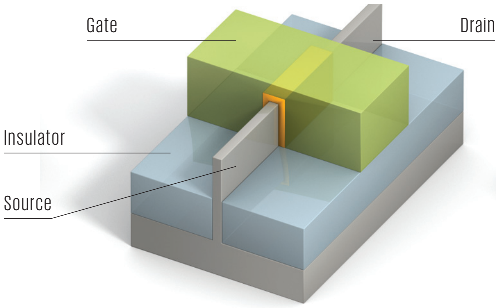


FINS ARE IN: Three-dimensional transistors, or FinFETs, control current between the source and drain more effectively by surrounding the transistor channel with the gate on three sides.

ties that were not necessarily fin-related was not prudent." All told, the hybrid approach should allow the company to accelerate production by a year.

TSMC, which calls its FinFET scheme a 16-nm process, says its chips are "similar" in size and density to other foundries' 14-nm offerings. Later this year, both TSMC and GlobalFoundries hope to create small batches of test chips for customers and are targeting full production in 2014, which will put the companies' releases more or less on the same schedule as that of Intel's own 14-nm chips.

"I think this incremental strategy is probably a very sound, safe way of not changing too many things at the same time and developing something they can be sure can be production worthy," says Chi-Ping Hsu, who heads up research and development for the Silicon Realization Group at Cadence, an electronic design automation firm based in San Jose, Calif.

FinFETs are "a huge challenge for the whole industry," Hsu says. He estimates that his team at Cadence has already spent some 4000 man-years overhauling computer code for today's generation of chips so that processor operation can be simulated in a realistic time frame. FinFETs, which boast stronger electrical effects on their neighbors and have dimensions that can't be adjusted, are an added challenge. Hsu reckons it will cost the foundries and their partners some US $6 billion to develop the manufacturing prowess and the computational tools needed to make 14-nm and 16-nm chips.

Whether the investment will pay off in the end is unclear, says Sam Tuan Wang, chief analyst for semiconductor foundries at Gartner. "People say if Intel can do it, I can do it. That's not true," he says. We may not have to wait long to find out.

—RACHEL COURTLAND

At the IEEE International Electron Devices Meeting in December, Intel claimed that its FinFETs for mobile chips were 22 to 65 percent faster than the previous generation.

AN INTERNET-INSPIRED ELECTRICITY GRID

Japanese consortium aims to transform the country's centralized grid into islands of interconnected cells

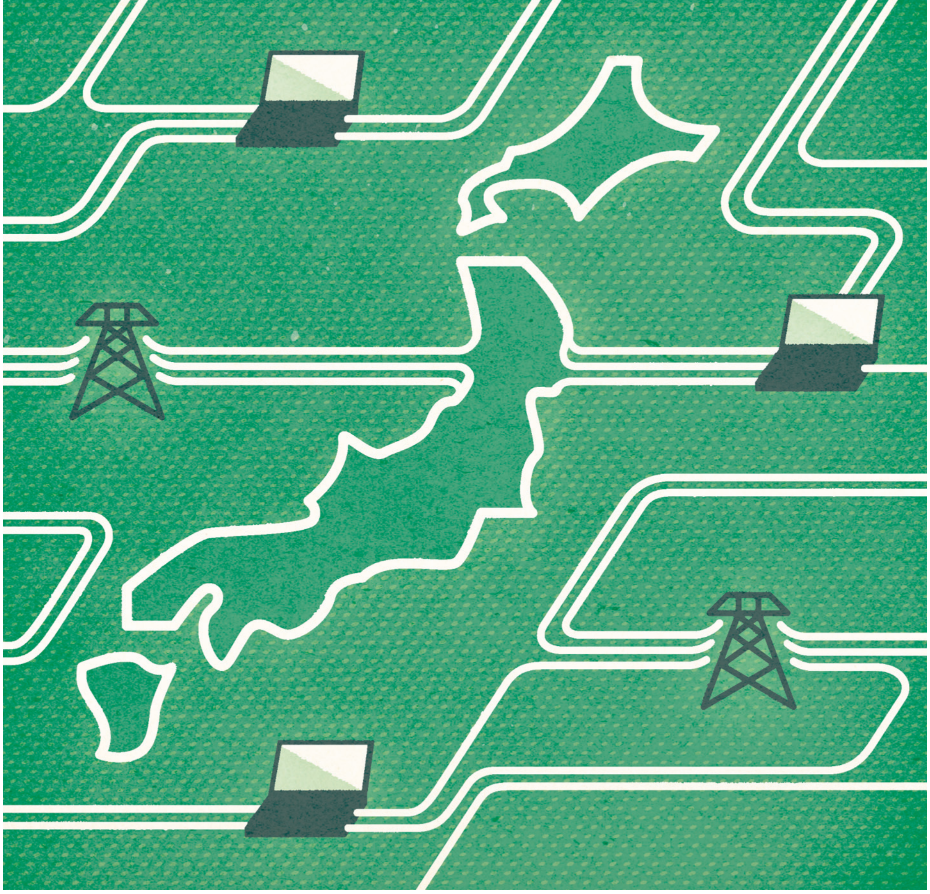
Japan's plan to phase out its nearly 50 gigawatts of nuclear capacity over the next two to three decades has opened a window for renewable energy in the country. But swapping wind and solar power for that nuclear generation, which produced 30 percent of Japan's electricity prior to the 2011 Fukushima crisis, could also lead to major disruptions in energy supply, warns Rikiya Abe, a University of Tokyo professor. The problem, says Abe, who came to academia after working in the electrical generation industry for 30 years, is that Japan's grid—and indeed that of many developed countries—is set up to be centrally controlled. The utilities have to carefully regulate the grid's frequency and voltage by maintaining a fine balance between power generation and changing demand. A diverse group of large Japanese firms is starting to explore a solution—a gradual reorganization of the country's power system so that in the end it resembles the Internet, routers and all.

