SMART GRID PROGRAM AT THE U.S. DOE

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The Smart Grid Defined

Smart Grid - Convergence of Electric, Communication, and Information infrastructure for a Modernized Electric Grid System

1. Power System Infrastructure

2. Information Infrastructure

Source: Electric Power Resource Institute (EPRI)
OE’s Role in Grid Modernization

**Reliability**: reduced power interruptions

**Efficiency**: improved asset utilization, increased energy efficiency

**Resiliency**: mitigation of impact, restoration time

**Flexibility**: clean energy, diversified generation (size, type), load management
# OE’s Research & Development Program

<table>
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<tr>
<th>Program Areas</th>
<th>Goals</th>
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<tbody>
<tr>
<td>Clean Energy Transmission and Reliability</td>
<td>Develop advanced monitoring, control, and computational applications to reliably operate the US transmission system.</td>
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<tr>
<td>- Transmission Reliability and Renewables Integration</td>
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<tr>
<td>- Advanced Modeling Grid Research</td>
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<tr>
<td>Smart Grid</td>
<td>Develop advanced digital technology for applications at the distribution level to achieve self-healing from grid disturbances and full customer participation and choice in load management.</td>
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<tr>
<td>- Smart Grid R&amp;D</td>
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<tr>
<td>- Power Electronics</td>
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<tr>
<td>Energy Storage</td>
<td>Develop new and advanced energy storage technologies that will enhance the stability and reliability of the future electric grid.</td>
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<tr>
<td>Cybersecurity for Energy Delivery Systems</td>
<td>Develop resilient energy delivery systems that can survive a cyber incident while sustaining critical functions.</td>
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Smart Grid R&D Program

Focusing on distribution systems and customer solutions, including interfaces and integration with T&G systems

**Intelligent Load Management**
Develop tools to greatly expand demand response and consumer energy management for improved system efficiency.

**Microgrids**
Develop commercial scale microgrid systems to meet power quality and reliability needs and economic and noneconomic objectives of individual end users.

**Distribution Automation**
Develop advanced sensors, communications, and information technologies, with modeling and decision support tools, to provide intelligent responses to changing loads, supply, and failure conditions for improved system reliability.
GridLAB-D: A Unique Tool for Designing and Studying Smart Grids

Unifies models of the key elements of a smart grid:
- **Power Systems**
- **Loads**
- **Markets**

- Smart grid analyses
  - field projects
  - technologies
  - control strategies
  - cost/benefits
- Time scale: sec. to yrs
- Open source
- Contributions from
  - government
  - industry
  - academia
- Vendors can add or extract own modules

GridLAB-D is a DOE-funded, open-source, time-series simulation of all aspects of operating a smart grid from the substation level down to loads in unprecedented detail.

Simultaneously solves:
- Unbalanced, 3-phase power flow (radial or network), w/explicit control strategies
- End use load physics, voltage-dependency, behavior & control in 1000s of buildings
- Double-auction retail supply/demand markets
## Defining Microgrids

### Microgrid Definition

- A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.

### Key Attributes

- Grouping interconnected loads and distributed energy resources
- Can operate in both island mode or grid-connected
- Can connect and disconnect from the grid
- Acts as a single controllable entity to the grid
Microgrid RD&D

To date, the bulk of work has been on microgrid demonstrations

**FY 2012 and prior**
- Renewable and Distributed Systems Integration
- Consortium for Electric Reliability Technology Solutions (CERTS)
- The Distributed Energy Resources Customer Adoption Model (DER-CAM)
- Energy Surety Microgrids
- Smart Power Infrastructure Demonstration for Energy, Reliability, and Security (SPIDERS)
- Standards Development – Interconnection and Interoperability

**FY 2013 and beyond**
- RD&D to reach 2020 microgrid performance targets* on costs, reliability, system energy efficiencies, and emissions

*Develop microgrid systems capable of reducing outage time of required loads by >98%; cost comparable to non-integrated baseline solutions (UPS + diesel genset); reduce emissions by >20%; improve system energy efficiencies by >20%
Renewable and Distributed Systems Integration (RDSI)

- 9 demonstration projects in 8 states to integrate use of DER to provide at least 15% peak demand reduction on distribution feeder or substation
- Projects are either microgrids or are developing technologies that will advance microgrids
- Systems must be capable of operating in both grid parallel and islanded modes
- $55 million of DOE funds over five years (total value of awards will exceed $100 million, including participant cost share)

25% of distribution & 10% of generation assets (transmission is similar), worth 100s of billions of US dollars, are needed less than 400 hrs/year!
When a disturbance to the utility grid occurs, the automatic disconnect switch enables the facility to “island” itself from the main utility grid and independently generate and store its own energy.

