OE Microgrid R&D Initiative

Electricity Advisory Committee
October 20, 2011

Smart Grid R&D Program Goals

Long-term Goals

Self-healing Distribution Grid
for Improved Reliability

Integration of DER/DR/PEV
for Improved System Efficiency

2020 Targets

20% SAIDI reduction in distribution outages

>98% reduction in outage time of required loads

2020 Target

20% load-factor improvement

Smart Grid Research and Development

Dollars in Thousands	
FY 2011	FY 2012 Planning
23,000	20,000

Promotes the development of an efficient, fully integrated "smart" grid through the adaptation and integration of digital information and communication technologies into the Nation's electricity delivery system.

R&D Areas Guided by MYPP* on:

- Renewable & distributed systems integration
- Microgrids
- Integration of Plug-in Electric Vehicles (PEVs)
- Modeling & Analysis
- Advanced communications & controls
- Foundational standards and best practices
- Demand response and consumer acceptance

* MYPP available at: http://www.oe.energy.gov/DocumentsandMedia/SG_MYPP.pdf

Defining Microgrids

Microgrid Definition	Key Attributes
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.	1. Grouping interconnected loads and distributed energy resources 2. Can operate in both island mode or grid-connected 3. Can connect and disconnect from the grid 4. Acts as a single controllable entity to the grid

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

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

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 Related Funding

FY 2011 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 2012-2013

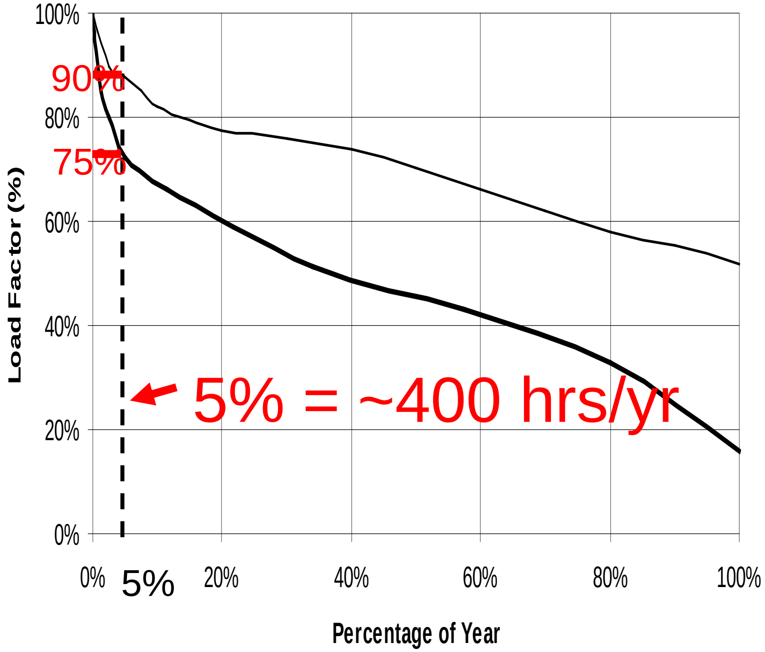
- **Microgrid Development** RD&D to reach 2020 targets on costs, reliability, system energy efficiencies, and emissions

  Industry workshop on August 30-31, 2011, to define needed research areas and activities

Renewable and Distributed Systems Integration (RDSI)

- 9 demonstration projects in 8 states to integrate use of distributed resources to provide power during peak load periods (minimum of 15% reduction in peak load on distribution feeder or substation) and for other functions/services
- 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)

