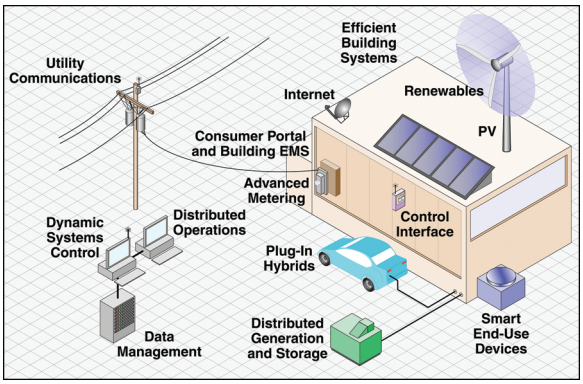
Energy efficiency and the smart grid

Two days before his inauguration, President Barack Obama pledged to "spark a clean-energy economy" by doubling alternative-energy production, improving energy efficiency, and starting to "retrofit America" with a smart power grid. The approach has gained support from diverse sectors, but the road map for achieving this triple policy imperative is still on the drawing table.

The three goals are intimately related. A December 2008 report by the U.S. Department of Energy's Electricity Advisory Committee (EAC) cites pressing reasons for decisive action, which include national security; global warming; mounting electric power demand; rising costs for energy, capital, and raw materials; and environmental and social considerations. Furthermore, EAC stresses that "while much of the technical and policy discussion on how to ensure a sustainable energy future focuses on energy efficiency, renewable energies, storage, and plug-in electric vehicles, ...these solutions all depend on a smarter grid to achieve scale and cost-effectiveness."

Even the nation's largest utility trade group, the Edison Electric Institute (EEI), is on board. In a February speech, EEI President Tom Kuhn said that his industry's future success "will rest upon aggressive action in...energy efficiency, [a] smart grid, ...and transmission technologies."

The newly approved American Recovery and Reinvestment Act makes a sizable down payment on these priorities, channeling tens of billions of dollars into clean-energy programs. It increases the budget of the federal office of Energy Efficiency and Renewable Energy (EERE) by 10-fold and funds scores of activities ranging from weatherizing buildings to research on renewable-energy storage technology and smart-grid demonstration projects. "It sets all the right motivation to move forward," says Steve Pullins, an energy consultant for the National Energy Technology Laboratory.



EPRI

As conceptualized in this diagram, a smart grid can streamline operations and enable utilities to tap into new avenues to save energy and reduce carbon emissions.

Vision for a new grid

The basic idea behind the smart grid is to convert the unwieldy system—which, conceptually, has changed little since Thomas Edison's time—into an interconnected, automated, and interactive network akin to the Internet. The intelligence, proponents say, will come from using digital tools for monitoring, analysis, control, and communication between utilities and consumers as well as among power stations within the network. The ultimate goal is to optimize efficiency, reliability, flexibility, and responsiveness in the power-grid system.

Key tools for enabling this massive makeover, including smart meters and thermostats, energy management and storage systems, and dynamic lighting controls, are already available. Such "demand-response" technologies help manage customer consumption of electricity in response to supply conditions. For example, advanced metering infrastructure (AMI)—which is generally seen as a starting point for a more intelligent grid—measures power usage in time intervals; this allows utilities to better manage energy transmission loads and to set pricing that more accurately reflects actual costs.

AMI also can be used to communicate this information to consumers. "With the ability to track their power usage at various times of day and see the corresponding rates, consumers can choose, for example, to avoid running power-draining appliances when rates are steepest," explains Melissa McHenry, spokesperson for the utility company American Electric Power. The company has recently installed smart meters for 10,000 Indiana customers, who will be able to monitor their usage through a web-based interface and receive time-of-day discounts, she says. Other ready-to-launch projects include plans for Southern California Edison to install 5.3 million advanced meters and for ONCOR, a Texas utility, to install 3 million meters.

A few demonstration projects have gone further. For example, in the GridWise program, sponsored by Pacific Northwest National Laboratory from 2006 to 2007, workers installed a handful of appliances equipped with power controllers in Washington state homes and gave customers access to real-time energy pricing via the Internet to manage their usage. The results showed that even a limited demand-response program could reduce peak power loads by about 15% and save participants an average of 10% on their electric bills. Far more ambitiously, Xcel Energy is currently working to convert Boulder, Colo., into a fully integrated

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"Smart Grid City" and to test the claim that a smart grid could better support plug-in hybrid electric vehicles by using vehicle-to-grid technology.

