Driving Grid Resilience

Office of Electricity - Advanced Grid R&D

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Office of Electricity

The Office of Electricity (OE) provides national leadership to ensure that the Nation's energy delivery system is secure, resilient and reliable. OE works to develop new technologies to improve the infrastructure that brings electricity into our homes, offices, and factories, and the federal and state electricity policies and programs that shape electricity system planning and market operations.
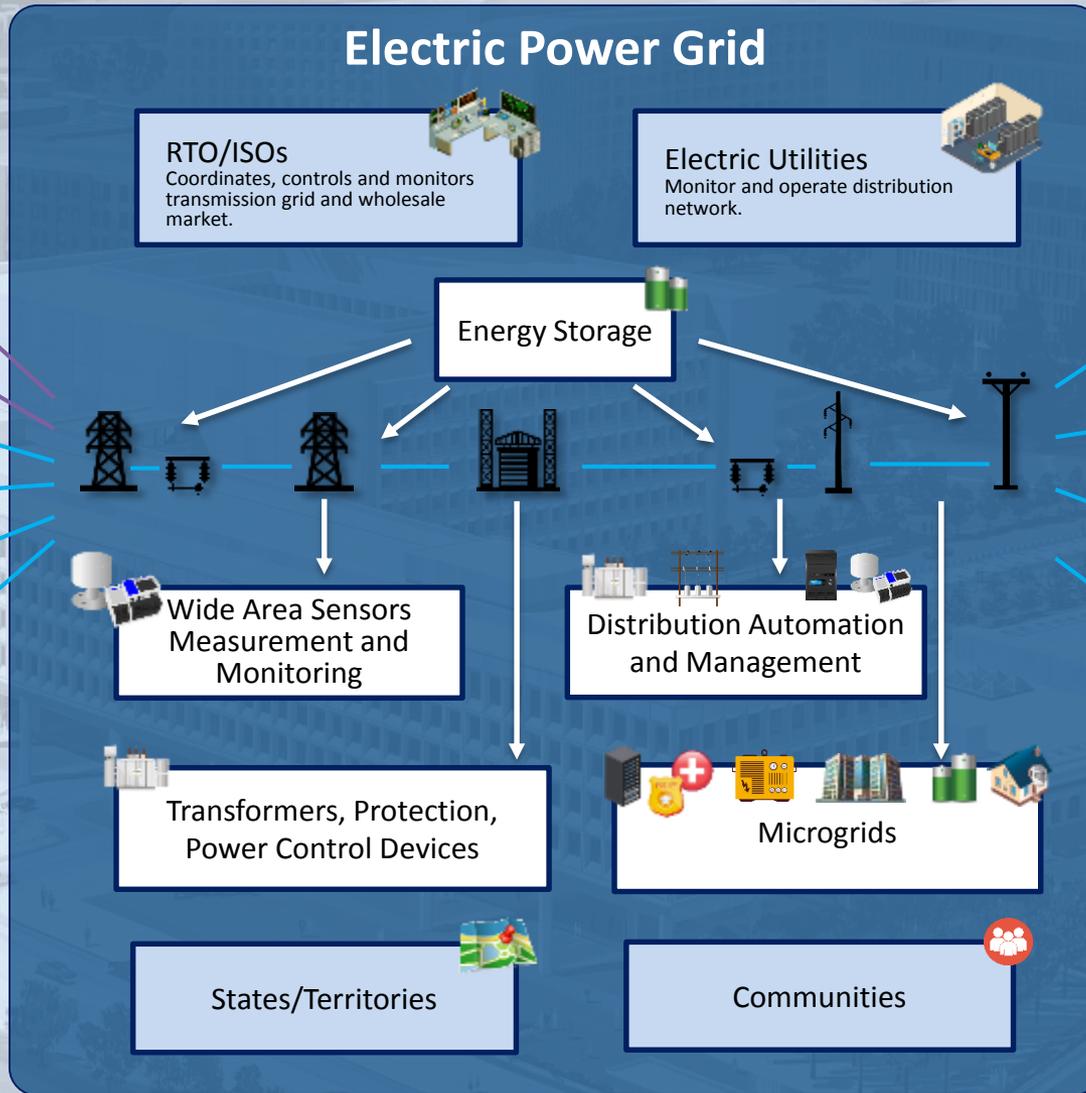
OUR MISSION
OE drives electric grid modernization and resiliency in the energy infrastructure.
OE leads the Department of Energy's efforts to ensure a resilient, reliable, and flexible electricity system. OE accomplishes this mission through research, partnerships, facilitation, and modeling and analytics.

energy.gov/oe

OE's Advanced Grid R&D Portfolio

Electric Power Grid

RTO/ISOs
Coordinates, controls and monitors transmission grid and wholesale market.

