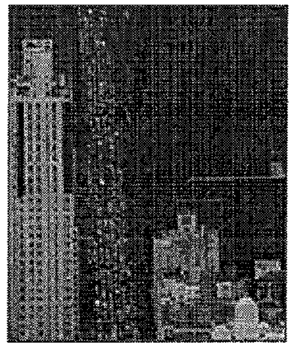
American Electric Power Co., Inc.
SEC Admin. Proceeding
File No. 3-11616
AEP Exhibit No. 4

U.S. Department of Energy - Energy Efficiency and Renewable Energy
State Energy Program
September-October 2004

Is Our Power Grid More Reliable One Year After the Blackout?

The electric power grid collapsed on August 14, 2003 — a gritty summer afternoon in Cleveland. It happened so fast that 50 million people in the northeastern United States and Canada did not know what hit them or why their lights went out.



With the lights out in New York City, traffic grinds to a halt.
Credit: DOE's Office of Electric Transmission & Distribution

Before it was over, three people were dead. One and a half million people in northern Ohio had no running water for two days. Twelve airports closed in eight states and one Canadian province. The estimated economic damage was $4.5-$10 billion.

The speed at which the outages cascaded over such a vast area — more than 1 million square miles — is sobering. Between 4:05 p.m. and 4:13 p.m. Eastern Daylight Time, more than 250 power plants — with a total 61,800 megawatts (MW) of generating capacity — experienced emergency shutdowns. This made the 2003 blackout twice as large as any in American history.

Commuters walk home across the Brooklyn Bridge in New York City during the August 14, 2003 blackout.
Credit: DOE's Office of Electric Transmission & Distribution

This extraordinary event focused the nation's attention on the reliability of the power grid. In April 2004 a joint task force of U.S. and Canadian regulators, in conjunction with the North American Electric Reliability Council (NERC), completed a massive analysis of the blackout, identified its causes, and made 42 recommendations for improvements. The events are documented by a massive investigation by the U.S.-Canada Power System Outage Task Force titled, *Final Report on the August 14 Blackout in the United States and Canada: Causes and Recommendations*.

The task force also brought to light some of the institutional pressures on the power industry. After the initial phase of restructuring in the 1990s, industry investment in transmission and distribution (T&D) decreased dramatically despite continued growth in electricity generation and consumption. As a result, the T&D system operates very close to its margins. Today there is widespread agreement that the grid is in need of modernization.

How the Blackout Cascaded across the Northeast

A normal summer day in Ohio quickly soured for power system operators as small problems grew into bigger ones. By themselves, these problems were not enough to cause a catastrophic failure. But they confused system operators who had computer problems and did not understand what was happening until it was too late.

Power System Basics
Headaches for System Operators
Power Surges Across the Northeast
The Causes: "Tools, Trees, and Training"

Power System Basics

The North American power system is an engineering wonder. Every second of every day, power generators produce exactly the amount of electricity that consumers require when they turn on lights. With a miniscule amount of storage on the system, electric utilities and grid operators continuously perform a balancing act. Grid operators schedule power flows across transmission lines to meet the supply and demand of the market.

The Eastern Interconnection is perhaps the world's largest synchronized machine. Spread across the eastern half of the United States, hundreds of large and small generating stations (all of which are connected electrically and spin in perfect unison) generate electricity at 120 volts and 60 hertz (cycles per second). Any deviance from this cyclical unison causes grid instability that could damage power plant and transmission equipment. Obtaining custom-built replacement parts for some of this equipment, such as large steam or generating turbines, can take months or longer.

Damage occurs very quickly and all this equipment is expensive, so complex computer and management systems are in place to guard against damage. The primary protections are breaker switches that trip offline automatically if electrical parameters such as frequency or voltage stray outside narrow boundaries. Electric power grid operators manage all this by calling for power plants to come online and cycle off to meet the ebb and flow of demand. They also direct traffic on the transmission system for a specific territory. Their work is much like that of air traffic controllers, who are bombarded with data and must make quick decisions based on computer simulations and on their understanding of the system. In a nutshell, their job is to detect the conditions that cause blackouts, implement steps to avoid them, and restore normal operations as soon as possible. In regions that have them, regional transmission organizations provide input to system operators about conditions outside their control areas that might affect operations.