Omar Siddiqui of the Electric Power Research Institute (EPRI), a nonprofit R&D organization, believes such "live experiments are essential before a massive rollout of effort occurs, and now is the time. We need to take an empirical approach to see what works and what doesn't—how these technologies, in conjunction with energy efficiency, affect demand response and carbon savings."

Wasted energy

According to EPRI, the nation's appetite for electricity grew about 1.7% annually from 1996 through 2006, and the total projected growth through 2030 will top 26%. Translating that into climate impacts, the EAC report quotes the National Renewable Energy Laboratory: If "'we do nothing, U.S. carbon emissions are expected to rise from 1700 million tons of carbon per year today to 2300'" million tons by the year 2030. However, the implementation of energy-efficiency programs and use of renewable energy sources "'could not only displace that growth, but actually have the opportunity to reduce the carbon output to below 1000'" million tons of carbon by 2030.

A major reason underlying the U.S.'s voracious energy consumption is its abysmally low levels of output from power sources—the lowest among the world's developed economies, experts say. "By capturing the potential available from existing technologies with an internal rate of return of 10 percent or more, the U.S. has the potential to cap its energy demand, as well as its greenhouse gas emissions, at today's levels," according to a report by McKinsey Global Institute. The largest opportunities for saving are in the residential sector, the report says.

Amping up productivity in power generation also could slash the need for new power plants. Case in point: figures from EERE show that more than two-thirds of the fuel used to generate U.S. electricity is lost as heat, and each year that adds up to more power than Japan's total annual energy consumption. Using cogeneration technologies that capture waste heat and channel it to industrial and residential heating or convert it to steam for power generation can boost thermal efficiencies up to 80%.

Power transmission is another highly fertile area for improvement. Much of the country's electricity infrastructure is at least a half-century old, and vintage low-voltage transmission lines can leak 10% or more of their energy load. According to American Electric Power, one state-of-the-art, extra-high-voltage line carries as much electricity as six standard ones, at 1/3 the cost, using 25% less land, and with 1/10 the line losses.

Such megacapacity is considered critical for meeting future energy demand and integrating renewable power into the grid. "Today we have roughly 30,000 power generation units," Pullins notes. "Output from the average coal-fired plant averages 300 megawatts, whereas a wind turbine produces about 2 megawatts, so transmission and distribution networks will need to accommodate 500,000 or more units," he explains. "Although energy generated by the sun and wind can be fed directly into the grid, they are inherently variable sources. We need a nimble, intelligent grid to manage that variability, and options for storing energy produced at low-demand hours."

Moving cautiously

Despite leadership from the White House and successful demonstration projects, the majority of utilities are moving cautiously, if at all, toward a smart grid. Estimates vary on the levels of utility interest. Figures from KEMA, a technical consulting group, show that approximately 70 utilities have embarked on advanced metering plans. Spokesman Don Kintner says that among the EPRI membership—which collectively produces more than 90% of U.S. electricity—only about 15 utilities have major efforts under way that actively deploy smart-grid technologies.

Other stakeholders voice concerns that too much emphasis on adopting smart-grid technologies could crowd out investments in energy-efficiency measures that could pay bigger dividends in reducing carbon emissions. Steve Nadel, with the nonprofit American Council for an Energy-Efficient Economy, which compiles state-by-state energy-efficiency scorecards, says, "We believe energy efficiency will get us more than halfway to the Intergovernmental Panel on Climate Change goal of reducing emissions 80% by 2050. A smart grid can help to achieve some of these savings, but it will only be one among many contributors."

Free-market advocates, such as those at the Institute for Energy Research, generally criticize what they view as "massive government intervention in energy markets." A recent report from the institute charged that green-energy stimulus funding "would likely increase [the costs of] consumer energy and...a wide array of energy-intensive goods and slow GDP growth....Government picking of winners and losers [is] a classic example of unsound energy policy."

Despite the broad range of opinions, a new paradigm seems to be emerging. "This isn't about a program with a timeline, and it won't be measured that way," says Pullins.

—NOREEN PARKS