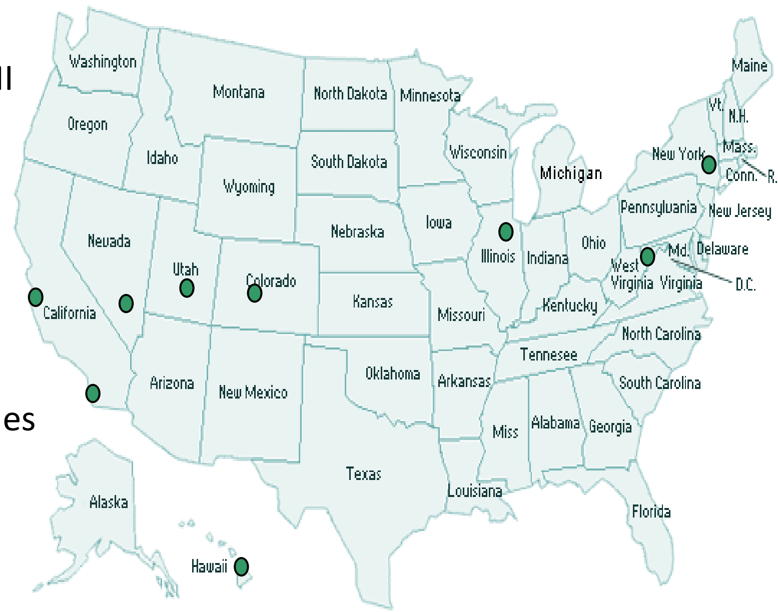
Lower Peak Demand Reduces Infrastructure Investments



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

RDSI Projects

- **Chevron Energy Solutions**—CERTS Microgrid Demo at the Santa Rita Jail - large-scale energy storage, PV, fuel cell
- **SDG&E**—Borrego Springs Microgrid - demand response, storage, outage management system, automated distribution control, AMI
- **U of HI**—Transmission Congestion Relief, Maui - intermittency management system, demand response, wind turbines, dynamic simulations modeling
- **UNLV**—“Hybrid” Homes - Dramatic Residential Demand Reduction in the Desert Southwest - PV, advanced meters, in-home dashboard, automated demand response, storage
- **ATK Space System**—Powering a Defense Company with Renewables - Hydro-turbines, compressed air storage, solar thermal, wind turbines, waste heat recovery system
- **City of Fort Collins**—Mixed Distributed Resources - PV, bio-fuel CHP, thermal storage, fuel cell, microturbines, PHEV, demand response



- **Illinois Institute of Technology**—The Perfect Power Prototype - advanced meters, intelligent system controller, gas fired generators, demand response controller, uninterruptable power supply, energy storage
- **Allegheny Power**—WV Super Circuit Demonstrating the Reliability Benefits of Dynamic Feeder Reconfiguration - biodiesel combustion engine, microturbine, PV, energy storage, advanced wireless communications, dynamic feeder reconfiguration
- **Con Ed**—Interoperability of Demand Response Resources - demand response, PHEVs, fuel cell, combustion engines, intelligent islanding, dynamic reconfiguration, and fault isolation

Role of Microgrids in Facilitating Integration of Distributed Renewable Electricity Sources

Objective

Expand CERTS Microgrid concepts to address system integration challenges presented by need to accommodate intermittent, distributed renewable electricity sources within utility distribution systems.

Technical Scope

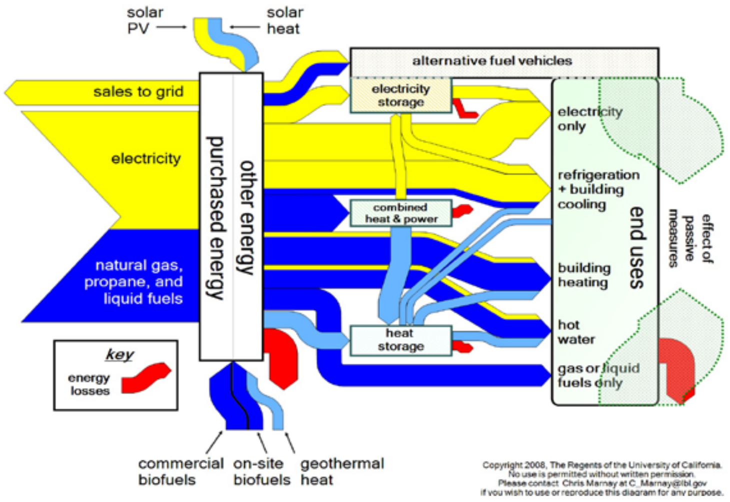
The CERTS Microgrid Test Bed is being expanded through the addition of new hardware elements: (1) a CERTS compatible conventional synchronous generator; (2) a more flexible energy management system for dispatch; (3) intelligent load shedding; (4) a commercially available, stand-alone electricity storage device with CERTS controls; and (5) a PV emulator and inverter with CERTS controls.