Headaches for System Operators

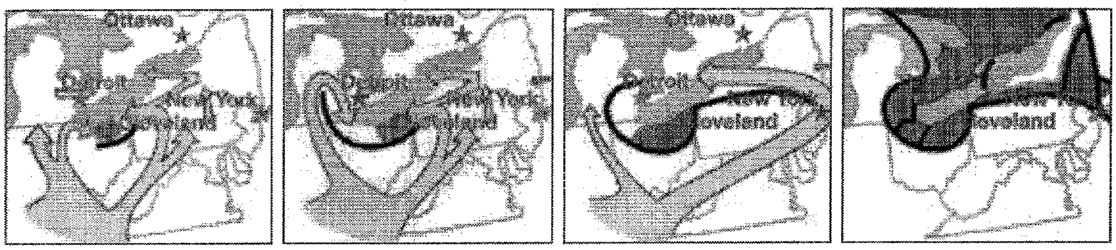
The first hint of trouble came just after lunch when the Eastlake 5 power plant on the shores of Lake Erie tripped offline. FirstEnergy of Akron, Ohio, operates the power grid in northeastern Ohio and provides electricity to customers in Ohio, Pennsylvania, and New Jersey. FirstEnergy immediately began to import power across northern Ohio from power plants along the Ohio River Valley to the east to supply Cleveland.

Then computer problems began. The Midwest Independent System Operator (MISO) in Carmel, Indiana, was dealing with a power line outage south of Dayton, Ohio. The system simulator was experiencing problems that day, partly because of faulty data updates, and the operator booted the computer. Unfortunately, he forgot to turn the computer back on when he went to lunch. Meanwhile, FirstEnergy operators also began to experience their own computer problems as their emergency management system, which provides a visual and audible alarm when a serious problem occurs, went down for almost an hour.

By 2:30 p.m., the aura of a migraine had settled around the control room when another 345-kilovolt (kV) power line sagged into a tree near Canton, Ohio, and shut down from a ground fault, which caused electricity to reroute to other power lines that attempted to carry the load. Within an hour, two more 345-kV power lines touched trees and faulted offline. System operators in surrounding states telephoned FirstEnergy to sound an alarm. By now the entire transmission system in northern Ohio was on serious overload. But lacking alarms, FirstEnergy operators waited instead of taking decisive action.

Power Surges across the Northeast

The fate of the blackout was sealed once the Sammis-Star 345-kV transmission line went down at 4:05 p.m. because of an overload. To this point, FirstEnergy operators might have been able to avert the blackout by dropping part of their load off the system.



Reacting to the outage of a critical transmission line that tripped offline because of an overload, power surges west and east around the line try to load centers in Cleveland and Detroit. The power surges take out all the electrical equipment in their paths, which overloads other parts of the system.

With Sammis-Star out, power from the south had to reroute around central Ohio to try to reach Cleveland. This in turn overloaded the 138-kV lines across northern Ohio, and line outages formed across the entire northern third of the state. The lights went out in Cleveland and the breakers on the Pennsylvania border opened and disconnected from Ohio.

By 4:09 p.m. the system was in full collapse. Within seconds, power surged back across central Ohio and up through Michigan as it tried to reach demand centers around Detroit. This surge, in turn, opened the breakers to all the electrical equipment in its path. The blackout now encompassed Detroit to the west and the entire area south of Lake Erie and Lake Ontario.

But Detroit was still connected to Canada, which in turn connected with New York and the East Coast across Niagara Falls. Now a great power surge that consisted of tens of thousands of megawatts swept toward the coast and then north and east through upstate New York as it tried to reach the Great Lakes region. By 4:13 p.m. the lights were out across the Northeast and Canada (see map).