Electric Utilities
Monitor and operate distribution network.

Energy Storage

Wide Area Sensors Measurement and Monitoring

Distribution Automation and Management

Transformers, Protection, Power Control Devices

Microgrids

States/Territories

Communities

Electricity Producers

Distributed Energy Resources

Electricity Consumers

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Advanced Grid R&D Programs At-A-Glance

Grid Controls and Communications	Transmission Reliability and Resilience	Synchrophasors		Advanced Grid Modeling	
	Resilient Distribution Systems	Advanced Distribution Systems	Advanced Microgrids	Dynamic Controls and Communications	High-Fidelity & Low-Cost Sensors
Grid Systems and Components	Transformer Resilience and Advanced Components	Advanced Power Grid Components			
	Energy Storage Systems	Energy Storage			

Five Priorities for OE Going Forward

North American Energy Systems Resiliency Model

Operational Strategy for Cyber and Physical Threats

Megawatt-Scale Grid Storage

Revolutionize Sensing Technology Utilization

Puerto Rico and US Virgin Islands Resiliency Efforts

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Research
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Integrated Technical Thrusts

Technology Innovation

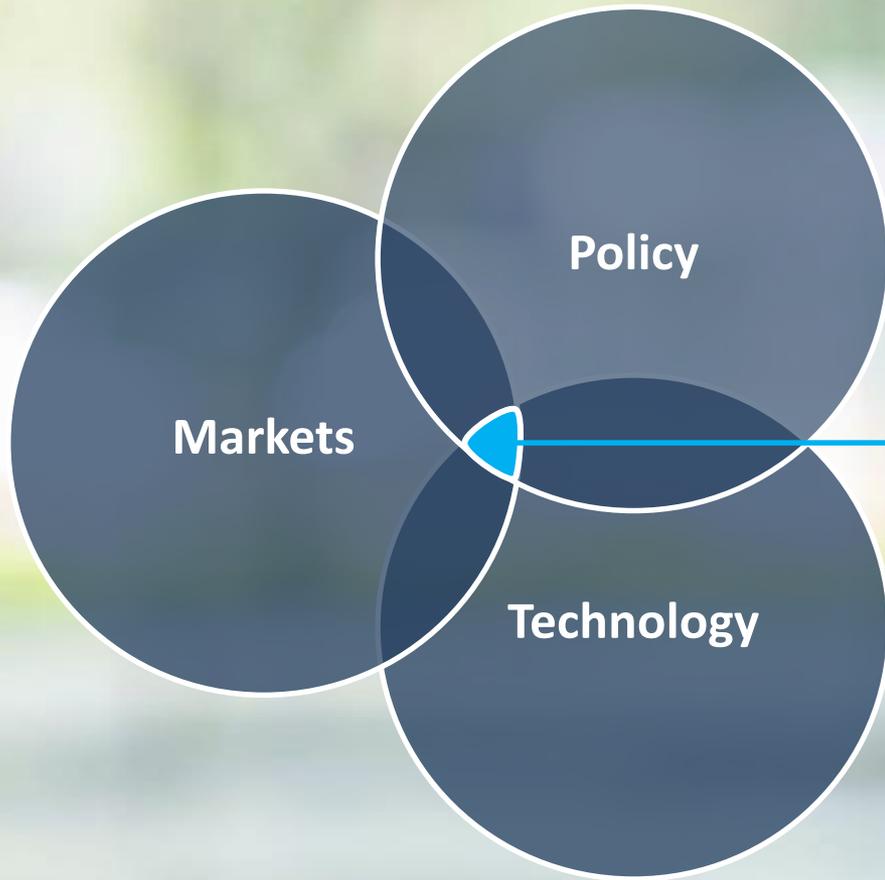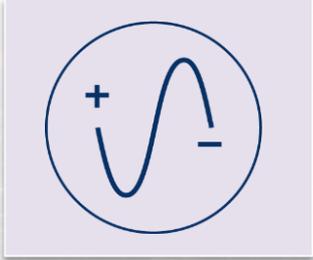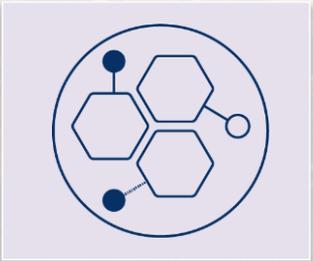|	
Design and Planning	• Create grid planning tools that integrate transmission and distribution system dynamics over a variety of time and spatial scales
System Operations, Power Flow, and Control	• Design & test technologies that enhance/enable the capability to control and coordinate millions of assets for grid operations through EMS/DMS
Sensing and Measurements	• Explore integrating advanced sensors, communications, visualization and analytics to enable 100% observability
Devices and Integrated Systems	• Evaluate and develop new devices and components for improved reliability/resilience
Security and Resilience	• Develop resilient and advanced security (cyber and physical) solutions and real-time incident response capabilities for emerging technologies and systems
Institutional Support	• Enable regulators & utility/grid operators to make more informed decisions & reduce risks on key issues that influence the future electric grid/power sector