The concepts are explored initially through detailed simulation and bench-scale tests at UW and then demonstrated at full-scale using the CERTS Microgrid Test Bed operated by American Electric Power in Groveport, OH.

Renewable Systems Integration Modeling (DER-CAM)

Objective

- Provide algorithms, controls, software, analysis, and international exchanges that facilitate and accelerate the development and deployment of microgrids, and
- Commercialize the controls and software



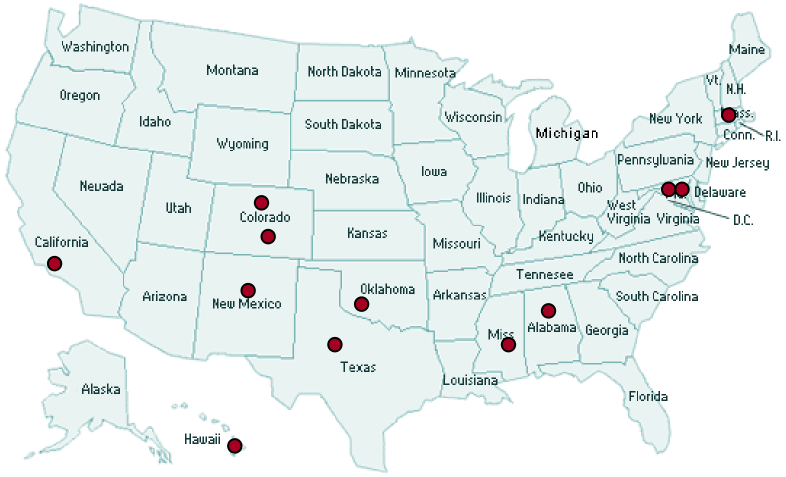
Technical Scope

– Mathematical models for controls and software for microgrids
– Web-optimization using a software as a service (SaaS)
– Consider key technologies as heat pumps, CHP, storage, electric vehicles
– Organize meetings, microgrid symposiums, international conferences, and collaborate with international researchers

Energy Surety Microgrids

Objective

- Use military bases to develop approaches for implementing high reliability microgrids because of immediate needs, interest, and funding to implement
- Use cost/performance data and lessons learned from military efforts to accelerate additional DoD and commercial implementation



12 Bases evaluated, several more in process

Technical Scope

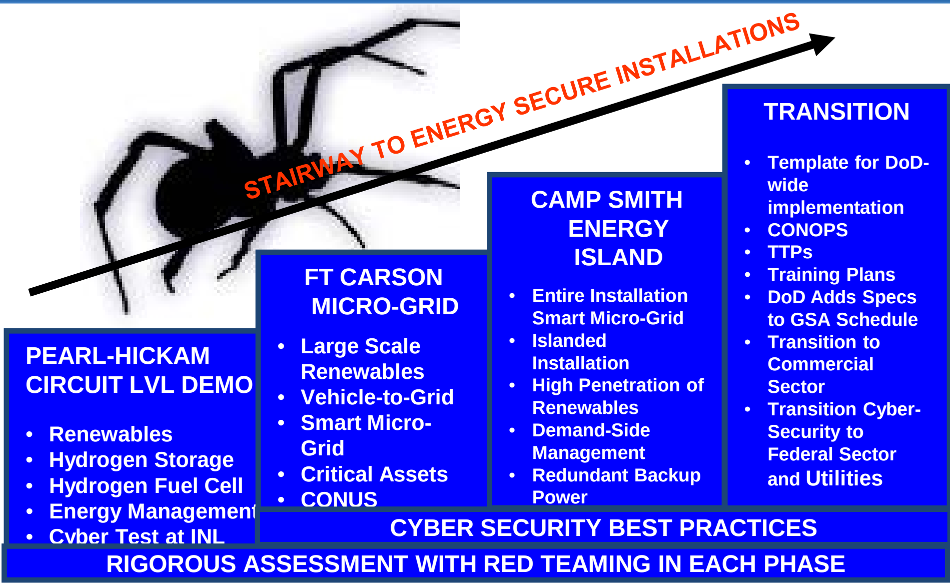
Use risk-based energy assessment to develop microgrids that:

- Can use distributed and renewable energy resources
- Will improve site energy infrastructure safety, security, and reliability
- Enhance critical mission assurance at military bases

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

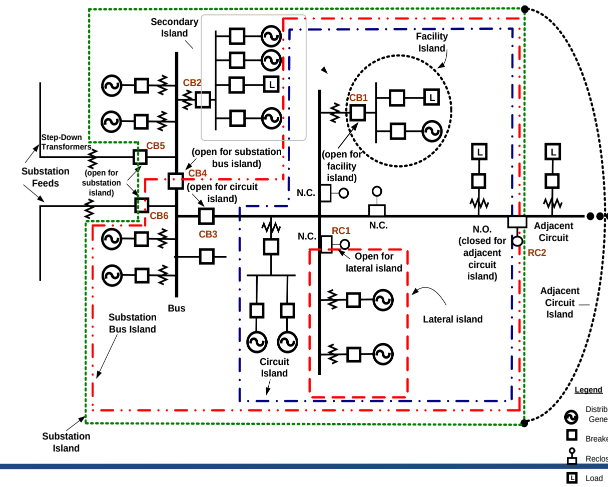
A key part of the project is the standardization of the design approach, contracting, installation, security, and operation of these microgrids to support future applications.

Smart Grid Interconnection and Interoperability Standards Development

Purpose

For use by EPS designers, operators, system integrators, and equipment manufacturers. Document is intended to provide an introduction, overview and address engineering concerns of DR island systems.

DR island Systems



Technical Scope

Design, operation, and integration of distributed resource (DR) island systems with electric power systems (EPS). Includes ability to separate from and reconnect to part of the area EPS while providing power to the islanded local EPSs.

IEEE P1547.4

"MICROGRIDS"

Guide for Design, Operation, and Integration of Distributed Resource Island Systems with Electric Power Systems

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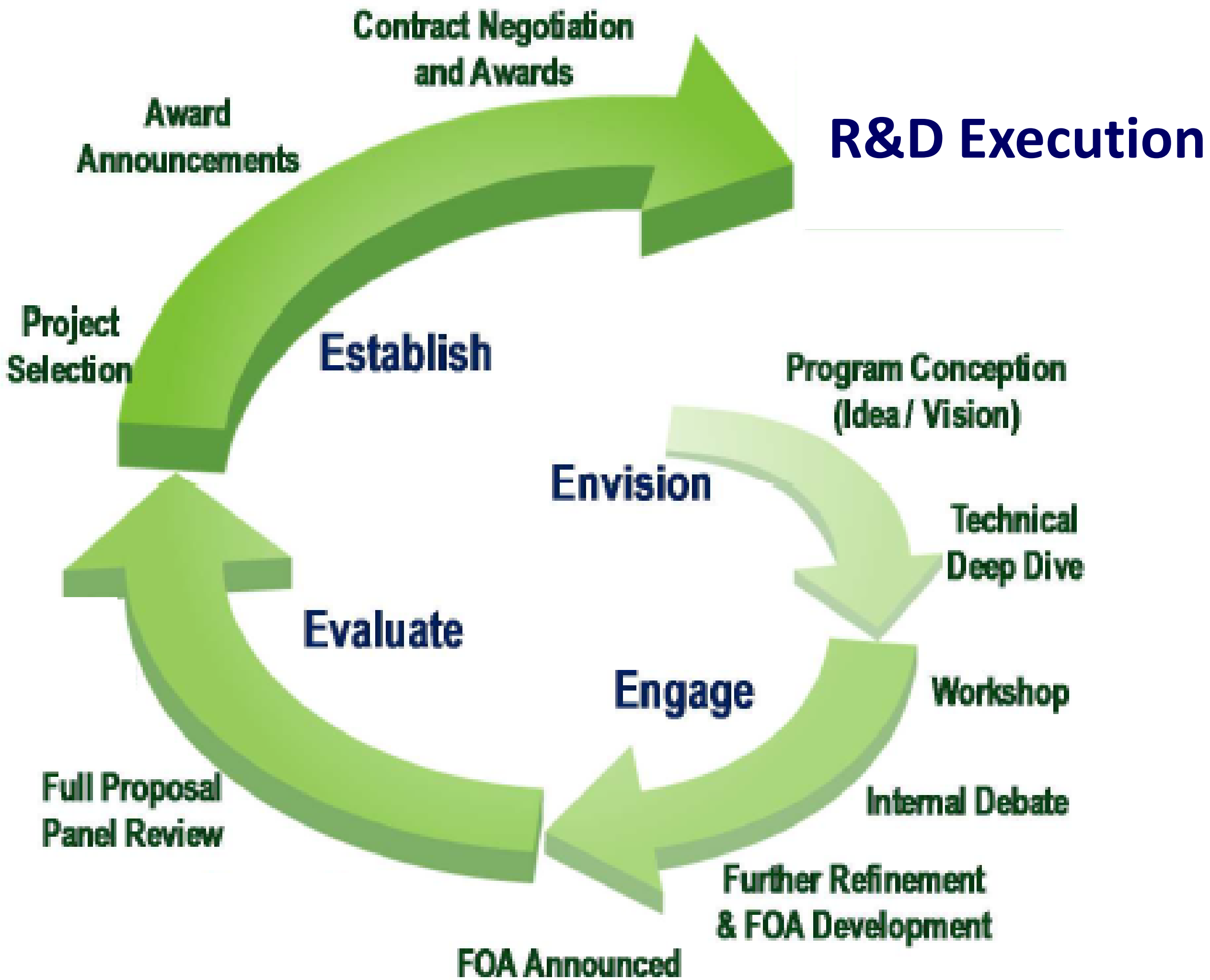
Microgrid R&D Initiative Development Process for Future microgrid research



