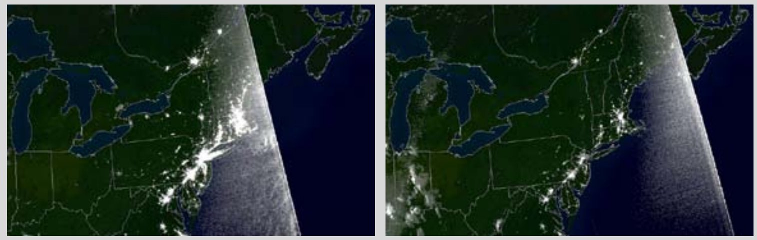
Synchrophasor Technologies for a Better Grid

August 14, 2003 was a typical hot summer day. Across the eastern U.S. air conditioners were humming keeping people cool as they went about their daily activities at home and work. In the afternoon, without warning, a series of power line failures in northern Ohio triggered a cascading set of events that led to the collapse of the grid in eight states and two Canadian provinces. The "Northeast Blackout of 2003" ultimately affected 55 million people, cost billions of dollars, contributed to six deaths in New York City, and led to four million people in Detroit being under a "boil water" alert for four days.



NOAA satellite imagery of lights at night the day before and the night of the Northeast Blackout of 2003.

A U.S.-Canada investigation team uncovered many contributing factors, including a power plant going offline, poor tree trimming, inadequate operator training, and computer failures. The investigation team also found a lack of "situational awareness" on the part of grid operators and a failure of the reliability organizations to provide effective real-time diagnostic support. If grid operators had been equipped with tools to share real-time information on grid conditions that day, then the problem in northern Ohio might have been contained.

The Smart Grid Investment Grant (SGIG) Program's Synchrophasor Projects

Synchrophasor technologies can monitor electrical conditions across regional transmission grids and deliver that information to operators and reliability coordinators. Deployment of these technologies is revolutionary for two reasons. First, phasor measurement units (PMUs) record power system data 30-to-120 times per second, which is more than 100 times faster than current technologies. Second, each PMU time-stamps every measurement it takes, enabling all data to be synchronized across large regions of the country. This data can be used to create in-depth "pictures" of operating conditions on the grid and enable operators to detect disturbances that would have been impossible to see in the past. Some experts have compared synchrophasor technologies to "MRIs" for the transmission system because of the detailed operational pictures they can provide. Synchrophasor data are being used for forensic analysis of grid disturbances, because the detailed, time-synchronized data allow investigators to immediately understand grid conditions before,

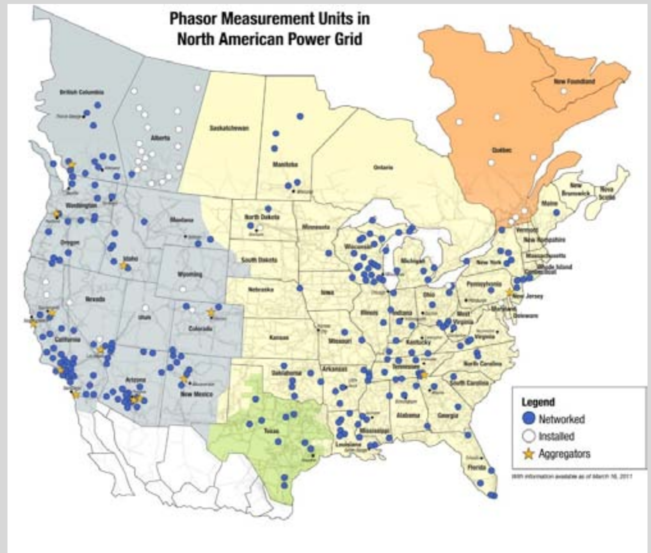
<u>SGIG Synchrophasor Projects</u>

- American Transmission Company, Wisconsin (two projects)
- Duke Energy, North Carolina
- Entergy Services, Louisiana
- PJM Interconnection, Pennsylvania
- ISO New England, Massachusetts
- Midwest Energy, Kansas
- New York Independent System Operator, New York
- Western Electricity Coordinating Council, Utah

during, and after the event and diagnose its causes.

Thanks to SGIG there are ten more synchrophasor projects underway involving 57 utilities and grid operators across the U.S. These projects are installing about 850 networked PMUs and by 2013 the devices will be operating in nearly all regions of the country. The total budget of the SGIG projects is more than $300 million, including 50% from Recovery Act funding, making the projects collectively the single largest synchrophasor effort ever undertaken.

The result of this deployment effort should help reduce grid congestion, permit more electricity to flow through existing wires, and identify disturbances in advance to enable preventative actions.



Source: NERC 2010

Thanks to SGIG about 850 more networked PMUs will be added to the North American grid through 2013.