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Technology Adoption

Policy

Markets

Technology

Interaction between Policy, Markets, and Technology

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Transmission Reliability and Resilience

Synchrophasors

50 million people were without power in 2003 due to cascading failures on the electric grid across 8 states. We cannot provide reliable electricity without synchrophasors and the applications that use the data from those sensors.

Advanced Grid Modeling

The successful coordination in grid modeling research will lead to a new era of operations and planning. These tools will be essential during this era of major change to our energy system.

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Advanced Synchrophasor Program

North American Synchrophasor Initiative

- Realize promise of synchrophasor technology
- Facilitate intelligent deployment of synchrophasors

Advanced Application Development

- Automatic switchable network for reliable early warning for informed remedial reaction
- Reliability monitoring and NERC compliance tools
- Oscillation behavior

Reliability and Models

- Research, develop, and implement electricity infrastructure and market simulations

Equipment Standards

- Data quality
- Device calibration (NIST)

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Advanced Grid Modeling Program

Data Management & Analytics

- Facilitate standardizing data
- Create an environment for data sharing
- Build capability to handle Big Data

Mathematical Methods & Computation

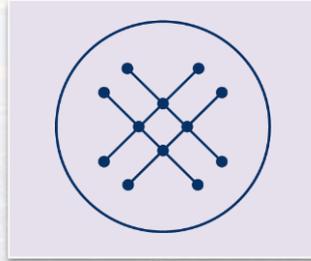- Increase pace to information
- Reduce computational strain

Models & Simulation

- Rapid
- Accurate
- Precise
- Interfacing

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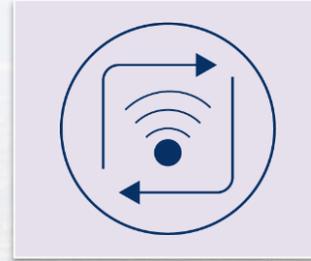OFFICE OF ELECTRICITY
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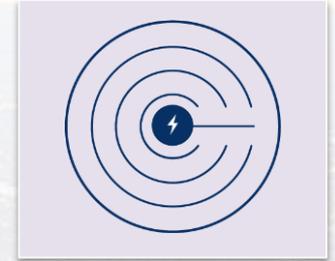
Resilient Distribution Systems

Advanced Distribution Systems

Microgrids

Dynamic Controls & Communications

High Fidelity, Low-Cost Sensors

The advent of digital grid technology, the evolution and availability of renewable and distributed energy resources, and the emerging participation of prosumers and third-party merchants to provide grid resources challenge the traditional approaches for grid planning and operations.

Our holistic distribution grid research provides the broad guidance to protect the grid and support decision-makers to make informed grid investments and management strategies.

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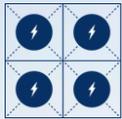
Advanced Microgrid Program

CORE

Remote, Off-grid Microgrids

- Active control of electrical and thermal energy
- Standardized methods for system designs and performance monitoring
- Integration of local energy sources

Grid-connected Microgrids

- Planning/design tools
- Operations/control tools
- Integration w. distribution systems
- Standardized cost/performance data

Networked Microgrids

- Tools for planning and evaluation with new modeling/simulation/optimization capabilities
- Enabling implementation in cities and regionally

CROSSCUT

Resiliency Tools

- Pre-event preparation
- During-event detection and mitigation
- Post-event response, recovery, and remediation

Standards and Testing

- New and revised microgrid standards
- Standardized test methods & testing

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Dynamic Controls & Communications Program

Policy and Market Design

- Continued reliability
- Understand volatility of generation and demand
- Varying timescales and cost effectiveness

Business Models and Value Realization

- Understanding of customer value streams
- Understand DER transactions

Conceptual Architecture Guidelines

- Clear structure
- Establish traditional and distributed interfaces

Strong Interfaces and Partners

- Enhance intra-grid information and value flows
- Ensure "docking" with critical partners at the grid edge.

