SMART GRID PROGRAM AT THE U.S. DOE

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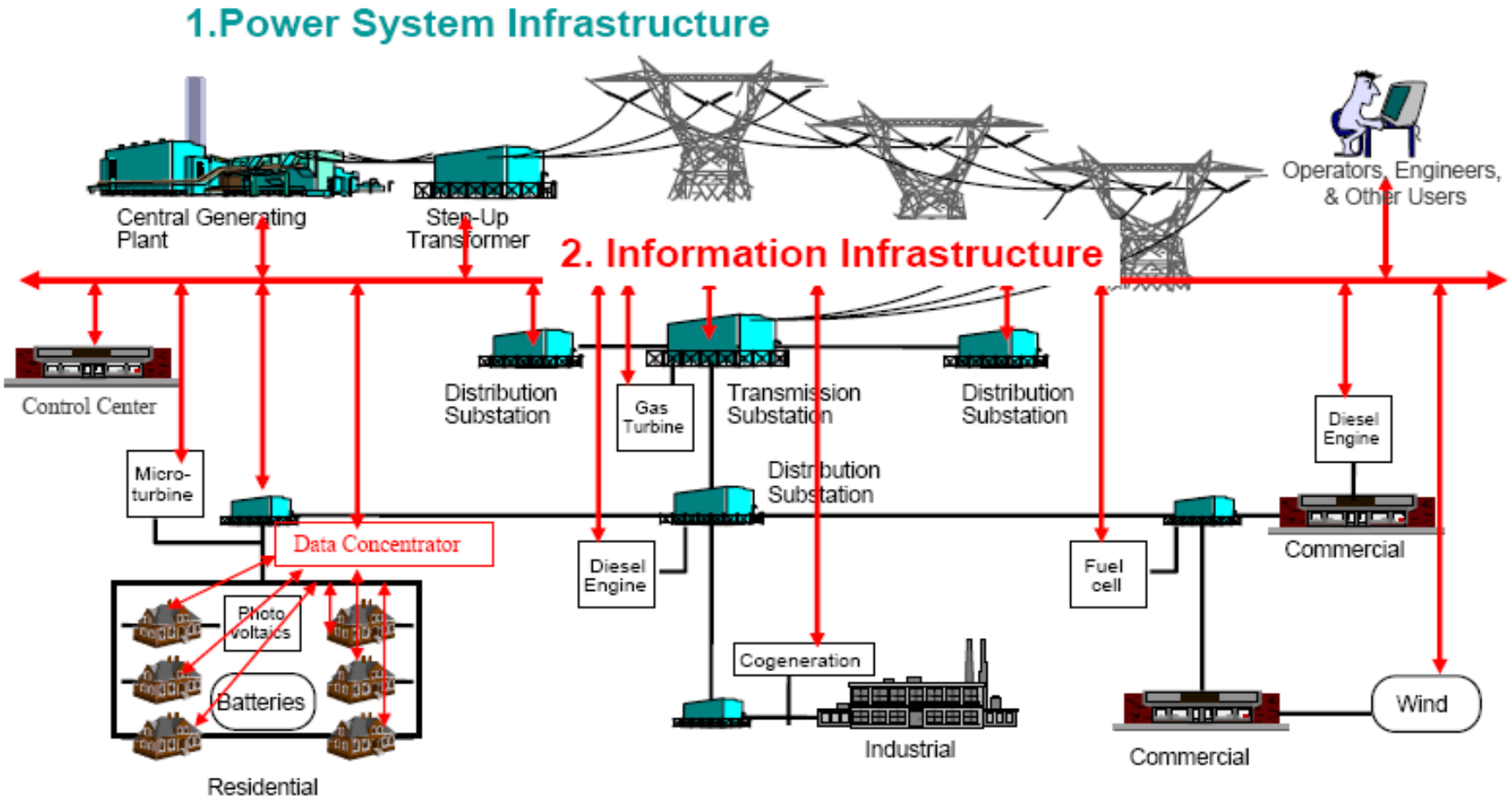
The Smart Grid Defined

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



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

Program Areas	Goals
Clean Energy Transmission and Reliability ▪ Transmission Reliability and Renewables Integration ▪ Advanced Modeling Grid Research	Develop advanced monitoring, control, and computational applications to reliably operate the US transmission system.
Smart Grid ▪ Smart Grid R&D ▪ Power Electronics	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.
Energy Storage	Develop new and advanced energy storage technologies that will enhance the stability and reliability of the future electric grid.
Cybersecurity for Energy Delivery Systems	Develop resilient energy delivery systems that can survive a cyber incident while sustaining critical functions.

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.

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.

