Modernizing the Grid for Increased Renewables and Electric Vehicles

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NREL at-a-Glance

2,926

Workforce, including
219 postdoctoral researchers
60 graduate students
81 undergraduate students

World-class
facilities, renowned technology experts

More than 900
Partnerships
with industry, academia, and government

Campus
operates as a living laboratory
Mega Trends
Impacting our Use of Energy

- Population Growth
- Food & Water
- Mobility
- Urbanization
- Distributed Energy Resources
Trends Impacting the Grid

- Increasing Interdependencies
- Energy Diversification
- Vehicle Electrification
- Grid-Connected Smart Buildings
- Big Data, Artificial Intelligence, and Machine Learning
- Cybersecurity
- Resilience
- Millions of Devices at the Grid Edge
The Grid of the Past
Energy systems are changing

They are becoming more:
- complex
- distributed
- interdependent
The US Energy Supply is Shifting

Renewable Energy

In 2019, 17% of annual electricity was from renewable sources.

- 7% Wind
- 7% Hydro
- 2% Solar
- 1% Biomass
- 0.5% Geothermal

Largest increase is in wind and solar

Note: Electricity generation from utility-scale facilities. Hydroelectric is conventional hydropower.
Power Electronics-Based Energy System
Operating with Less Inertia

**Generation**
- Solar PV, wind, microturbines, fuel cells use power electronics (PE) interfaces to connect to the grid
- Over 50% PE generation by 2050
- Other bulk source work synergistically

**Storage**
- Batteries use PE interfaces to connect to the grid
- Pumped hydro can add PE to increase controllability and provide grid services

**Building Loads**
- Over 60% of major home appliances expected to be PE-based by 2021
- Lighting switching to LEDs
- Variable speed drives for motors

**Mobility**
- EVs – 7 million by 2025
- MD/HD – Electrifying
Several energy system transformation scenarios assume a great degree of future electrification, especially for transportation.

Through the Electrification Futures Study, NREL is exploring scenarios with and impacts of widespread electrification in the United States.

Work is ongoing and planned, including developing future load scenario snapshots, to help us understand pathways to effective electricity.

Further exploration is needed to enable widespread electrification.
NREL’s AES Research developed advanced controls for integrating hundreds of million controllable grid assets

- Scalable, distributed-hierarchical control
- Fast and accurate real-time optimization
- Network-cognizant making best use of available data

- Campuses
- Communities
- Cities
- Regions

Enabling large-scale deployment of distributed energy resources (EVs, Buildings, Generation) through advancements in optimization, control, data analytics, and complex system simulation
Detailed, ultrahigh resolution analysis evaluating a range of future scenarios to equip LA decisionmakers to understand:

- What are the **pathways and costs** to achieve a 100% **renewable electricity supply** while electrifying key end uses and maintaining the current high degree of reliability?
- What is the **impact on the environment**?
- How might the **economy** and **rates** respond to such a change?
NARIS: North American Renewable Integration Study Highlights Continental Low-Carbon Grid Opportunities

- Applied a suite of advanced modeling tools to model the entire continent
- Analyzed scenarios to understand the impacts of renewable technology cost trajectories, emission constraints, and demand growth on emissions, resource adequacy, and the specific technologies that help enable the transition to a low-carbon grid
- Results show increasing electricity trade between countries and expanding interregional transmission can support a reliable future power system

nrel.gov/analysis/naris.html
Sources of Energy System Disruption

Natural Disasters
Space Weather
Physical Threats
Electromagnetic Pulse
Cyber Threats

Natural Hazards
Human Threats
NREL’s Cyber-Energy Emulation Platform (CEEP)

The CEEP generates emulated, multilayer grid environments that allow researchers to visualize and evaluate the interdependencies of power systems and network communication flows—and to safely explore vulnerabilities and mitigation effectiveness.
Advanced Research on Integrated Energy Systems (ARIES)
ARIES: A research platform to accelerate the transition to a modern energy system

- Identify the best path to reach local and national decarbonization goals
- Look at system-wide resilience to pinpoint weaknesses and solutions
- Troubleshoot and de-risk new technologies before they are connected to the electric grid
- Embed cybersecurity as a fundamental layer to all research
- Accelerate deployment by providing a research platform that can replicate the real-world
Thank You

www.nrel.gov