Energy

Building the smart grid

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Energy: By promoting the adoption of renewable-energy technology, a smart grid would be good for the environment—and for innovation


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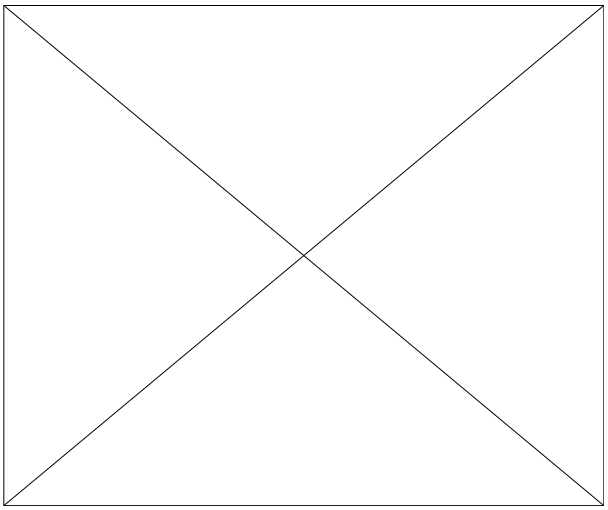
AROUND the world billions of dollars are being invested in clean-energy technologies of one sort or another, from solar arrays and wind turbines to electric cars. But there is a problem lurking in the power grid that links them together. Green sources of power tend to be distributed and intermittent, which makes them difficult to integrate into the existing grid. And when it comes to electric cars, a study by America's Pacific Northwest National Laboratory (PNNL) found that there is already enough generating capacity to replace as much as 73% of America's conventional fleet with electric vehicles—but only if the charging of those vehicles is carefully managed. In order to accommodate the flow of energy between new sources of supply and new forms of demand, the world's electrical grids are going to have to become a lot smarter.

Even though the demands being placed on national electricity grids are changing rapidly, the grids themselves have changed very little since they were first developed more than a century ago. The first grids were built as one-way streets, consisting of power stations at one end supplying power when needed to customers at the other end. That approach worked well for

many years, and helped drive the growth of industrial nations by making electricity ubiquitous, but it is now showing its age.