Microgrids

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

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

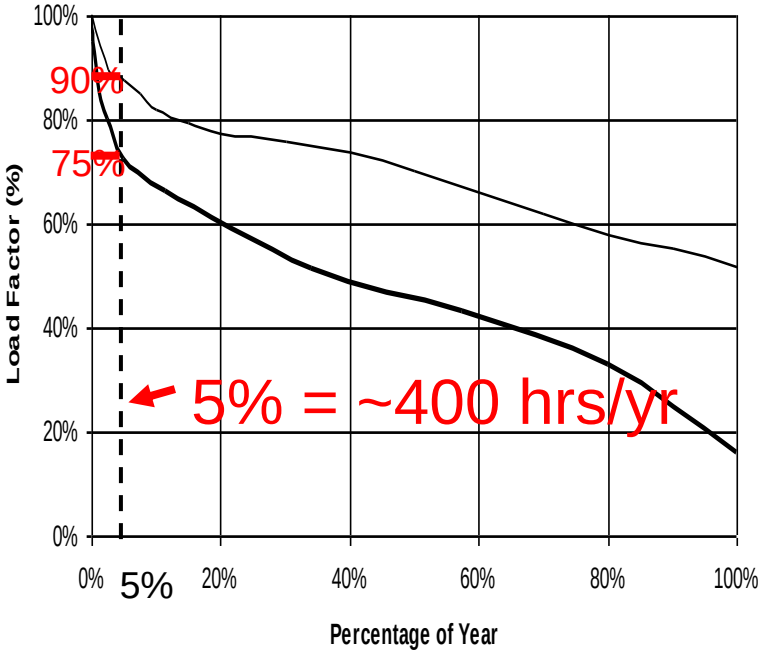
- RD&D to reach 2020 microgrid performance targets* on costs, reliability, system energy efficiencies, and emissions

*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)

Lower Peak Demand Reduces Infrastructure Investments



25% of distribution & 10% of generation assets (transmission is similar), worth 100s of billions of US dollars, are needed less than 400 hrs/year!

Santa Rita Jail Microgrid

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

Two 1.2 MW backup diesel generators

Distributed Energy Resources Management System (DERMS)

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

1 MW fuel cell

2 MW advanced energy storage system

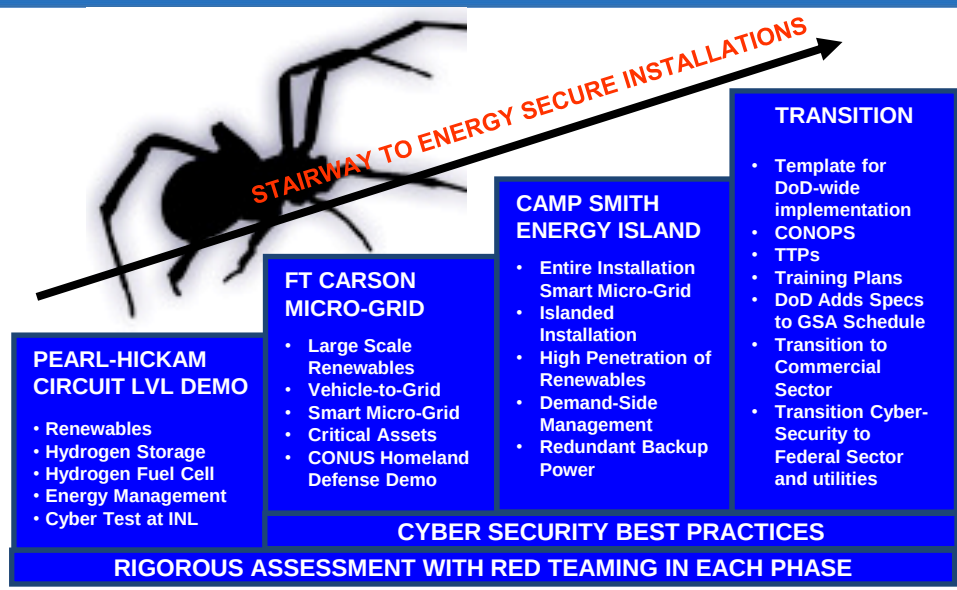
Five 2.3 kW wind turbines

1.2 MW rooftop solar photovoltaic system

SPIDERS: Smart Power Infrastructure Demonstration for Energy, Reliability, and Security

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.



