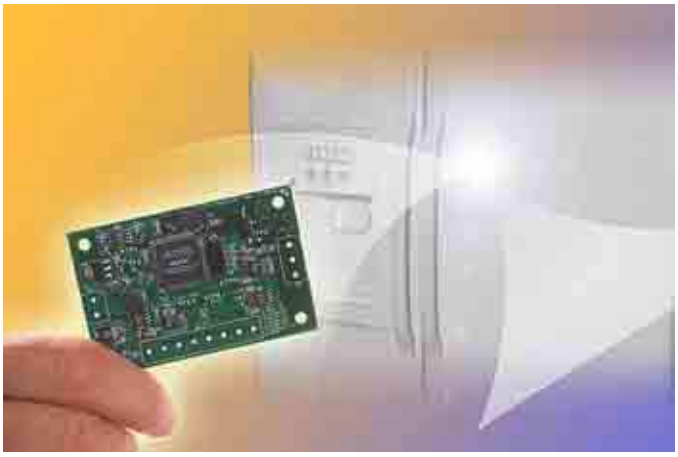
PNNL advances future power-grid reliability

The Department of Energy's Pacific Northwest National Laboratory is a leader in power-grid reliability. To mitigate impacts of aging infrastructure, deregulation and vulnerabilities to terrorism, PNNL envisions a power grid of the future using technological advancements. Lab experts are supporting DOE and other industry stakeholders to provide insight into the factors that play a role in large-scale outages such as those that occurred on the East Coast on Aug. 14, and to determine how susceptibility to such events can be minimized with new technology and better cooperation.



Engineers with Pacific Northwest National Laboratory are designing smart chips that would be fitted into household appliances to continually monitor fluctuations in the power grid. When the grid is under high stress, a grid-friendly appliance would identify these fluctuations and, within milliseconds, automatically shut down for a short period of time to give the grid operators time to stabilize the system. It could even turn on momentarily to absorb excess power from fluctuations during a crisis.

"We're using the grid in ways that it wasn't designed for, and the results can be cascading outages that cripple entire regions," said Jeff Dagle, PNNL chief electrical engineer and grid-reliability expert, echoing an opinion widely shared among utility engineers. "The grid architecture must be changed to support the new demands that are being placed upon it, making it more resilient to failure or attack and flexible enough to evolve as better technological solutions emerge.

"One option we are considering is integrating advanced technology into the system — from the consumer level in a person's home to the generators and substations," he said. "Also, development of new energy sources such as fuel cells will further reduce demands on the grid. Tighter cooperation between private and public organizations must be the foundation for either of these efforts."

Grid of the future

The East Coast power outage further proves that despite the country's technological might, its power system is stuck in the 20th century. Efforts to modernize the grid and incorporate new technologies that could reduce vulnerability to major outages are under way at PNNL through its Energy Systems Transformation Initiative.

"Called GridWise™, our vision draws on new technologies enabling collaboration among generators, the grid and customer loads to collectively increase the stability and cost-effectiveness of the power system beyond what is possible today," said Rob Pratt, program manager of PNNL's initiative. "We foresee solutions that involve adapting and influencing information, and control technology approaches to deliver a reliable energy infrastructure that's in step with the information revolution in the nation's economy in general. Major corporations like IBM, Alstom, PJM Interconnect and Sempra have created an alliance to jointly define this vision for the smart grid of the future."

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As part of GridWise™, PNNL engineers are designing smart chips that would be fitted onto household appliances and would continually monitor fluctuations in the power grid. When the grid is under high stress, a grid-friendly appliance would identify these fluctuations and, within milliseconds, automatically shut down for a short period of time to give the grid operators time to stabilize the system. It could even turn on momentarily to absorb excess power from fluctuations during a crisis.

"These brief interruptions of five or 10 minutes wouldn't be noticeable to the consumer, but if millions of hot water heaters, refrigerators and air conditioners shut down, the cumulative effect could reduce demand enough to stabilize the grid and give operators time to get it back under control," Pratt said. "These grid-friendly appliances could respond nearly instantly and much more quickly than a utility can start up additional generators or re-route power to compensate for disruptions in the system.

"By relieving stress on the grid, chances of a problem spinning out of control and cascading into a major blackout would be greatly reduced. These same appliances could stagger their return to service after an outage, easing the restoration of power."

PNNL is establishing a mock household environment where grid-friendly appliances would be tested for their effectiveness in monitoring grid fluctuations, responding to such fluctuations, and assessing past power outages using information from those events. The test bed is expected to be fully operational this fall.

Learning from outages

While the Aug. 14 East Coast outage was unprecedented in its impact, it is not the first time a major outage has struck highly populated areas. Dagle has co-authored two major reports for DOE that analyzed factors contributing to past power outages that crippled California and the East Coast. In the report, "Review of Reliability Issues and System Events," Dagle and colleague John Hauer, PNNL Laboratory Fellow and former BPA principal engineer for power-system dynamics, provided a detailed analysis of how 11 major North American outages occurred. The authors also offered insight into technology investments that could reduce chances of repeat events, institutional weaknesses that contributed to the events and options for addressing these problems.

In the report, the PNNL authors note that, for more than a decade, looming deregulation has provided little incentive for utilities to invest in higher-capacity systems, or increased load capacity.

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"A massive infusion of better technology is emerging as the final option for continued reliability and adequacy of electrical services," Dagle and Hauer write. "If that technology investment will not be made in a timely manner, then the fact should be recognized and North America should plan its adjustments to a very different level of electrical service."

New technology

One such technology solution is a monitoring system called WAMS, for Wide-Area Measurement System. Developed at PNNL in conjunction with Bonneville Power Administration, it monitors fluctuations in transmission lines, predicts failure-level problems, and analyzes the causes of outages. WAMS is an example of how information technology can help utilities and governments learn from past outages and recognize failure-level events in time to minimize damage. WAMS has been provided to utilities along the West Coast.

"Over the past couple of years, we've been discussing implementation of WAMS with several utilities on the East Coast," Dagle said. "The goal is to incorporate information technologies to better predict events, match power need and demands, and consider real-time needs in hopes of improving management of the grid.

"Beyond technology incorporated into the grid, innovations in the area of fuel cells could also serve as new energy resources for consumers and the grid," he said. ■