Summary of the Reliability and Markets Activity Area

Increasing grid reliability and reducing costs for customers using integrated market and engineering tools

U.S. DEPARTMENT OF ENERGY | Electricity Delivery & Energy Reliability

Transmission Reliability and Renewables Integration Program

The electric delivery system—a complex network of transmission and distribution lines, substations, and electrical components—is aging. To deliver more electricity and ensure reliability, the grid needs to be modernized. As the grid is being upgraded, it is also being challenged by increased needs to integrate variable renewable energy resources such as solar and wind, the potential growth of electric vehicles and related charging infrastructure, and the potential development of new electricity market designs and operating practices.

To help decision makers better understand how these changes and challenges are shaping electricity delivery systems, as well as provide the industry with the tools necessary to cope with the new designs, the Reliability and Markets activity is developing a broad set of integrated market and engineering tools and technologies. These tools and technologies, when applied to carefully chosen case studies, provide useful information and analysis that informs policy-making and investment decision making. Applying these tools and technologies to address today's electricity challenges helps ensure electric reliability, while also improving the efficiency and economics of market operations.

Overview

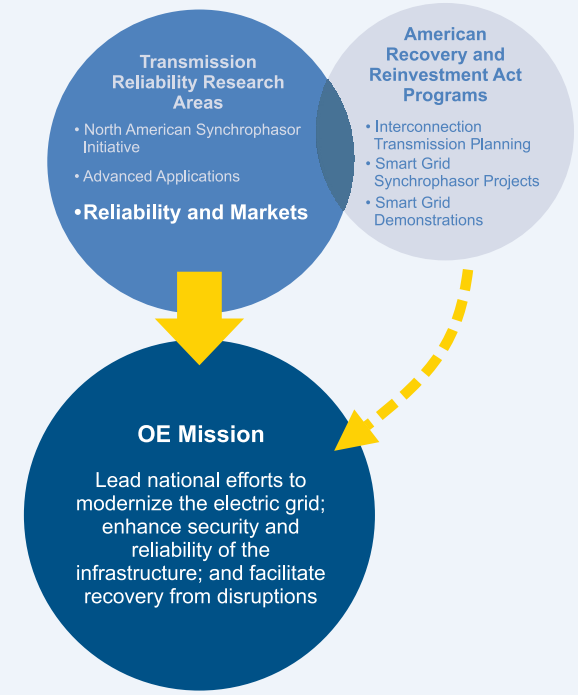
The Reliability and Markets activity researches, develops, and implements electricity infrastructure and market simulations that integrate economics and engineering principles. Researchers are concerned principally with five key areas including market design, long-term supply and transmission investment, renewable integration, demand response, and environmental impacts. Researchers use new models and simulations to assess how new technologies, policies, environmental regulations, or market designs will impact electric grid reliability and electricity costs. This critical step allows researchers to understand and optimize the impacts on the grid before actual implementation.

Ultimately, program activities can help policy makers, regulators, and grid operators avoid potential problems. In addition to simulations, the Reliability and Markets activity is also conducting analyses and demonstrations of frequency control (regulation and frequency response) through advanced control of customer loads. The optimized implementation of new technologies, policies, regulations, operating practices, or market designs should result in increased grid reliability and reduced costs for customers.

Sample Projects

Demonstrating provision of regulation at industrial facilities. Unlike other types of demand response, which may have slower response times, regulation is the automated minute-to-minute control of electric loads under normal operating conditions. This is a difficult ancillary service or demand response service to provide due to the need of advanced communication and control infrastructure. Regulation through demand response can significantly enhance the efficiency and reliability of the electric delivery system by allowing load (instead of generation) to perform the necessary act of balancing load and generation.

Demonstrations at an Alcoa aluminum plant showed that fast and accurate regulation response can be supplied from an industrial facility to the electric delivery system. Conventionally, the aluminum plants have been designed to deliver constant power levels to the aluminum smelters. However, this significant shift in process is necessary for Alcoa within the U.S. to be competitive globally. Since electricity is directly correlated to more than 30% of the cost in aluminum production, reducing the rate at which Alcoa pays for electricity while increasing local system reliability is a "win-win" for both Alcoa and the power system.



The Reliability and Markets activity is one of three key activity areas within the Transmission Reliability and Renewables Integration Program. This activity has a collaborative role with American Recovery and Reinvestment Act (ARRA) programs in helping to improve grid planning and operations and ultimately achieve the OE mission.

These five areas work collectively to support the Reliability and Markets activity.

This demonstration is a highlight of the vast potential of regulation response at industrial plants, which represents one of the largest potentially underutilized regulation resource in the United States. To ensure successful implementation, the Reliability and Markets activity is evaluating the use of regulation response across facilities in different industries, exploring needed metering changes, and confirming that regulation does not degrade manufacturing product quality. Studies of this nature are also now targeting regulation supplied from load control at large commercial buildings.

Development of the SuperOPF modeling tool. The SuperOPF (Optimal Power Flow) tool is a large-scale modeling tool that integrates both economic and engineering components to simulate effects on the electric delivery system from a variety of future conditions and possibilities including the uncertainty of contingencies, renewable resources, and customer demand. Because the SuperOPF tool more precisely represents complicated electrical networks (compared to traditional OPF models), it allows grid operators to more accurately and quickly analyze the feasibility and effects of implementing new policies, technologies, or operating practices.

