U.S. DOE Microgrid Initiative Overview

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The U.S. Interconnected Electric Grid

U.S. Figures

22% of world consumption

3,200 electric utility companies
17,000 power plants
800 gigawatt peak demand
165,000 miles of high-voltage lines
6 million miles of distribution lines
140 million meters
$1 trillion in assets
$350 billion annual revenues
## Defining Microgrids

<table>
<thead>
<tr>
<th>Microgrid Definition</th>
<th>Key Attributes</th>
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<tbody>
<tr>
<td>A microgrid is a group of interconnected loads and distributed energy resources</td>
<td>1. Grouping interconnected loads and distributed energy resources</td>
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<tr>
<td>within clearly defined electrical boundaries that acts as a single controllable</td>
<td>2. Can operate in both island mode or grid-connected</td>
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<tr>
<td>entity with respect to the grid. A microgrid can connect and disconnect from the</td>
<td>3. Can connect and disconnect from the grid</td>
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<td>grid to enable it to operate in both grid-connected or island-mode.</td>
<td>4. Acts as a single controllable entity to the grid</td>
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Microgrids: Integral Part of a Smart Grid

SMART GRID
A vision for the future — a network of integrated microgrids that can monitor and heal itself.

- **Smart appliances**: Can shut off in response to frequency fluctuations.
- **Demand management**: Use can be shifted to off-peak times to save money.
- **Sensors**: Detect fluctuations and disturbances, and can signal for areas to be isolated.
- **Generators**: Energy from small generators and solar panels can reduce overall demand on the grid.
- **Processors**: Execute special protection schemes in microseconds.
- **Storage**: Energy generated at off-peak times could be stored in batteries for later use.

Picture courtesy of: Smart Grid 2030
Enhancing Security and Reliability Through the Use of Microgrids

DOE’s Goal: lead national efforts to modernize the electric grid, enhance security and reliability of the energy infrastructure, and facilitate recovery from disruptions to energy supply.

### Grid Modernization

<table>
<thead>
<tr>
<th>Attributes</th>
<th>DOE Goals</th>
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<tbody>
<tr>
<td>Energy Efficiency</td>
<td>Increase efficiency of the electric delivery system through reduced energy losses.</td>
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<tr>
<td>System Efficiency</td>
<td>Reduce peak price and price volatility of electricity, increased asset utilization and provide accessibility to a variety of fuel sources.</td>
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<tr>
<td>Reliability</td>
<td>Strengthen grid stability and reduce the frequency and duration of operational disturbances.</td>
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<tr>
<td>Security</td>
<td>The energy infrastructure is hardened to detect, prevent and mitigate external disruptions to the energy sector.</td>
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### Microgrid Enhanced Distribution

- Ease of CHP application
- Supports increase of renewables—firms intermittent resources
- Arbitrage of energy price differentials
- Enhance G&T by use of plug-and-play DER for peak shaving
- Enhance reliability with international islanding
- High local reliability
- Energy during outages
Microgrid RD&D

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

**FY 2013 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 (SPIEDERS)
- 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 essential loads by >98%
   - Cost comparable to non-integrated baseline solutions (UPS + diesel genset)
   - Reduce emissions by >20%
   - Improve system energy efficiencies by >20%

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

<table>
<thead>
<tr>
<th>Type</th>
<th>Power Range</th>
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<tr>
<td>Residential</td>
<td>Less than 10-kW, single-phase</td>
</tr>
<tr>
<td>Small Commercial</td>
<td>From 10-kW to 50-kW, typically three-phase</td>
</tr>
<tr>
<td>Commercial</td>
<td>Greater than 50-kW up to 10MW</td>
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Ref. EPRI
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.
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 were awarded in 2008 and spent 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!
DOE Awards $8 Million for Microgrids

• On September 8, 2014, in support of President Obama's Climate Action Plan and the Administration’s commitment to improve national power grid resiliency, today the Energy Department announced more than $8 million for 7 microgrid projects to help cities and towns better prepare for extreme weather events and other potential electricity disruptions.