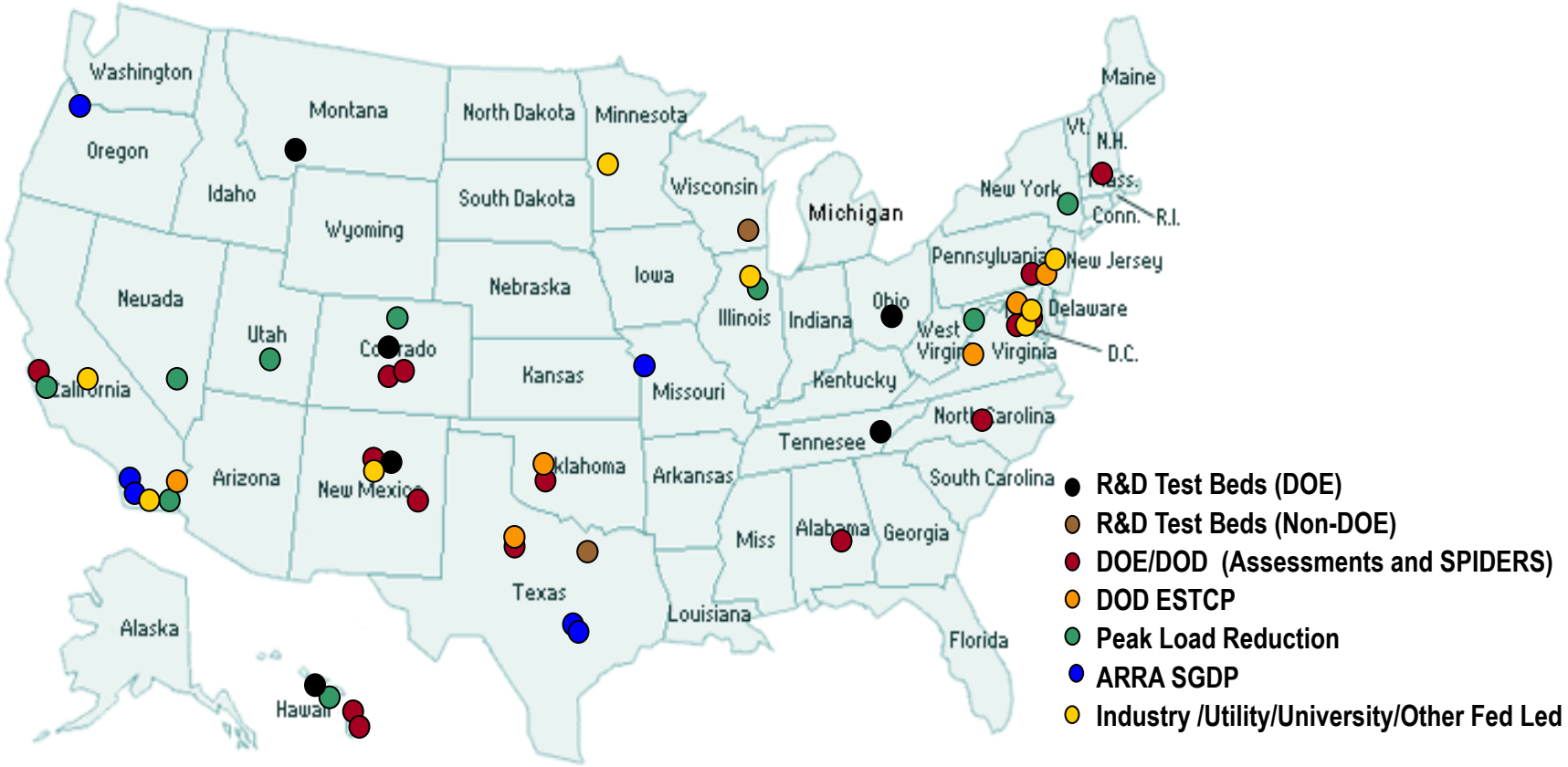
Technical Scope

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

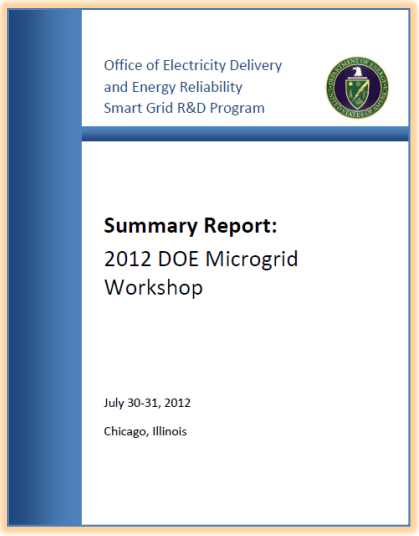
A key part of the project is the standardization of the design approach, contracting, installation, security, and operation of these microgrids to support future applications.