Why did the blackout stop where it did? Like a ripple from a stone falling in a pond, the intensity of the disturbance lessened the further it traveled from the center. System operators in New England and the Mid-Atlantic states were able to stabilize their systems and prevent blackouts from overtaking them.

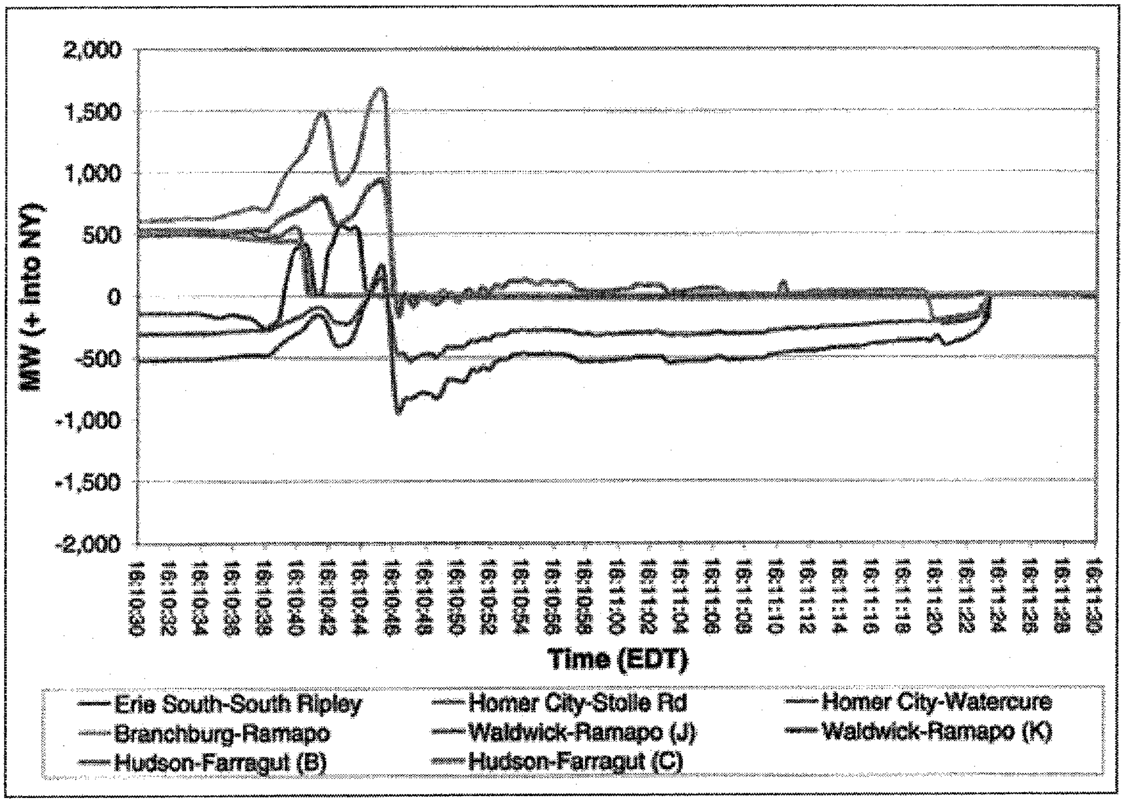
The Causes: "Tools, Trees, and Training"
The task force report points out the complexity faced by grid operators and notes that "planning and reliable operation of the power grid are technically demanding." Thus, U.S. and Canadian electricity experts needed to understand what happened and take steps needed to prevent a recurrence. They collected data, analyzed the events, and recommended possible solutions. The Final Report is the culmination of that effort. It points out that the blackout had three main causes: "tools, trees, and training."

They concluded that that system operators in and around Ohio:

- Did not have the proper computers and automated equipment to analyze the situation
- Had been lax in tree trimming
- Did not have the proper training to identify a serious problem once it developed.