• Each project received approximately $1.2 million and also includes a company cost share ranging from 20 percent to about 50 percent.
DOE 2014 Microgrid Projects (1)

- **ALSTOM Grid, Inc.**
  Located in Redmond, Washington, ALSTOM Grid will research and design community microgrid systems for the Philadelphia Industrial Development Corporation and the Philadelphia Water Department.

- **Burr Energy, LLC**
  Headquartered in Little Falls, Minnesota, Burr Energy will design and build a resilient microgrid to allow the Olney, Maryland Town Center to function normally as a “lights-on” district for weeks in the event of a regional outage. A second microgrid will be designed for multi-use commercial development in nearby Prince George’s County, Maryland.

- **Commonwealth Edison Company (ComEd)**
  Headquartered in Chicago, ComEd will develop and test a commercial-grade microgrid controller capable of controlling a system of two or more interconnected microgrids.
DOE 2014 Microgrid Projects (2)

- **Electric Power Research Institute (EPRI)**
  Located in Knoxville, Tennessee, EPRI will develop a commercially-viable standardized microgrid controller that can allow a community to provide continuous power for critical loads.

- **General Electric Company (GE)**
  Based in Niskayuna, New York, GE Global Research will develop an enhanced microgrid control system by adding new capabilities, such as frequency regulation.

- **TDX Power, Inc.**
  Headquartered in Anchorage, Alaska, TDX will engineer, design, simulate, and build a microgrid control system on Saint Paul Island, an island located in the Bering Sea hundreds of miles from mainland Alaska.

- **The University of California, Irvine (UCI)**
  The Advanced Power and Energy Program at UCI will develop and test a generic microgrid controller intended to be readily adapted to manage a range of microgrid systems.
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.

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

- Two 1.2 MW backup diesel generators
- Distributed Energy Resources Management System (DERMS)
- 2 MW advanced energy storage system
- 1 MW fuel cell
- 1.2 MW rooftop solar photovoltaic system
- Five 2.3 kW wind turbines
- PG&E utility interconnection or “Point of Common Coupling” and static disconnect switch

Commercial Application of a CERTS Microgrid at Santa Rita Jail
Commercial Application at the White Oak Federal Center in Maryland*

- 55 MW of generation (gas turbines, steam turbines, IC engine, back start diesel generator)
- 25 KW fixed and 5 KW tracking PV arrays
- Absorption chillers and waste heat boilers
- 2 million gal. of chilled water thermal storage

Microgrids for Energy Surety: 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 standardization of the design approach, contracting, installation, security, and operation of these microgrids to support future applications.
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

National lab R&D focusing on addressing priorities of workshop findings

- Use case development to define performance requirements and technology specifications
- Cost and benefit analysis to ID high-impact R&D for investments
- Standardized design tools for decision-support analysis
- Integrated controller with μSCADA/μEMS functionalities

Microgrids: Supporting Communities in Preparing for Climate Impacts

### Short-term
- Partner with States (CT, NY, NJ) to deploy microgrids for rebuilding electric infrastructure by providing technical assistance and advanced R&D products
- Examples: partnerships with NJ on a stronger and more resilient transit system (TRANSITGRID) and on rebuilding electric grid in the Hoboken region, in the aftermath of Hurricane Sandy

### Mid-term
- Expand multi-state and regional partnerships to promote microgrids for enhanced recovery and resilience of electric grid

### Long-term
- Fully integrate a network of microgrids at customer sites and varying scales (feeders, substations) to support achieving a self healing distribution and transmission system
Microgrids: Supporting Grid Reliability and Resilience

Reduced incidents of outages

- Microgrids will provide energy surety to critical loads and will reduce outages for other loads

Enhanced reliability

- Microgrids will support faster restoration during power disturbances that cost American businesses (and all of us) billions

Reduced vulnerability

- Microgrids will enhance resiliency of electric power system against both cyber and physical threats
Microgrid Resources

- Office of Electricity Delivery and Energy Reliability

- Smart Grid
  [http://www.smartgrid.gov](http://www.smartgrid.gov)

- Sandia National Laboratory - Advanced Microgrids

- Berkley Lab (DER-CAM and International Symposium)

- Microgrid workshop results
  [http://www.e2rg.com/reports](http://www.e2rg.com/reports)
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Smart Grid: smartgrid.gov