OE's 2020 Targets for Microgrids

Measurable & Trendable Targets over Baseline Performance

Develop commercial scale* microgrid systems at a cost comparable to non-integrated baseline solutions** that are capable of

- Reducing outage time to required loads by >98%
- Reducing emissions by >20%
- Improving system energy efficiencies by >20%

* Commercial scale refers to any systems with a capacity of <10MW that meets the definition of a microgrid by the Microgrid Exchange Group

**Non-integrated baseline solutions are UPS plus diesel genset

Major Cost Components of a Microgrid

Energy Resources (30-40%)	**Switchgear Protection & Transformers** (20%)	**Smart Grid Communications & Controls** (10-20%)	**Site Engineering & Construction** (30%)	**Operations & Markets**
Energy storage; controllable loads; DG; renewable generation; CHP	**Switchgear utility interconnection** (incl. low-cost switches, interconnection study, protection schemes, and protection studies)	**Standards & protocols**; **Control & protection technologies**; Real-time signals (openADR); Local SCADA access; Power electronics (**Smart Inverters**, DC bus)	A&E (**System design and analysis**); **System integration, testing, & validation**	O&M; Market (utility) acceptance

Results--High-priority R&D Needs to be utilized as input for future funding

Impactful R&D Areas	High-priority R&D Projects
Standards and Protocols	Universal Microgrid Communications and Control Standards
	Microgrid Protection, Coordination, and Safety
Systems Design and Economic Analysis	Microgrid Multi-objective Optimization Framework
System Integration	Common Integration Framework for Cyber Security/Control/Physical Architectures
Switch Technologies	Legacy Grid-Connection Technologies to Enable Connect/Disconnect from Grid
	Requirements based on Customer and Utility Needs
Control and Protection Technologies	Best Practices and Specifications for Protection and Controls
	Reliable, Low-cost Protection
Inverters/Converters	Topologies & Control Algorithms for Multiple Inverters to Operate in a Microgrid
	Advanced Power Electronics Technologies

Microgrid Resources

- Office of Electricity Delivery and Energy Reliability
  http://www.oe.energy.gov
- Smart Grid
  http://www.smartgrid.gov
- Sandia National Laboratory – Energy Systems
  http://www.sandia.gov/ERN/fuel-water/index.html
- Berkley Lab (DER-CAM and International Symposium)
  http://der.lbl.gov/
- Microgrid workshop results
  http://www.e2rg.com/reports