



“We’re developing the most comprehensive system in the world to monitor the grid state and ensure resilience.”

Yilu Liu,  
Governor’s Chair for  
Power Electronics



## Solutions for a Secure, Resilient Grid

America’s safety, security, and vitality depend upon the uninterrupted delivery of electricity to homes, businesses, and public spaces. The nation’s power grid, one of our greatest strengths, is uniquely vulnerable to both cyber and physical disruption whether from natural events or malicious attacks. At Oak Ridge National Laboratory (ORNL), our scientists and engineers are working in close partnership with the private sector to develop innovations to harden the grid’s defenses and to ensure it can quickly recover from disruption.

### Innovations for a Modern Grid

**Modeling**—Creating a reliability and resilience model of the North American power grid that identifies energy system interdependencies and infrastructure investments needed for faster recovery.

**Cyber-physical risk mitigation**—Advancing a strategy to eliminate cyber and physical threats to the grid with a focus on real-time interdependency monitoring and critical facilities defense.

**Sensors**—Increasing the visibility of grid assets by developing and embedding high-fidelity sensors to provide essential data.

**Megawatt-scale energy storage**—Providing greater control of power demand and supply for a more flexible, responsive grid, with solutions ranging from networked microgrids to low-cost redox flow batteries to mechanical electricity storage, hydrogen fuel cells, and the recycling of electric vehicle batteries.

**Supporting Puerto Rico restoration**—Developing a comprehensive grid model that can guide infrastructure investments for better resilience; technical analysis of microgrid solutions for industrial corridors; and the installation of advanced sensors to improve situational awareness.



**MODELING** grid functions for improved resilience



**GUARDING** the grid with novel cyber-physical security methods



**AUTOMATING** control monitoring with sensors



**SECURING** communications, controls with a private network



**ENGINEERING** power systems with modern electronics



ORNL scientists have created a living simulation of the grid fed by real-time data called a Digital Twin to test cyber physical security solutions for the nation’s complex power system.

## Partnerships and Collaborations

We work closely with organizations such as Southern Company, Chattanooga EPB, Duke Energy, the Tennessee Valley Authority, the Electric Power Research Institute, and the Center for Ultra-Wide-Area Resilient Electric Energy Transmission Networks at the University of Tennessee. ORNL also partners with numerous other universities, hardware and cybersecurity firms, and national labs to devise and deliver solutions for a secure, reliable, and resilient electric grid.

## Recent Impacts

**Smart Neighborhood**—Deploying unique transactive controls to harness Internet of Things devices for better load balancing in a new residential community with industry partner Southern Company.

**Microgrid controls**—Creating and testing open source, cyber-secure software for efficient control of distributed energy resources.

**DarkNet**—Exploring methods to move grid communications and controls onto a secure, private network.

**Protective relay modeling**—Ensuring optimal design and location of hardware to protect the flow of power to customers.

**Cybersecurity solutions**—Developing unique, trusted software to automatically detect and deter cyberintrusion.

**Energy storage**—Creating new, low-cost methods for grid-scale electricity storage, including new redox flow battery components; a system to store electricity in pressure vessels; and packs utilizing secondary electric vehicle batteries.

**Sensors**—Developing low-cost, high-fidelity sensors to increase situational awareness of the grid and protect critical assets.

## Comprehensive Capabilities

**Goal Operations Analytics Laboratory**—Grid control room simulation fed by real-time operating information.

**Digital Twin Framework**—Cyber-physical testbed provides living simulation of a working grid.

**Distributed Energy Communications and Controls Facility**—Controls lab for ORNL's working microgrid.

**SI-GRID**—Low-voltage testbed for microgrid controllers and cybersecurity solutions.

**Powerline Conductor Accelerated Test Facility**—Accelerated testing of components for power transmission lines.

**Power Electronics and Electric Machinery Lab**—Advanced power electronics to enable a modern grid.

**Eagle-I**—Real-time grid monitoring using data science and utility feeds.

**Manufacturing Demonstration Facility**—Innovative low-cost manufacturing methods and materials.



*ORNL and Southern Company's Smart Neighborhood features a networked microgrid and transactive controls for intelligent load balancing.*



*ORNL is working to develop high-fidelity, affordable, easily deployed sensors to monitor the grid state using 3D printing.*

Contact:

Tom King, Sustainable Electricity  
Program Manager

kingtj@ornl.gov

865-241-5756

One Bethel Valley Road,  
Oak Ridge, TN 37830