Current Microgrid Landscape



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



Workshop report available at http://energy.gov/oe/articles/2012-microgrid-workshop-summary-released

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

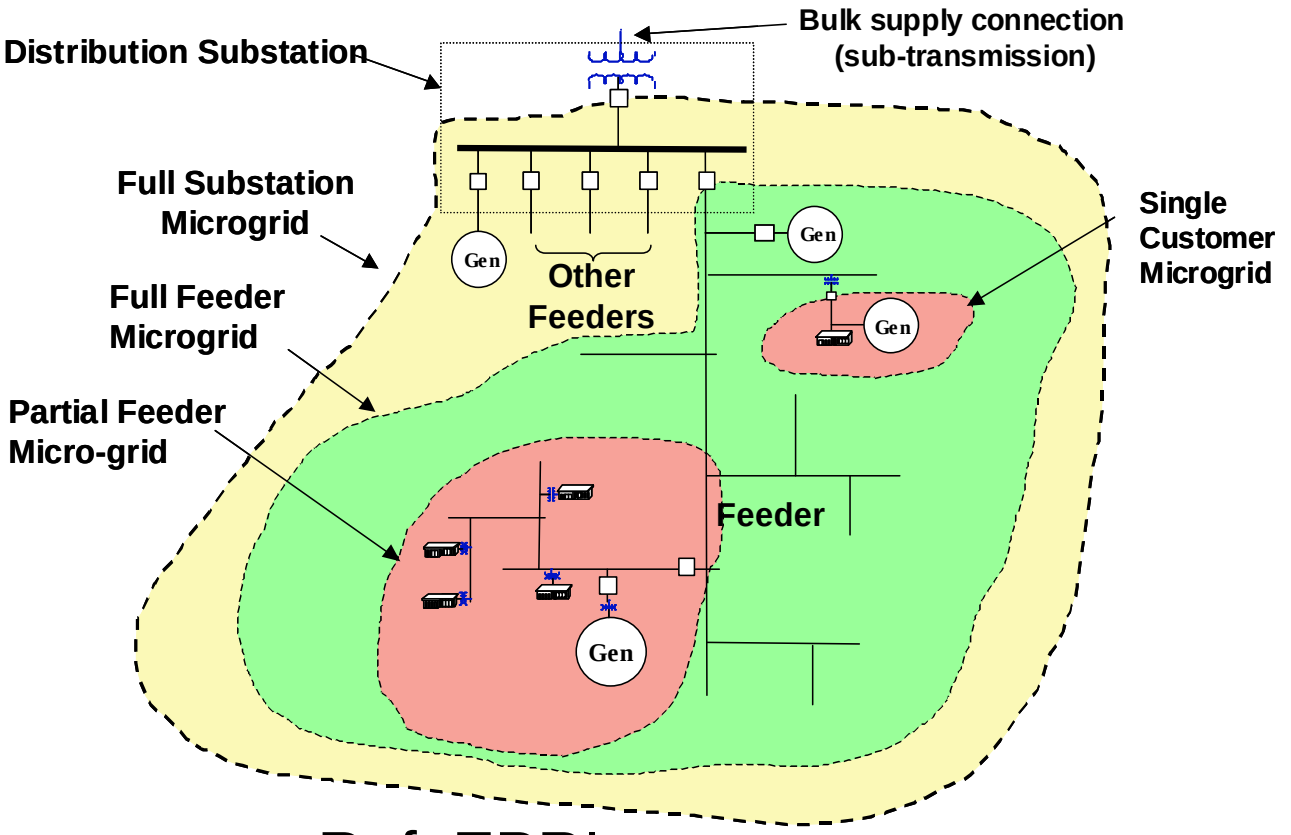
- Hospitals and Other Critical Facilities
- Universities
- Municipalities
- Military Installations

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



Ref. EPRI

Residential	Less than 10-kW, single-phase
Small Commercial	From 10-kW to 50-kW, typically three-phase
Commercial	Greater than 50-kW up to 10MW

