation to offset peak demand on the grid. Intelligence within the smart grid will be required to maintain reliability and stability once tens of thousands

of micro-generation devices and PHEVs are brought online.

Grid management - delay construction of new infrastructure

It is estimated that the cost to renew the world's aging transmission and distribution grid will exceed US \$6 trillion over the next 25 years⁶. Utility companies are turning to IT solutions to monitor and control the electrical grid in real time. Utility companies that implement electronic monitoring and management technologies can prolong the useful life of some electrical grid components, thus delaying major investments needed to upgrade and replace current infrastructure. Until now, monitoring has focused only on high-voltage transmission grids. Increasing overall grid reliability and utilization, however, will also require enhanced monitoring of medium- and low-voltage distribution grids.

Making the smart grid a reality

Rising fuel costs, underinvestment in an aging infrastructure, and climate change are all converging to create a turbulent period for the electrical power-generation industry. So, as utility companies prepare to meet the growing demand for electricity, greenhouse gas emissions from electricity generation may soon surpass those from all other energy sources⁷.

Creating smart grids to meet the challenge

Practically speaking, most of the technologies required to create a smart grid are available today. In fact, forward-looking utility companies are already using these technologies to deliver solutions to their customers. For example, many utility companies are offering demand-response programs for their corporate customers, and, increasingly, for residential customers. In addition, some utility companies are implementing large numbers of smart electric meters to offer variable pricing to consumers and to reduce manual meter-reading costs. While these first steps are encouraging, more needs to be done.

Despite its promise and the availability of most of the core technologies needed to develop the smart grid, implementation has been slow. To accelerate development, governments, electric utility companies, public electricity regulators, and IT companies must all come together and work toward making the smart grid a reality, to ensure we have enough power to meet current and future demand, while at the same time reducing greenhouse gases that cause global warming. ●

³ Ibid

⁴ "International Energy Outlook 2008," Energy Information Administration, 2008, <http://www.eia.doe.gov/oiaf/ieo/highlights.html>

⁵ Ibid

⁶ World Energy Outlook, 2006

⁷ Stern Review on the Economics of Climate Change, 2006