Pacific Northwest NATIONAL LABORATORY

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Visualization and Decision Support for Grid Operators

As the scale and complexity of the power grid increase, so does the need for tools that can transform relevant data streams into visual formats of actionable information. To develop the solutions that will help analysts make effective tactical and strategic grid management decisions, commercial vendors need to offer products that convert large-amounts of data into accessible and understandable knowledge.

Partner with PNNL to see how our leading visualization and decision support technologies can help you develop the products that operators and planners need. The technologies described here incorporate coordinated visualization interfaces, human factors research, automated reasoning, and online aids. All technologies provide a modular, extensible software environment that can be used for both real-time grid operations as well as long-term planning.

Power grid operators run simulations with the Graphical Contingency Analysis tool at PNNL's Electricity Infrastructure Operations Center.

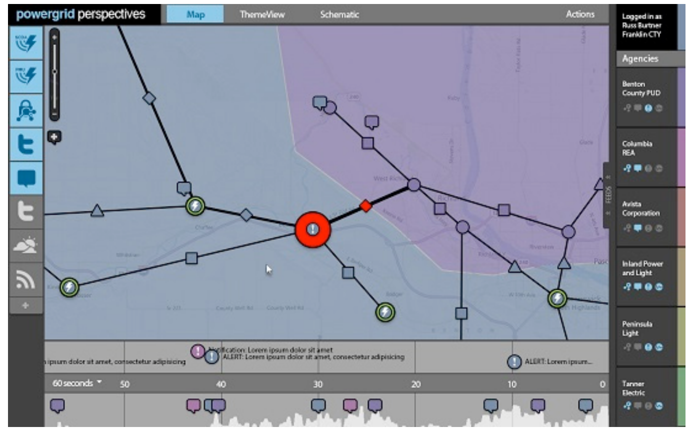
MANGO (Modal Analysis for Grid Operations): MANGO is a real-time modal analysis application of phasor measurements for enhancing modal control of the power grid through operator controllable variables (e.g., dispatchable loads and generation, switchable shunts). Based on real time Phasor Measurement Unit (PMU) data, a MANGO model can provide control suggestions (such as increasing generation or decreasing loads) for operators to mitigate inter-area oscillations. This tool incorporates two major innovations: First, MANGO control suggestions are generated in real time, which shorten the operator response time. Second, MANGO adopts an operator-in-the-loop control strategy, which provides a solid framework for combining the operators' expertise and math models in making informed operational decisions.

Graphical Contingency Analysis Tool: This tool is a method of advanced contingency analysis visualization for power grid operations. It converts the large volume of contingency analysis results to a visual space and presents the results as user-friendly, color-contoured maps. This novel visualization method reduces power grid operators' burden of examining raw data and enables them to focus on critical portions of the grid and respond to adverse situations in a timely manner. Geographical information is readily included in the visualization techniques, as well as a quantitative assessment of the contingency risks. See more online.

Hybrid Storage Controller/Optimizer: This is an optimizing controller for a hybrid energy storage system that coordinates the operation of fast and slow generation units. The controller will allocate the control signal between the slow unit and fast unit so that the slow unit will respond to the low-frequency variations and the fast unit will respond to the high-frequency variations. In addition, the storage unit will be operated close to its optimal rated output, maintain a certain charge level, or at a depth-of-discharge favorable to prolong its lifetime. Furthermore, the hybrid system will be able to provide energy and ancillary services similar to those provided by a conventional generator. The algorithm will also determine the optimal percentages of bids from power capacities into energy and ancillary service markets. This will provide energy arbitrage and peak shaving, intra-hour balancing, and other payable services that will help maximize the life cycle revenue of the hybrid energy storage system. See more online.

Renewables Integration Suite: Three related tools were developed to aid in the integration of renewable resources on the grid. Originally developed for the California independent system operator (CAISO), these tools are available for licensing to other independent system operators (ISO) and balancing authorities. The first tool is a method to analyze the impact of integrating wind generation on the regulation and load following requirements. The methodology developed is based on a mathematical model of the ISO's actual scheduling, real time dispatch, and regulation processes and their timelines. Minute-to-minute variations and statistical interactions of the system parameters involved in these processes are depicted with sufficient details to provide a robust and accurate assessment of the additional capacity, as well as the ramping and ramp duration requirements that the ISO's regulation and load following systems are expected to face with the additional wind generation. The second tool is a method for predicting day-ahead regulation requirements. This tool has been developed to estimate needed procurement of upward and downward regulation reserve by the ISO in terms of capacity, ramp rate and ramp duration for each operating hour of the next day. Based on a scientific approach that uses a pre-specified level of confidence, the estimate minimizes procurement requirements without compromising reliability and mandatory control performance standards. The third tool is a probabilistic analysis of forecast errors and how to incorporate them into the determination of capacity, ramp rate, and ramp duration. The software uses actual historical data for day-ahead analysis and simulated data for hour-ahead and real-time analysis.

Shared Perspectives: Sustainable, efficient power grid operations rely heavily upon real-time information transparency and wide-area situation awareness (WSA) for all organizations in the power grid. For example, operators who communicate across organizations often depend on telephone calls to create a foundation of common understanding. By applying advanced technologies that augment existing communication techniques, operators can prevent miscommunications that during critical and complex events can lead to incorrect assumptions about events and even disastrous consequences. This technology addresses the fundamental need for greater WSA through actionable visualization tools that increase the effectiveness of communication between organizations. This is achieved by supporting inter-organizational planning and problem solving efforts, and by integrating information from domains external to the power industry with power grid information so that organizations have better awareness of events that can impact grid stability. This technology supports the need for WSA through new visual communication mechanisms that allow organizations to securely and flexibly share information across organizational boundaries. These shared communication mechanisms are enhanced with visual analytic strategies that incorporate germane information from domains outside of the power grid, such as weather, political/social, and cyber. This application's framework is based on a scalable web architecture that supports a highly-interactive, highly-customizable collection of visualization components that support rapid design and deployment for custom applications for industry. See more online.



The Shared Perspectives tool provides situational awareness through actionable visualizations that increase the effectiveness of communication between organizations.

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ABOUT PNNL

Interdisciplinary teams at Pacific Northwest National Laboratory advance science and technology to understand our world and address America's most pressing problems in energy, the environment, and national security. Founded in 1965, PNNL employs 4,400 staff and has an annual budget of more than $1 billion. It is managed by Battelle for the U.S. Department of Energy's Office of Science.

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