FirstEnergy and all the system operators in the region did not identify the Sammis-Star transmission line as critical to the T&D system. If they had, they would have acted within seconds to contain the disturbance.

Although significant efforts have been made to make the grid more reliable, increased involvement by the electric industry and local, regional, state, and national agencies is needed to ensure systems function properly, operators are fully trained and ready, and trees in transmission corridors are trimmed properly.



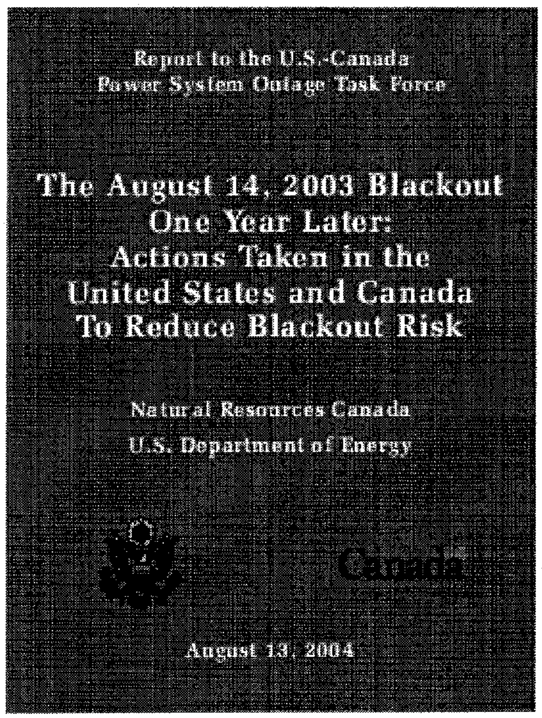
PJM Interconnection in Valley Forge, Pennsylvania recorded radical fluctuations in power flows over its system seconds before it disconnected from New York. *Credit: U.S. Canada Power System Outage Task Force*

What's Been Done Since the Blackout?

Reliability Standards
The U.S.-Canada Power System Outage Task Force publication, The August 14, 2003 Blackout One Year Later: Actions Taken in the United States and Canada to Reduce Blackout Risk (PDF 236 KB) Download Acrobat Reader, details the actions taken to improve grid reliability. For example, shortly after the Task Force identified direct causes of the August 14 blackout, the Federal Energy Regulatory Commission (FERC) and NERC set to correct them.

In December 2003, FERC ordered FirstEnergy to study the adequacy of transmission and generation facilities in northeastern Ohio. The results were submitted in April 2004 and recommendations are now being incorporated into FirstEnergy's operations and strategic plan. In February 2004, NERC directed

FirstEnergy, the MISO, PJM Interconnection, and the East Central Area Reliability Coordination Agreement on actions each organization needed by June 30, 2004, to reduce the potential of future blackouts. NERC then approved and verified their compliance plans.



The U.S. Canada Power System Outage Task Force conducted a massive investigation into the causes of the blackout and made 42 recommendations to improve power system operations.

In response to the April 2004 Final Report, FERC took the following actions to clarify and develop reliability standards:

- Commissioned a firm to analyze transmission line outages related to inadequate tree trimming — a major contributor to the August 14 blackout — and determine best practices for preventing this problem. See the "Utility Vegetation Management and Bulk Electric Reliability Report from the Federal Energy Regulatory Commission" (PDF 92 KB).
- Began to require transmission owners to file reports on their tree trimming practices.
- Affirmed the need to strengthen and clarify NERC's operating reliability standards.

Meanwhile, NERC strengthened its policies on emergency operations, operations planning, and reliability coordinator procedures and will include compliance metrics in its operating policies and planning standards by February 2005. New standards for managing vegetation and calculating transmission line ratings are also being developed; procedures for training and certifying operators are being revised.