Utility power enters the facility at the “Point of Common Coupling”

PG&E utility interconnection or “Point of Common Coupling” and static disconnect switch

Five 2.3 kW wind turbines

1.2 MW rooftop solar photovoltaic system

Distributed Energy Resources Management System (DERMS)

Two 1.2 MW backup diesel generators

1 MW fuel cell

2 MW advanced energy storage system

The distributed energy resources management system (DERMS) serves to reduce peak demand during normal grid-connected operation or during a demand response event.

Facility Electric Load

Santa Rita Jail Microgrid
Objective

- **Improve reliability** for mission-critical loads by connecting generators on a microgrid using existing distribution networks.
- **Reduce reliance on fuel** for diesel power by using renewable energy sources during outages.
- **Increase efficiency** of backup generators through coordinated operation on the microgrid.
- **Reduce operational risk** for energy systems through a strong cyber security for the microgrid.
- **Enable flexible electrical energy** by building microgrid architectures that can selectively energize loads during extended outages.

Technical Scope

DoD, DOE, and DHS collaborate to design and implement three separate microgrids supporting critical loads at DoD bases. Each one is slightly larger and more complex in scope than the previous. The sites include:

- Joint Base Pearl Harbor Hickam
- Fort Carson
- Camp Smith

A key part of the project is the standardization of the design approach, contracting, installation, security, and operation of these microgrids to support future applications.
Federal programs, institutions, and the private sector are increasing microgrid development and deployment. The number of successfully deployed microgrids will verify the benefits and decrease implementation risks, further expanding the market for microgrids.
R&D Pathway toward DOE 2020 Microgrid Performance Targets

Workshops to engage stakeholders for R&D planning

- 2011 workshop affirmed DOE 2020 targets and defined R&D areas for component and system integration technologies
- 2012 workshop integrated R&D areas (from 2011) into Planning/Design and Operations/Control and prioritized R&D topics in each

Rescoping lab AOPs to address workshop priority R&D topics

- Use case development to define performance requirements and technology specifications
- Cost and benefit analysis to ID high-impact R&D for investments
- Integrated tool sets for conceptual/preliminary designs and operations/control

FY14 microgrid R&D FOA

- In synergy with lab AOPs to achieve cost parity for the identified microgrid use case

## Microgrid Potential Opportunities

### Opportunities
- Hospitals and Other Critical Facilities
- Universities
- Municipalities
- Military Installations

### Drivers
- Energy Security and Reliability
- Renewable Energy Mandates and Directives
- Costs (peak load reduction, demand charges)
Microgrids Advance Renewable and EE Technology Implementation

- Small combustion and µ-turbines
- Fuel cells
- IC engines
- Small hydro and wind
- Solar electric and solar thermal
- Energy storage (batteries, flywheels, ...)
- Plug in hybrid vehicles
- Modular energy sources

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<tr>
<th>Category</th>
<th>Description</th>
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<tr>
<td>Residential</td>
<td>Less than 10-kW, single-phase</td>
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<tr>
<td>Small Commercial</td>
<td>From 10-kW to 50-kW, typically three-phase</td>
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<tr>
<td>Commercial</td>
<td>Greater than 50-kW up to 10MW</td>
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Ref. EPRI
What Smart Grid Means for Electric Distribution Services

Reduced incidents of outages

- Smart Grid technologies will enable grid operators to identify, relieve, or replace failing equipment even before a breakdown can occur.

Enhanced reliability

- The Smart Grid will reduce the cost of power disturbances that cost American businesses (and all of us) billions.