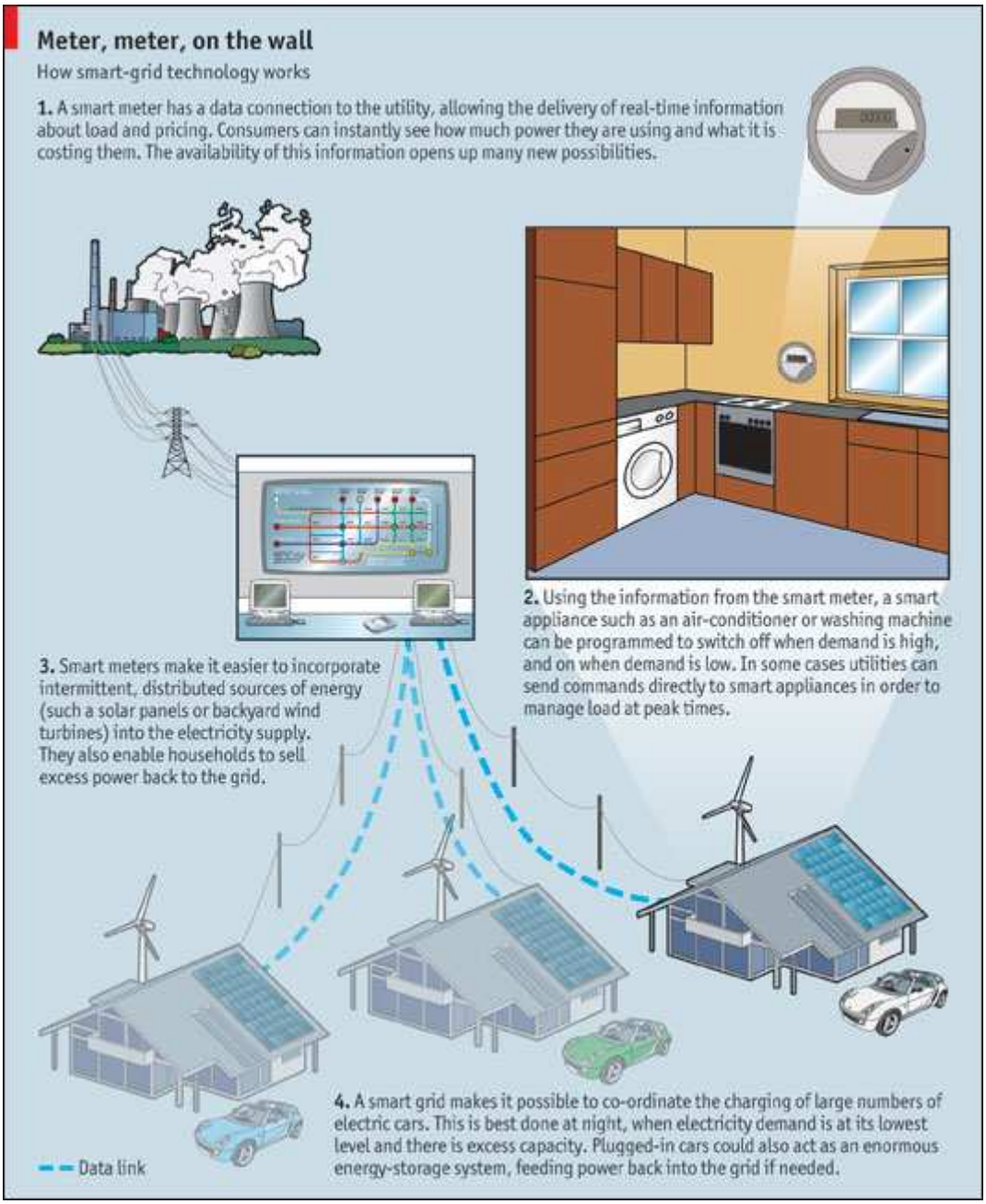
One problem is a lack of transparency on the distribution side of the system, which is particularly apparent to consumers. Most people have little idea how much electricity they are using until they are presented with a bill. Nor do most people know what proportion of their power was generated by nuclear, coal, gas or some form of renewable energy, or what emissions were produced in the process. In the event of a power cut, it is the customer who alerts the utility, which then sends out crews to track down the problem and fix it manually. "I can't think of another industry that still has that lack of visibility over its networks," says Heather Daniell of New Energy Finance, a research firm in London.

According to projections from America's Energy Information Administration, electricity generation around the world will nearly double from about 17.3 trillion kilowatt-hours (kWh) in 2005 to 33.3 trillion kWh in 2030. Poor countries will show the strongest growth in electricity generation, increasing by an average of 4% per year from 2005 to 2030, compared with 1.3% per year for their richer counterparts. In some countries, including America, the grid has not kept up with the growth in demand for power. The deregulation of America's utilities in the 1990s encouraged companies to transfer power over long distances. At the same time, regulatory uncertainty and increased competition led to reduced investment in new transmission lines. As a result, some parts of the system have become increasingly congested. Black-outs cost America an estimated $80 billion a year, according to a study by the Lawrence Berkeley National Laboratory.

Plugging in

The cure, many believe, is to apply a dose of computer power to the grid. Adding digital sensors and remote controls to the transmission and distribution system would make it smarter, greener and more efficient. Such

a “smart grid” or “energy internet” would be far more responsive, interactive and transparent than today’s grid. It would be able to cope with new sources of renewable power, enable the co-ordinated charging of electric cars, provide information to consumers about their usage and allow utilities to monitor and control their networks more effectively. And all this would help reduce greenhouse-gas emissions. “We have a fundamental belief that a fully effective smart grid is going to radically change the way an energy grid operates,” says Michael Carlson, until recently a senior executive at Xcel Energy, a power company that is using the city of Boulder, Colorado, to test various smart-grid technologies.



What exactly would a smart grid look like? Many of the changes would be invisible. On the transmission and distribution side, sensors and digital relays installed on power lines will enable utilities to operate systems with greater efficiency and reliability. Today's supervisory control and data acquisition systems, for example, typically provide data on the state of transmission lines every four seconds. Devices called synchrophasors can sample voltage and current 30 times a second or faster—giving utilities and system operators a far more accurate view of the health of the grid. A broad deployment of synchrophasors could be used as an early warning system to help halt or prevent power surges before they develop into massive blackouts, says Jeff Dagle of PNNL.