To better ensure compliance with reliability standards, the report recommended that reliability monitoring capabilities be improved. NERC has taken the following steps to fulfill this recommendation:

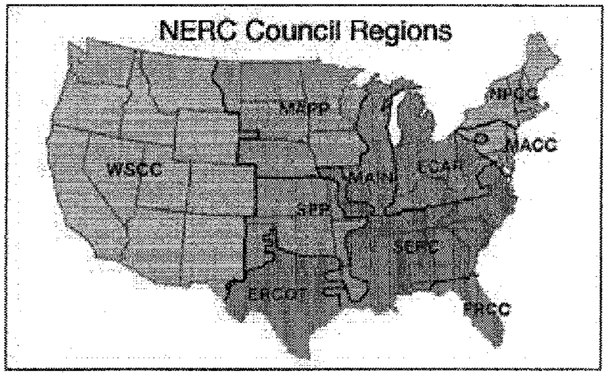
- Requires regional reliability councils to report major violations of standards within 48 hours and submit quarterly reports that detail all violations.
- Strengthens the compliance audit program by ordering organizations that coordinate and control areas where reliability is an issue to certify that they are in compliance with standards.
- Created a Readiness Audit Program; 23 audits were completed by June and another 25 are scheduled to be completed by the end of the year. To see conclusions from September 2004 review of these audits by the Federal Energy Regulatory Commission (FERC), see two presentations by Kueck and Kirby at the Reliability Readiness Reviews.

FERC declared in April 2004 that adherence to reliability standards is required under its Open Access Transmission Tariff.

Since systems protection plans and practices are essential to grid reliability, NERC now:

- Requires transmission owners to evaluate zone 3 relays on lines 230 kV and higher to minimize tripping.
- Requires transmission owners to implement changes by December 2005.
- Orders regional reliability councils to investigate and report on the benefits of undervoltage load shedding by February 2005.
- Requests that the NERC System Protection and Control Task Force propose recommendations concerning load-shedding programs.

Training Requirements
NERC requires power system operators to provide their staff with five days of emergency preparedness training. This work had to be completed by June 30, 2004. FERC and NERC are currently designing parallel and coordinated studies of operator training requirements, which will include reviews of training practices used in other industries. The results of this study will help NERC determine how to revise requirements for grid operator training and certification.



The North American Reliability Council has primary responsibility for ensuring grid reliability.

NERC recently created a Real-Time Tools Best Practices Task Force to identify best practices and develop relevant guidelines. The group's recommendations will be presented in April 2005. Additionally, NERC is implementing a plan to provide operators with hourly updates about unplanned equipment outages.

Security Concerns
NERC is working with the U.S. Department of Homeland Security, Public Safety and Emergency Preparedness Canada, and DOE to strengthen the physical and cyber security of bulk power systems. The groups have implemented procedures that reduce the risk of inadvertently disclosing sensitive infrastructure information and are studying ways to mitigate infrastructure vulnerabilities. The agencies are also developing the electricity sector component of the U.S. National Infrastructure Protection Plan to increase grid security, and are working with industry to design an educational program on physical and cyber security and establish a database of spare transformers.

Office of Electric Transmission and Distribution
DOE's Office of Electric Transmission and Distribution (OETD) was formed in 2003 to help ensure a robust and reliable U.S. transmission grid. It combines DOE's electricity T&D R&D programs with electricity policy analysis in a single, focused office.

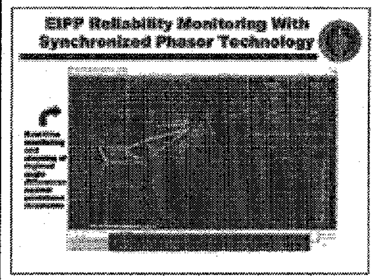
OETD's mission is to lead a national effort to modernize and expand America's electricity delivery system to ensure economic and national security. Broadly, that effort will:

- Reduce regulatory and institutional barriers to efficient T&D.
- Act as a neutral facilitator of broad-based solutions.
- Provide a national vision for building strong public-private partnerships.