"The present synchronized system has served us well," says Abe. "But when you introduce various sources of renewable energy, they will certainly increase fluctuations in the system, until at some point they become unmanageable." What we need, he says, "is a shift from central to decentralized control, with generated power being segmented and widely distributed."

The answer is what he calls "the digital grid," the architecture of which is based on the Internet. The idea is to gradually subdivide the existing synchronized grid into asynchronous, autonomous but interconnected cells of varying sizes. These assign the equivalent of IP addresses to generators, power converters, wind farms, storage systems, rooftop solar cells, and any other grid infrastructure within the cells.

"Theoretically it's sound; technically it's doable," says Paul Scalise, a former energy analyst who is now a research fellow at Temple University Japan and the University of Tokyo. "And it has the added benefit of dealing

ILLUSTRATION BY Emily Cooper



transported to complete the transaction. The actual communication in the digital grid is done primarily over the Internet, or in the case of power lines, by adding on a high frequency signal. "Each energy transaction will automatically be recorded and collected by certified service providers, along with additional properties such as location, time, generation source, price, and CO_2 credits," he says.

Since the 2011 earthquake, Abe says he's seen a great upsurge of interest in the concept, but he agrees that to turn the digital grid into a viable reality in Japan, he will have to win over the power utilities and major electrical equipment manufacturers, which so far have declined to join the consortium, "though we continue to talk with them and with METI [Ministry of Economy, Trade and Industry]," he says. "Eventually, they will have to accept the reality of renewably generated energy and [that] the present system is not set up to manage it," says Abe. "If they're going to remain key players in the coming renewable energy era, they really need to start changing their present business model."

with the renewable energy issue," he says. "So it's an idea that could hold sway with utility companies worldwide. The question is, though, who is going to pay for it?"

To get the concept off the ground, last September Abe established the Digital Grid Consortium, which he heads. To date it has six members: Hitachi Yokohama Research Laboratory, Kanematsu Electronics, National Instruments Japan, NEC, Orix Corp., and Sekisui Chemical. In the same month, Abe says, the group successfully demonstrated a key enabling technology—the Mark I, a 2-kilowatt, three-legged "digital grid router." DGRs would manage and regulate power demands by providing asynchronous connections and coordination within and between cells. The multilegged DGR comprises a solid-state AC/DC/AC converter using insulated gate bipolar transistors and other power electronics. These enable voltages to be raised or lowered on the fly as cell frequencies change, according to various demands. Early next year, the consortium plans to demonstrate two or more routers working together at the Knoxville, Tenn., Electric Power Research Institute test facility.

Equipped with a CPU, memory, data storage, and network communications, a DGR assigns tags (the equivalent of IP addresses) to discrete "packets" of power from various generated or stored sources that are sent into the grid, while receivers simultaneously extract the same amount of power from the grid. To illustrate how this would work, Abe gives as an example a cooperative residential group that puts in an order for renewably generated power at a certain cost. Using an Internet-based market mechanism similar to a stock exchange system for buying and selling securities, a broker locates a solar farm that accepts the order, and a contract is agreed on. "If the order is not matched, then there is no transaction," he says. "This maintains balance in the grid."

Abe likens the process to the banking system. If one person remits money to another person, the cash need not be physically

Scalise, author of an upcoming book on Japan's energy restructuring effort, agrees. "Any developed country moving towards a renewable energy portfolio will sooner or later have to deal with the transmission and distribution grid issue," he says. "And this is going to apply as much to the United States as it does to Europe."

In the meantime, the consortium is continuing to improve the DGR and has begun looking for opportunities to introduce the technology first in an underdeveloped country where countrywide grids don't exist. "In such countries...they may not even require a conventional grid system over the long run," Abe says. —JOHN BOYD

ILLUSTRATION BY Jesse Lefkowitz