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

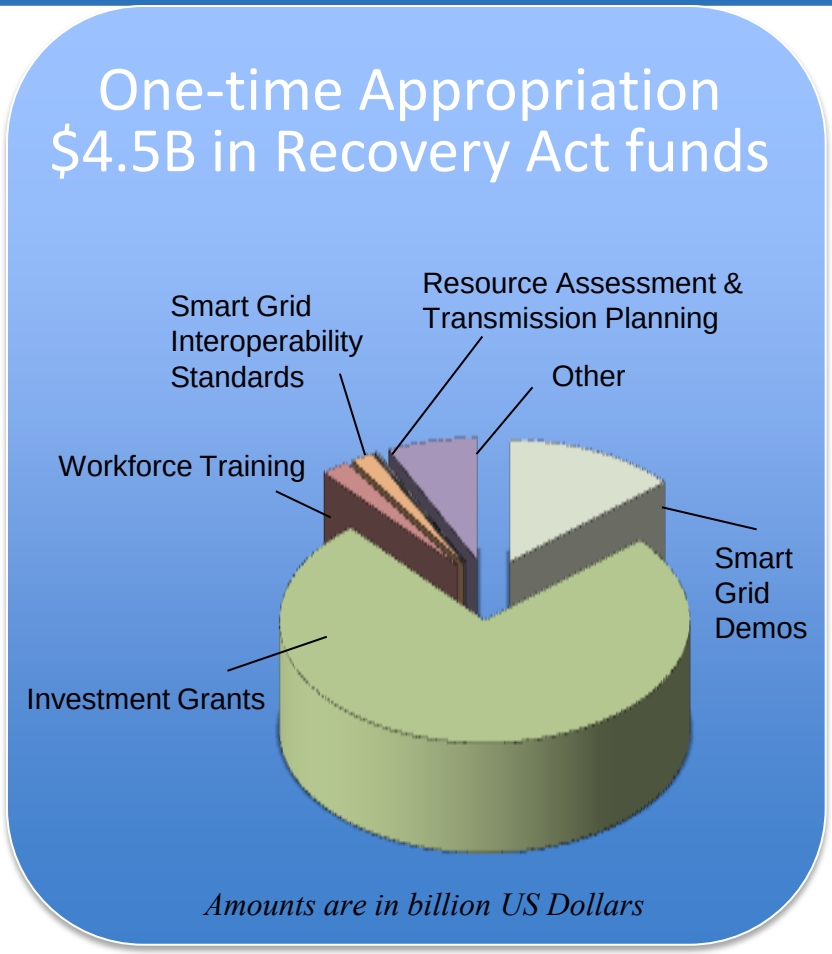
Programs created by statute:

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



Source: www.smartgrid.gov

**Originally authorized by the Energy Infrastructure Security Act 2007, EISA 1306 and EISA 1304*

Catalytic Effect of the Recovery Act

Significant deployment of Smart Grid assets leading to:

- **Additional 10% of the population being served by smart meters**
  - **However, a small percentage will have enabling technology and access to dynamic pricing**
- **Additional 5% of distribution circuits being upgraded with sensors and smart switches**
  - **However, few are achieving the level of automation required in sophisticated circuits**
- **Over 1,000 networked phasor measurement units installed (compared to 166 in 2010)**
  - **However, several years required to apply synchrophasor measurements into operations**

Improvements in grid performance:

- **Reduction in peak demand**
- **Operations and maintenance (O&M) cost reductions**
- **Reliability improvements in transmission and distribution (T&D) systems**
- **System efficiency improvements (both T&D)**
- **Possible greenhouse gas reductions**

Generation of data that will:

- **Lead to an enhanced understanding of consumer behavior with respect to dynamic prices and enabling AMI technologies**
- **Demonstrate the technical and cost performance of smart grid and energy storage technologies**

Interoperability and cyber security standards development

Workforce development

Initiation of integrated planning and analysis efforts with States across the US

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				
Customer Systems	**Advance Metering Infrastructure**	**Electric Distribution Systems**	**Electric Transmission Systems**	**Equipment Manufacturing**
				
• Displays • Portals • Energy management • Direct load controls	• Smart meters • Data management • Back office integration	• Switches • Feeder optimization • Equipment monitoring • Energy storage	• Wide area monitoring and visualization • Synchrophasor technology • Energy storage	• Energy devices • Software • Appliances

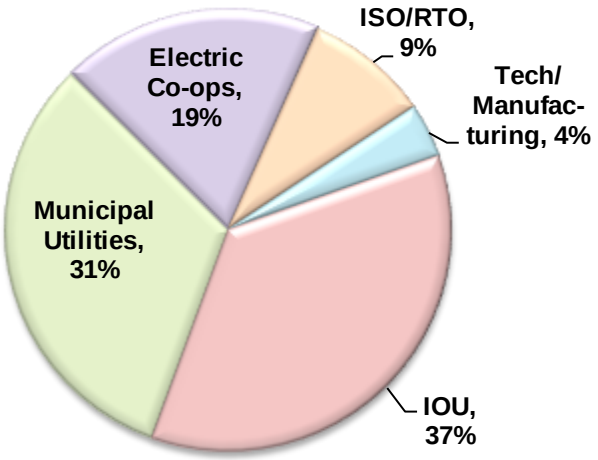
Smart Grid Investment Grant (SGIG)

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



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