Reduced vulnerability

- The Smart Grid’s communications “backbone” will enable detection and lessening of both cyber and physical threats.
Contact Information

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For more information:
OE: www.oe.energy.gov
Smart Grid: smartgrid.gov
Backup Slides
on
Recovery Act Investments
Recovery Act Overview

Programs created by statute:

American Recovery and Reinvestment Act of 2009
- $3.4 billion - Smart Grid Investment Grants*
- $620 million - Smart Grid Regional Demonstrations*
- $100 million - Workforce Training
- $80 million - Interconnection-wide Transmission Planning and Resource Analysis
- $12 million - Interoperability Standards

Additional OE Recovery Act Initiatives:
- $44 million - Technical Assistance to States
- $10 million - Local Energy Assurance Planning

*Originally authorized by the Energy Infrastructure Security Act 2007, EISA 1306 and EISA 1304
Catalytic Effect of the Recovery Act

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<th>Significant deployment of Smart Grid assets leading to:</th>
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<td>- Additional 10% of the population being served by smart meters</td>
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<td>- However, a small percentage will have enabling technology and access to dynamic pricing</td>
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<td>- Additional 5% of distribution circuits being upgraded with sensors and smart switches</td>
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<td>- However, few are achieving the level of automation required in sophisticated circuits</td>
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<tr>
<td>- Over 1,000 networked phasor measurement units installed (compared to 166 in 2010)</td>
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<td>- However, several years required to apply synchrophasor measurements into operations</td>
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<th>Improvements in grid performance:</th>
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<td>- Reduction in peak demand</td>
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<td>- Operations and maintenance (O&amp;M) cost reductions</td>
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<tr>
<td>- Reliability improvements in transmission and distribution (T&amp;D) systems</td>
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<tr>
<td>- System efficiency improvements (both T&amp;D)</td>
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<td>- Possible greenhouse gas reductions</td>
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<th>Generation of data that will:</th>
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<td>- Lead to an enhanced understanding of consumer behavior with respect to dynamic prices and enabling AMI technologies</td>
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<tr>
<td>- Demonstrate the technical and cost performance of smart grid and energy storage technologies</td>
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<th>Interoperability and cyber security standards development</th>
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<td>Workforce development</td>
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<tr>
<td>Initiation of integrated planning and analysis efforts with States across the US</td>
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Source: Office of Electricity Delivery and Energy Reliability
Smart Grid Investment Grant (SGIG)

Deploying technologies for immediate commercial use supporting manufacturing, purchasing, and installation of smart grid technologies

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<td>Displays</td>
<td>Smart meters</td>
<td>Switches</td>
<td>Wide area monitoring and visualization</td>
<td>Energy devices</td>
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<tr>
<td>Portals</td>
<td>Data management</td>
<td>Feeder optimization</td>
<td>Synchrophasor technology</td>
<td>Software</td>
</tr>
<tr>
<td>Energy management</td>
<td>Back office integration</td>
<td>Equipment monitoring</td>
<td>Energy storage</td>
<td>Appliances</td>
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<tr>
<td>Direct load controls</td>
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<td>Energy storage</td>
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Smart Grid Investment Grant (SGIG)

99 SGIG projects with a total budget of $8 billion. Federal share is equal to $3.4 billion; private share is equal to $4.6 billion.

**Smart Grid Investment Grant Projects**

- Cross Cutting Projects: $4,925,826,664
- Advanced Metering Infrastructure: $1,997,812,053
- Electric Distribution: $511,700,775
- Electric Transmission: $308,014,431
- Customer Systems: $66,534,058
- Equipment Manufacturing: $52,009,278

**SGIG Recipient Types**

- Municipal Utilities, 31%
- IOU, 37%
- Tech/Manufacturing, 4%
- Electric Co-ops, 19%
- ISO/RTO, 9%

Source: www.smartgrid.gov
Smart Grid Demonstration Program (SGDP)

Demonstrate emerging technologies and alternative architectures to validate business models and address regulatory/scalability issues.

Grid-Scale ES Applications
- Large Battery Systems (3 projects, 53MW)
- Compressed Air (2 projects, 450MW)
- Frequency Regulation (20MW)
- Distributed Projects (5 projects, 9MW)
- Technology Development (5 projects)

Smart Grid Regional Demonstrations
- 12 AMI
- 10 PEV charging points
- 10 HAN
- 9 In-home displays
- 9 SCADA improvements
- 8 Energy storage
- 8 Distribution automation

32 projects, $620M Federal + $980M Private Investments