OETD's primary functions involve R&D; modeling and analysis; electricity import and export authorization, and a power marketing administration liaison. In fact, OETD's first major task was to lead the U.S. part of the U.S.-Canadian investigation into the August 2003 blackout. Today we are following up on the report's 42 recommendations.

OETD's research portfolio includes longer term technologies such as superconducting cables and equipment, medium-term work in storage, and nearer term work in transmission reliability. OETD develops grid monitoring and visualization systems that can give early warnings of danger to grid operators and works with the electric industry to adopt them. For example, DOE-funded researchers developed a Synchronized Phasor Network, which was installed after the 1996 West Coast Blackout, to provide early warning to operators in the western grid.

Before the blackout in the Eastern Interconnection, OETD worked with industry to develop and install a similar grid early warning network on the East Cost, known as the sponsored Eastern Interconnection Phasor Project. This phasor network is being installed through a cooperative project involving the U.S. Department of Energy and the power industry. All of the major transmission corridors in the Eastern Interconnection will have data collection devices and computer software in place by the end of this year, and the entire system should be fully operational by the end of 2005. See a 15-page online presentation on this project from February 2004 (PDF 1.74 MB).



Eastern Interconnection Phasor Project
The phasor network measures the heartbeat and vital signs of the Eastern Interconnection and communicates those data to system operators in time for them to make important operating decisions (PDF 304 KB). Download Acrobat Reader.

A new area for DOE is the coming identification of "National Interest Transmission Bottlenecks." This designation is expected to spur interest and investment in transmission and transmission alternatives in key locations of the grid. OETD is currently evaluating public comments on its bottlenecks evaluation.

State Energy Offices—What Is Their Role?

State energy offices need to ask (and answer) two critical questions about their power systems:

1. Is there enough power?
2. Can the grid deliver stable service to customers even if the most important element of the system (the largest generator) fails?

State energy offices also deal with the larger issue of the equation:

Reliability = Generation + Transmission + Distribution + *Demand*

By influencing components of this equation, state officials can greatly increase grid reliability. But reliability is not just power plants and power lines. It is also influenced by demand. Energy offices historically encourage and deliver energy efficiency, which directly reduces demand and improves reliability. Energy efficiency work can be targeted to high-growth areas that can help utilities avoid costs.

State energy offices may wish to work with other state agencies, such as public utility commissions (PUCs) or legislatures, to address issues such as:

- What are the interconnection standards for distributed generation?
- How can electric utilities and grid operators improve demand response?
- What are the most effective ways to develop new generation capabilities?

Working with groups that address regional electricity issues is increasingly important, and FERC and OETD are helping to build regional support for collaborative regional planning activities. For example, OETD supports work to improve regional coordination and planning in the West.

Of course, each state's PUC helps ensure grid reliability. Each state affected by the August 2003 blackout had a representative from their commission on the U.S.-Canada Power System Outage Task Force. PUCs use their oversight and regulation over their jurisdictional electric utilities to influence investment decisions and operational practices. These commissions, or sometimes state siting bodies, can determine whether and where new generation and transmission are built. After the blackout, PUCs began to increase their oversight of tree trimming practices near transmission lines, especially in storm-prone locations.

Jimmy Glofelty, former director of DOE's Office of Electric Transmission and Distribution and co-chair of the official U.S.-Canadian investigation into the blackout, said about the process, "I think NERC and industry have made great strides in improving grid reliability. Audits have been completed for more than 80% of the many control areas across the United States, and corrective actions have been taken. In addition, every utility and control area has been required to provide additional training for their operators, vegetation management budgets are increasing, and the system is being operated more securely and conservatively. All this will help provide a more reliable grid."

Links to Other Sources

- U.S. Department of Homeland Security
- DOE Office of Electric Transmission and Distribution
- DOE Office of Policy and International Affairs
- Federal Energy Regulatory Commission
- National Council on Electric Policy
- National Energy Policy
- North American Electric Reliability Council
- Public Safety and Emergency Preparedness Canada
- Regulatory Assistance Project

U.S. Department of Energy
Content Last Updated: May 5, 2004