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High Fidelity, Low-Cost Sensor Program

Fault Detection

- Novel, low-cost sensors for deployment directly at/on the asset to be monitored
- Data analytics for asset health monitoring and anomaly detection and identification

Distribution System Resilience

- Low-cost for integrating multiple sensors that are self-powered and capable of spatially distributed measurements of multiple parameters
- High-fidelity data, ingestion, visualization, analytics, standardization to rapidly detect low probability, high consequence events to protect critical distribution grid equipment

Accurate DER Forecasting

- Low-cost platform technologies, including wireless, self-powered, self-calibrating sensors for large scale deployment with capability for auto self-configuration and commissioning
- Validate forecast models of load, variable renewable, net-load power, and ramps

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Advanced Distribution System Program

Platform
- Develop open-source platform
- Connect to operational systems
- Framework for benefits evaluation

Testbed
- Span multiple vendors and management/data systems
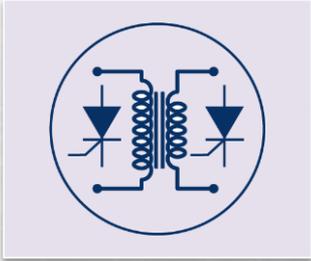- Integrate legacy and new

Applications
- Develop initial application suite
- Baseline safety, resilience and reliability, and integration

Industry Engagement and Crosscut Activities
- Enable the design and analysis of control algorithms for DERs
- Protect customer energy usage data
- Manage intermittence at distribution voltage levels

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Advanced Grid R&D Programs At-A-Glance

Advanced Power Grid Components

To ensure the electric grid remains reliable and resilient, next-generation transmission and distribution hardware will need to better withstand physical and cyber-threats, facilitate rapid recovery and restoration, and provide new capabilities that meet future grid requirements. Improvements in the materials used in these components and the way they are designed and built will enhance their performance, reduce their costs, and enable more flexible and efficient grid operations.

- Increased energy efficiency
- Improved operations and new architectural paradigms
- Enhanced asset utilization and management
- Increased system resilience
- More domestic manufacturing and jobs

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Advanced Components Program Areas

Market & System Impact Analysis

- Understand system impacts of new technologies and functions
- Techno-economic analysis for costs/benefits of advances

Component Design & Development

- Design and prototype components with enhanced features/functions
- Field validations to demonstrate and evaluate new capabilities
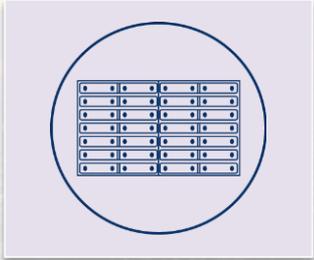
Monitoring, Modeling & Testing

- Develop embedded sensors and intelligence to improve reliability
- Testing and model validation to understand limits and performance

Applied Materials R&D

- Evaluate and develop new materials and devices that underpin advanced components

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Energy Storage Program

Energy Storage Systems

The goal of the Energy Storage program is to lower system costs while simultaneously defining and articulating the value and benefits storage can provide across the grid infrastructure. Going forward, the program will continue to accelerate the progression of grid-scale energy storage technology in America to protect our grid and ensure our nation's leadership in an emerging global marketplace.

Cost and Performance Goals

$150/kWh
Total, installed system cost by 2022 (for a flow battery)

2 Long-Duration Cycles per Day
(with deep discharge for each cycle) by 2028

6 Hours Output duration per cycle

10,000 cycles Lifetime (about 20 years)

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Energy Storage Program

Cost Competitive Technology

- Materials and chemistry
- Systems and manufacturing
- Cost reduction
- Expanded applications

Reliability & Safety

- Lab testing
- Codes and standards
- Guidebooks
- R&D Improvements

Regulatory Environment

- Policy analysis
- Valuation methods
- Resolution of benefits

Industry Acceptance through Demonstrations

- Stakeholder engagement
- Proving success
- Seamless integration
- Consumer benefits

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Storage Economics and Policy Implementation

- ❑ **Capacity**
- ❑ **Arbitrage**
- ❑ **Regulation**
- ❑ **Spin/Non-Spin Reserves**
- ❑ **Voltage Support**
- ❑ **Black Start**
- ❑ **Congestion Relief**
- ❑ **T&D Upgrade Deferral**
- ❑ **Power Reliability**
- ❑ **TOU Energy Charge Reduction**
- ❑ **Demand Charge Reduction**

The Cost of a Storage System depends on the Storage Device, Power Electronics, and Balance of Plant

The Value of a Storage System depends on Multiple Benefit Streams, both monetized and unmonetized

Energy Storage Device
25-50%

Power Electronics
20-25%

Balance of Plant
20-25%

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