# Solutions for a Secure, Resilient Grid

A resilient, reliable, and adaptable power grid is essential to America's safety, health, and economic vitality. The nation's power grid is one of its greatest strengths, yet it is uniquely vulnerable to disruption, whether from evolving demands, natural events, or deliberate attacks. Oak Ridge National Laboratory (ORNL) scientists and engineers work in close partnership with the private sector to develop innovations to modernize the grid and defend it from disruption.



**ORNL and partners use the realistic proving grounds at ORNL's Grid Research Integration and Deployment Center (GRID-C) to develop, validate, and demonstrate innovations spanning all grid sectors for a reliable, secure, and resilient power system.**

## Innovations for a Modern Grid

**Intelligence and automation**—Integrating systems and novel power electronics to support diverse types of energy generation and storage

**Advanced controls and algorithms**—Engineering controls for future grid networks to increase resilience and balance loads; creating control algorithms to smooth demand in response to price signals and utility loads

**Monitoring**—Increasing the real-time awareness of the grid by developing and embedding high-fidelity sensors in grid assets

**Simulation tools**—Modeling resilience of the North American power grid for greater insight into energy system interdependencies and resilience investment needs

**Data platforms and data analytics**—Increasing real-time situational awareness of outages and developing a secure, nationwide interoperable framework for outage data exchange

**Megawatt-scale energy storage**—Expanding energy storage to support resilient energy and supply chains, with solutions ranging from solid-state and seawater battery systems to recycled electric vehicle batteries

**Grid security**—Developing systems architectures to advance end-to-end grid security with sensing, alternative timing sources, data and communications security, and software tools that reduce cyber and physical threats to grid operations

**ENGINEERING** power systems with modern electronics

**MODELING** grid functions for improved resilience

**PROTECTING** the grid using novel cyber-physical security methods

**AUTOMATING** monitoring with sensors

**SECURING** communications and controls

"ORNL provides a unique array of expertise in electric grid modeling, architecture, controls, power electronics, and software for planning and supporting our nation's power system as it faces new and increasing demands."

—Grid Systems Architecture Group Leader **Michael Starke**

OAK RIDGE National Laboratory

U.S. DEPARTMENT OF ENERGY | Office of Science

# Partnerships and Collaborations

We work closely with organizations such as Southern Company, EPB of Chattanooga, Southern California Edison, Tennessee Valley Authority, and the Electric Power Research Institute. ORNL also partners with regional universities, hardware and cybersecurity firms, and other national laboratories to devise and deliver solutions for a reliable, secure and resilient electric grid.

# Recent Impacts

**Microgrid controls**—Invented advanced and automated controls for networked microgrids to support community resilience at the grid edge or where electricity is unreliable, such as the mountains of Puerto Rico

**Building energy modeling**—Modeled the energy use of almost every U.S. building and collaborated with international companies to improve infrastructure and real estate planning and financing, architecture, and efficient building technology applications

**Battery component recycling**—Generated non-polluting processes for direct recycling of cathode and anode materials from electric vehicle batteries and for chemically separating critical battery materials for reuse

**Power electronics**—Developed a power electronics technology suite for a modernized grid architecture that monitors equipment health, speeds communication, and increases grid security

**Sensors**—Increased situational awareness and protected critical grid assets by developing and deploying high-fidelity and low-cost sensors for applications such as detecting electrical arcing and wildfires using unmanned aerial vehicles. Honed AI software and near-edge processing for rapid analysis of resulting sensor data

**Operational awareness and security**—Maintained the Grid Signature Library for analyzing wave forms that represent grid behavior, and developed secure grid timing/control mechanisms.

# Comprehensive Capabilities

**Advanced power electronics**—Designing, building, and validating robust hardware components that interface between the transmission system, consumer loads, and renewables

**Advanced algorithms and software platforms**—Controlling integration of the grid with many types of energy loads

**Scale-up and demonstration**—Integrating hardware and software for automating a modern, intelligent power grid and testing innovations within ORNL-controlled grid infrastructure and ORNL's Powerline Conductor Accelerated Test Facility

**Grid analytics**—Using AI to analyze real-world operating data for increased grid resilience; creating and managing platforms, such as Eagle-I and the Outage Data Initiative Nationwide, to track and share standardized utility operating data

**Advanced computing infrastructure**—Utilizing the world's first exascale supercomputer, Frontier, to provide deeper understanding of how natural or human-caused events will impact the electric grid; using advanced computing to explore the best operational strategies for grids that encompass a variety of energy sources and flows

**Battery manufacturing ecosystem**—Developing and building advanced batteries for the grid and transportation, then creating battery recycling and reuse processes utilizing the nation's largest open-access battery manufacturing research facility

**Cybersecurity solutions**—Creating and implementing systems architecture to advance end-to-end grid security; developing unique, trusted methods to automatically detect cyber intrusion and validate grid communications using novel analysis algorithms, quantum computing solutions, and blockchain frameworks

## Looking Ahead
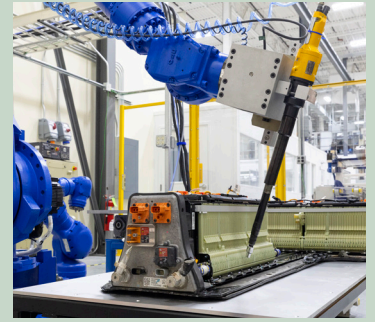


**Energy storage**
EV battery reuse/
automated recycling
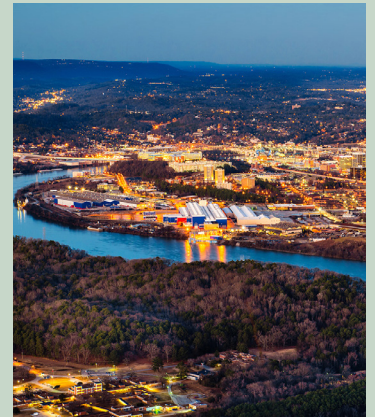


**Quantum communications**
Collaboration with
EPB of Chattanooga

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