Other smart-grid technologies would be more visible to consumers. Probably most important would be the introduction of smart meters, which track electricity use in real-time and can transmit that information back to the power company. Smart meters have been used by commercial and industrial customers for decades, says Eric Miller of Trilliant, an American company that installs communications networks and software to implement smart meters. But in recent years they have become cheap enough for wider deployment.

Smart meters establish a two-way data connection between the customer and the power company, by sending information over a communications network that may include power-line, radio or cellular-network connections. Once smart meters are installed, power companies can determine the location of outages more easily, and no longer need to send staff to read meters, or to turn the power on or off at a particular property. Smart meters also help to curtail the theft of electricity. Altogether some 76m of them have been installed worldwide, according to ABI Research, and that number is forecast to increase to 155m by 2013. So far the pioneer is Italy, where the main utility, Enel, has deployed more than 30m smart meters to its customers since 2001. About 12m smart meters will be installed in California over the next few years, and the province of Ontario has told its utilities to install a smart meter for every household by 2010.

But the smart meter is only the first step. Eventually smart meters will communicate with smart thermostats, appliances and other devices, giving people a much clearer view of how much electricity they are consuming. Customers will be able to access that information via read-outs in their homes or web-based portals, through which they will be able to set temperature preferences for their thermostats, for example, or opt in or out of programmes that let them use cleaner energy sources, such as solar or wind power.

As well as giving utilities more control, smart meters also give them more flexibility. In particular, they can vary the price of electricity throughout the day in response to demand. Telling people that electricity is more expensive when demand is high will encourage them to do their laundry when demand has fallen and electricity is cheaper, says Rick Stevens of Hydro One, a power

company in Ontario that has installed almost 900,000 smart meters to date and plans to start sending price signals to its customers in 2010.

This could be done by showing real-time price and usage information on a display so that consumers can decide whether to turn on the washing machine. Studies have found that when people are made aware of how much power they are using, they reduce their use by about 7%. With added incentives, people curtail their electricity use during peaks in demand by 15% or more. But eventually it should be possible to do it automatically, so that the dishwasher waits for the price to fall below a certain level before switching on, for example, or the air-conditioner turns itself down when the price goes up.

This is more complex than today's pricing, of course, but customers will be able to save money if they are prepared to put up with a bit more complexity. "If you don't want to participate, then you're going to pay a much higher rate per kilowatt-hour," says Peter Corsell of GridPoint, a company that has developed a web-based portal that lets people respond to price changes from utilities. "And if you want to opt in, you may save a whole lot of money." During a one-year pilot study carried out by PNNL, for example, consumers reduced their electricity bills by an average of 10% compared with the previous year.

The advantage from the utility's point of view is that it becomes easier to balance supply and demand by reducing consumption at times of peak demand, such as during very hot or cold spells, when people crank up their air-conditioners or heaters. As well as improving the stability of the system, it could also enable utilities to postpone the construction of new power stations, or even do without them altogether, by reducing the peak level of demand that they have to meet.

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Smarter than it looks

Moreover a smart grid will make it easier to co-ordinate the intermittent and dispersed sources of power, from rooftop solar panels or backyard wind-turbines, for example. And, of course, a smart grid could also help manage the charging of electric vehicles. The best time to charge vehicles is at night, when lots of cheap electricity is available. "If we don't do that, then we will add to peak loads and we'll have to build huge amounts of infrastructure to handle our vehicles," says Robert Pratt of PNNL. The flow of energy between the grid and electric cars need not be one-way. With millions of electric cars plugged in at any one time, they could act as an enormous energy-storage system, absorbing excess power from wind turbines on windy nights, for example, but also feeding power back into the grid if necessary (an approach called "vehicle to grid", or V2G) if the wind suddenly drops.