The North American Synchrophasor Initiative (NASPI)

Following the 2003 blackout, the U.S. Department of Energy's Office of Electricity Delivery and Energy Reliability (DOE-OE) expanded synchrophasor efforts in the eastern U.S. These efforts led to the formation in 2007 of NASPI as a voluntary, not-for-profit organization sponsored by the North American Electric Reliability Corporation (NERC) in partnership with DOE-OE. NASPI's primary mission is to identify barriers and assist industry to overcome them. Today, as many as 350 practitioners from power companies, equipment manufacturers, consulting firms, universities, and national laboratories regularly participate in NASPI activities and working groups. The SGIG synchrophasor projects participate in NASPI.

Accomplishments and Challenges

NASPI Project Manager Alison Silverstein recently said, "Before SGIG, our roadmap called for a ten-plus year synchrophasor deployment effort. Today, we are looking at half that time, or less." The SGIG synchrophasor projects have provided a "forcing function" to accelerate industry coordination and collaboration, and NASPI has been a critical facilitator.

For example, before SGIG there were about 250 PMUs installed around the country, many of them "research grade" PMUs. Many power companies had a few PMUs, but only a few had significant PMU systems collecting data. In addition, not all PMUs were providing consistent data quality, and maintenance was not always a top priority. Today, Ms Silverstein says, "The SGIG projects have spurred manufacturers to make better, faster "production grade" PMUs that are built to meet new industry specifications for data quality, performance, and cyber security." In addition, she says, "There are many senior industry executives who before SGIG were not aware of their company's synchrophasor efforts but who are now engaged and eager to understand the value and harvest the potential benefits."

Many NASPI members have been working with the National Institutes of Standards and Technology Smart Grid interoperability standards effort to accelerate development of new technical standards for synchrophasor data, equipment, and systems. Interoperability is paramount for synchrophasor technologies to succeed, as data must flow across multiple transmission system owners' synchrophasor systems, transmission systems, and communications networks. According to Ms Silverstein, "All this hard work on standards development activities is making interoperability for synchrophasor technologies and supporting communications systems possible within a year or two, rather than five years from now."

While these initial accomplishments are significant, challenges remain before the full benefits of synchrophasor technologies can be realized. A critical next step involves synchrophasor data sharing for research and analysis. As Ms Silverstein points out, "We have good software for displaying aggregated phasor data to visualize real-time system conditions, but now we have to figure out how it can be used to run the system better. The research community needs to analyze it for baselining and pattern recognition." This analysis will help identify patterns in the data that reveal "diagnostics," "precursors," and "markers" that grid operators can use to understand what is happening on the system and what emerging conditions could mean. SGIG-funded synchrophasor projects and research are conducting some of this research and developing new applications for synchrophasor data.

Path Forward

Getting the most out of the SGIG synchrophasor projects by sharing lessons learned, replicating what works, and avoiding what does not work remains a top priority. In this regard, NASPI serves as a catalyst, organizer, and facilitator. For example, NASPI member Southern California Edison is successfully using synchrophasors today to trigger some automated grid protection functions on their system. Other members are testing tools that use phasor data for dynamic line ratings so that more electricity can be delivered over congested transmission corridors for better economics and reliability. NASPI serves as a forum for exploring issues and sharing lessons learned from these kinds of initiatives.

In addition, NASPI has produced a report entitled the "Real-Time Application of Synchrophasors for Improving Reliability (RAPIR)." This report contains valuable data on the status of deployments and applications and includes information on the scope of the SGIG synchrophasor projects. The RAPIR report can be found at https://www.naspi.org/site/StaticPDF/resource/rapir_final_20101017.pdf. NASPI and DOE are working together to address issues being faced by SGIG recipients with respect to technology deployments and estimating benefits. Also, they will produce annual updates to the RAPIR report that convey progress made by the SGIG projects.

These SGIG projects are also investing in staff training to help grid operators and control centers use the real-time, wide-area grid visibility that synchrophasor technologies will provide. Consumers can look forward to the day when these future grid operators are better equipped than they are today with improved technologies, tools, and techniques for detecting and responding to grid disturbances such as those that occurred on that hot summer day in Ohio in 2003.

Learn More

The American Recovery and Reinvestment Act of 2009 (Recovery Act) provided DOE with $4.5 billion to fund projects that modernize the Nation's energy infrastructure and enhance energy independence. For more information about the status of other Recovery Act projects and how DOE is working with recipients to advance synchrophasor technologies, visit www.smartgrid.gov. There you will find a case study on the Western Interconnection Phasor Project. To learn about DOE's Office of Electricity Delivery and Energy Reliability's national efforts to modernize the electric grid, visit www.oe.energy.gov. Information about the North American SynchroPhasor Initiative is at www.naspi.org.

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