For example, independent system operators (ISOs) often use direct current (DC) approximations to model alternating current (AC) electrical systems. Approaches such as these reduce mathematical complexity, which can in turn speed up simulation calculations. However, they can also be inaccurate and create distortions when determining electricity prices, especially when the electric system is stressed. These price distortions can misrepresent incentives for generating facilities to contribute their generation capacity, further exacerbating stress on the system. The unique technical capabilities of current and future iterations of the SuperOPF tool can reduce these inaccuracies.

The table below illustrates the role Reliability and Markets projects play in addressing challenges from changing electricity policies, technologies, and markets and from limitations in existing operating practices and tools.

Benefits from Reliability and Markets (R&M) Activities

Challenge	Role for R&M Activity	Benefit from R&M Activity
Integrated Engineering and Economic Analysis of Wholesale Electricity Markets		
Showing the effect of a variety of potential operating conditions on the electricity delivery system	Develop simulation tools to accurately analyze the feasibility and effects of implementing new policies, technologies, or operating practices	Enables more complete understanding of the effects of new policies, technologies and operating practices, allowing for modifications prior to full implementation
Development of Real-Time Monitoring Tools for Wholesale Markets		
Preventing market manipulation in competitive wholesale operations	Simulate the effects of different market designs showing, for example, how a small number of suppliers have the ability to manipulate market prices	Enables greater understanding of market design impacts, leading to more accurate prices and increased grid reliability
Evaluation of Electric Grid Infrastructure Investments		
Investing in new transmission lines under market, technology, and policy uncertainties	Develop a methodology to illustrate the effects on transmission line investment from factors including, increased interregional trade, uncertain fuel prices, load growth, and renewables integration	Provides information for decision makers to better understand the trade-offs from alternative investments to build transmission capacity that meets demand requirements
Impact from the Integration of New Technologies into the Grid		
Addressing infrastructure needs for providing electricity to potentially millions of electric vehicles (EVs)	Determine the effects of EV charging loads on day-to-day grid management using models that can gather real time aggregate information about sensed EV arrivals and their associated charging times	Provides information for determining optimal charging schedules and scenarios for assessing alternative pricing options for EV charging and managing of EV demand
Impact of Renewable Electricity Generation on Markets		
Identifying public policies and market rules to support the integration of energy storage devices and renewables into the electric grid	Simulate the effects of different market designs, taking into account the unique capabilities of renewables and storage devices through a number of possible market conditions; this capability is not currently available	Provides information for decision makers to understand the relative merits of alternative renewable resources in terms of market impacts
Implementation of Real-Time Regulation Response Techniques		
Implementing minute-to-minute regulation response at commercial and industrial facilities	Estimate the amount of regulation that could be expected from commercial or industrial loads, identifying types of energy storage, exploring metering changes, and assessing the effect of regulation on manufacturing product quality	Demonstrates a more reliable and economically sound method for meeting the minute-to-minute real-power regulation requirements of the electricity grid

Further Reading

A. Lamadrid, S. Maneevitjit, T. Mount, C. Murillo-Sanchez, R. Thomas, and R. Zimmerman, "A 'SuperOPF' Framework", December 2008. Accessed at *http://certs.lbl.gov/pdf/superopf-framework.pdf*

Alcoa Power Generating, Inc. and Oak Ridge National Laboratory for the U.S. Department of Energy, Office of Electricity Delivery and Energy Reliability, Transmission Reliability Program, "Providing Reliability Services through Demand Response: A Preliminary Evaluation of the Demand Response Capabilities of Alcoa Inc.", January 2009. Accessed at *http://certs.lbl.gov/pdf/dr-alcoa.pdf*

R. Thomas, T. Mount, R. Schuler, W. Schulze, R. Zimmerman, F. Alvarado, B. Lesieutre, P. Overholt and J. Eto. "Efficient and Reliable Reactive Power Supply and Consumption: Insights from an Integrated Program of Engineering and Economic Research." The Electricity Journal. Volume 21, Issue 1, January/February 2008, Pages 70-81. *http://certs.lbl.gov/pdf/63782.pdf*

R. Zimmerman, "SuperOPF Research Roadmap", December 2008. Accessed at *http://certs.lbl.gov/pdf/superopf-roadmap.pdf*

W. Schulze, R. Thomas, T. Mount, R. Schuler, R. Zimmerman, D. Tylavsky, D. Shawhan, D. Mitarotonda, and J. Taber, "Facilitating Environmental Initiatives While Maintaining Efficient Markets and Electric System Reliability", Power Systems Engineering Research Center, October 2009. Accessed at *http://certs.lbl.gov/pdf/schulze-emissions.pdf*

Office of Electricity Delivery and Energy Reliability: *http://energy.gov/oe/office-electricity-delivery-and-energy-reliability*

Recovery Act Smart Grid Programs: *http://www.smartgrid.gov/recovery_act*

About the Transmission Reliability Program

The Transmission Reliability Program was established by Congress in 1999 to support a national laboratory/electricity industry partnership to conduct research on the reliability of the nation's electricity delivery infrastructure during the transition from regulated markets to competitive markets under restructuring. Competition and market forces are creating an exponential increase in the volume of power transactions and causing the grid to be used in ways for which it was not designed. The Transmission Reliability Program is developing advanced technologies, including information technologies, software programs, and reliability/analysis tools to support grid reliability and efficient markets during this critical transition.