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](http://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

Transformers, Protection,
Power Control Devices

Distribution Automation
and Management

Microgrids

States/Territories

Communities

Electricity Producers

Distributed Energy Resources

Electricity Consumers
## Advanced Grid R&D Programs At-A-Glance

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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
Integrated Technical Thrusts

- **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
Technology Adoption

Interaction between Policy, Markets, and Technology
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.

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.
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)
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
Resilient Distribution Systems

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.
Advanced Microgrid Program

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

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
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.
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
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
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
**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
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)
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
Storage Economics and Policy Implementation

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%

- 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

- Capacity
- Arbitrage
- Regulation
- Spin/Non-Spin Reserves
- Voltage Support
- Black Start
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- T&D Upgrade Deferral
- Power Reliability
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- Demand Charge Reduction
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