Electricity bills

Implementing all this will not be cheap. A smart meter costs about $125, and can cost several hundred dollars more to install, once the necessary communications network and data-management software at the utility are taken into account. (Smart meters can collect customer readings as often as every 15 minutes, rather than every month, so utilities need new software to cope with all the extra data.)

The American government is spending some $4 billion from its economic-stimulus package on smart-grid initiatives, but providing a smart meter for every American home would cost far more: California's investor-owned utilities alone are spending about $4.5 billion on deploying smart meters over the next few years. That implies that a nationwide implementation could cost around $50 billion. But PNNL estimates that $450 billion would have to be poured into conventional grid infrastructure to meet America's expected growth over the next decade anyway. Mr Carlson, who now works for GridPoint, argues that a bit of thought is called for if the aim is to move to a new energy-management model, "as opposed to building more of what we've already got."

One problem is that power companies are understandably reluctant to invest in technologies that will reduce consumption of the product they sell, even if there are other benefits. One way to realign the public interest with that of the utilities is through a process called "decoupling" which breaks the direct relationship between electricity sales and profits, a measure that has been successfully employed in California. Energy use per person has remained largely flat over the past 30 years in California, but it has increased by roughly 50% for the rest of America. But in some instances the business case is straightforward. Enel spent around €2.1 billion ($3 billion) installing its 30m smart meters in Italy, but now saves around €500m a year as a result, so its investment paid for itself within five years.

As well as producing savings from improved operational efficiency, a smart grid could also save utilities money by reducing consumption, and with it the

need to build so many new power stations. Reducing peak demand in America by a mere 5% would yield savings of about $66 billion over 20 years, according to Ahmad Faruqui of the Brattle Group, a consultancy that has worked with utilities on designing and evaluating smart-meter pilot programmes. Moreover, studies have shown that the best in-home smart-grid technologies can achieve reductions in peak demand of up to 25%, which would result in savings of more than $325 billion over that period, calculates Dr Faruqui. "Technology is expensive," he says, "but not using it will be even more expensive."

Smart-grid technology offers a wide range of possibilities, so deployments will vary depending on each utility's business needs, existing infrastructure and regulatory environment. Some utilities may seek to use the technology to maximise energy efficiency, for example, while others may focus on the integration of renewable energy sources. "You're never going to build the same smart grid twice, so you have to look for overriding themes," says Brad Gammons of IBM, a computer giant, which has helped dozens of utilities with their smart-grid implementations. Amid all the variations, however, one point of consensus has emerged. To handle all of the information that must be sent to and fro to make a smart grid work, "more bandwidth is better", says Mr Gammons.

Although smart grids are often likened to an internet for energy, there is one important difference. The internet is built on open technical standards, from internet protocol to move packets of data around to hypertext mark-up language to define the appearance of web pages. But agreement on standards has yet to be reached for smart grids, which can pose a problem when different networks and technologies are expected to work together.

Some standards exist, but others are just emerging, says Don Von Dollen of the Electric Power Research Institute, whose organisation was recently asked by America's National Institute of Standards and Technology to develop a "smart-grid interoperability standards road map". Agreed-upon standards would allow companies to buy and sell devices, services and software in the knowledge that they would work together.

One area where such interoperability will be critical is in the home. Many utilities want people to be able to buy smart thermostats, smart appliances and other smart-grid technologies in shops, says Sam Lucero of ABI Research, "and if everything is proprietary that becomes much more problematic." Another complication is that there is currently no standard way to access historical billing information or real-time metering data, which would be extremely helpful to developers of web-based billing and energy-analysis services for consumers, says Erich Gunther of EnerNex, a consulting firm based in Knoxville, Tennessee, that is advising California's energy commission on smart metering and demand response programmes.

Once these issues are ironed out, though, the smart grid could provide the platform for a huge range of innovation and applications in energy, just as the internet did in computing. “I think that an open, standards-based network could give birth to a thousand new companies,” says Eric Dresselhuys of Silver Spring Networks, a firm based in California that works with utilities to implement smart-grid networks. A smarter grid will not only help people save energy or use it more efficiently, but will also promote the adoption of all kinds of green technologies, including wind, solar and plug-in vehicles. “It’s the platform that allows for the transformation of one of the largest and most important industries in the world to take place,” says Mr Dresselhuys.