Welcome and Overview

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Materials Innovation for Next Generation T&D Grid Components
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OE Mission

The Office of Electricity Delivery and Energy Reliability (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 serves as the Energy Sector Specific lead for the Federal emergency response when activated by DHS/FEMA.

Technology Innovation

Grid Modernization

Security & Resilience

Institutional Support & Alignment
• The last five years have been defined by dramatic changes across the energy sector:
  – Unconventional fossil fuel production
  – Renewables cost reduction and market penetration
  – Nuclear power opportunities
  – Transportation electrification
  – Buildings and industrial efficiency
  – Manufacturing and competitiveness
  – Increasing use of digital technologies in the energy sector: Power, Vehicles, Industry, and Buildings
• The grand challenges, shifting policies, and changes in available technologies require new approaches to better configure our national programs, capabilities, and policies for success.
• In November 2010, the President’s Council of Advisors on Science and Technology (PCAST) recommended an integrated federal energy policy.

• The Quadrennial Energy Review (QER) was called for by the President on January 9, 2014
  – Volume 1 released on April 21, 2015
  – Focused on energy infrastructure (TS&D)

• A review of DOE’s work on energy technology innovation—the Quadrennial Technology Review (QTR)—is one component.
  – First QTR published in September 2011
  – 2015 QTR will be released September 10
• From 2008 to the end of 2013, electricity generated from wind has more than tripled, and the amount from solar has increased by more than tenfold.
• Cost reductions and supportive policies have resulted in greater deployment of renewable resources and this trend is projected to continue.
Increased Flexibility Needed

- Increased variability and uncertainty introduced by renewable resources requires greater system flexibility
- There are many options for providing this flexibility
Evolving Customer

- Electricity more vital to GDP
- Decrease in retail sales varies by state
- Consumer becoming prosumer

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New Customer Technologies

Installed Smart Meters

Energy Consumption in the U.S.

Industry 33%
Buildings 39%
Transportation 28%
Commercial 18%
Residential 21%

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Increasing Risks


Intense precipitation events are becoming more frequent, particularly in the northeastern United States. The map shows percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1 percent of all daily events) from 1958 to 2012 for each region of the United States.
The future grid provides a critical platform for U.S. prosperity, competitiveness, and innovation in a global clean energy economy. It must deliver **reliable, affordable, and clean electricity** to consumers where they want it, when they want it, how they want it.

### Achieve Public Policy Objectives
- 80% clean electricity by 2035
- State RPS and EEPS mandates
- Access to reliable, affordable electricity
- Climate adaptation and resilience

### Sustain Economic Growth and Innovation
- New energy products and services
- Efficient markets
- Reduce barriers for new technologies
- Clean energy jobs

### Mitigate Risks and Secure the Nation
- Extreme weather
- Cyber threats
- Physical attacks
- Natural disasters
- Fuel and supply diversity
- Aging infrastructure
Transforming the Grid

Current System

- Monolithic
- Centralized generation
- Decisions driven by cost
- Catastrophic events
- Limited energy choices
- Vulnerable to new threats

Future Paradigm

- Modular and Agile
- Centralized and distributed generation
- Decisions driven by cost and environmental sustainability
- Contained events
- Personalized energy options
- Inherently secure to all threats
In 2009, the Office of Electricity Delivery and Energy Reliability (OE) received $4.5 billion in Recovery Act funds to support grid modernization activities:

- Smart Grid Investment Grants (SGIG) - $3.4 billion
- Smart Grid Demonstration Program (SGDP) - $620 million
- Workforce Training - $100 million
- Interconnection-wide Transmission Planning and Resource Analysis - $80 million
- Interoperability Standards (with NIST) - $12 million
- Technical Assistance to States - $44 million
- Local Energy Assurance Planning - $10 million
SGIG Deployment Status

99 Projects with 228 Utilities

SGIG Project Expenditures ($MM)

- **AMI**:
  - Reported as of March 2014: $4,120
  - Estimated at Completion: $4,520
  - $635

- **CS**:
  - Estimated at Completion: $850
  - $1,915

- **EDS**:
  - $470
  - $560

- **ETS**:
  - 1,075 which exceeds 800 expected at completion networked phasor measurement units
  - 8,659 which exceeds 7,500 expected at completion automated switches and 12,599 of about 18,500 automated capacitors
  - 15.3 of 15.5 million residential and commercial smart meters
  - 684,000 direct load control devices, programmable communicating thermostats, and in-home displays

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Next Generation Transformers

- Almost 50% of LPT failures are associated with the limits of insulation (e.g., lightning, electrical disturbances).
- Manufacturing and delivery of a LPT replacement can take up to two years.
- New design concepts for next generation components can address some challenges.
Next Generation Components

- The future grid will have more advanced components and systems across transmission and distribution
  - HVDC/MVDC Networks
  - Power Flow Controllers
  - Microgrids
• **Goals**
  – Ensure the resilience of aging assets and identify new requirements for future grid components (**Near-Term Focus**)
  – Accelerate the development, demonstration, and deployment of next-generation components (**Long-Term Focus**)

• **Activities**
  – Component Monitoring, Modeling, and Testing
  – Market and System Impact Analysis
  – **Applied Materials Research and Innovation**
  – Component Design and Development
The electric grid is at the core of the electric power system (dashed box).
Transmission and distribution components, the hardware responsible for carrying and controlling electric power, are the primary focus.
Energy storage, generators (i.e., inverters), and loads are NOT in scope.
Materials innovation can enhance grid components to address emerging system trends; simultaneously, system trends change grid component requirements that can drive new material innovations.
• Grid Applications Overview
  – Joe Schatz (Southern Company)
  – Richard Ord (EPRI)
  – Alex Huang (NCSU/FREEDM Center)

• Materials Development Overview
  – Debbie Haught (DOE/OE)
  – Paul Ohodnicki (NETL)
  – Jim Davidson (Vanderbilt University)

• Manufacturing Innovations
  – Mark Johnson (DOE/AMO)