U.S. Department of Energy

Office of Electricity Delivery and Energy Reliability

2010 Vancouver Symposium on Microgrids

U.S. Department of Energy's Research & Development Activities on Microgrid Technologies

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Defining Microgrids

Microgrid Definition	What a microgrid is NOT
• A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources, which as an integrated system, can operate in parallel with the grid or in an intentional island mode.	• One form of technology (e.g. a microturbine in a commercial building) – this is distributed generation • A group of individual generation sources that are not coordinated

Source: Navigant Consulting Inc. Final Report Microgrids Research Assessment for the US Department of Energy's Office of Electricity Delivery and Energy Reliability and the California Energy Commission's Public Interest Energy Research Program, May 2006

Evolving Definition

- Newly developed definitions will be presented.

Microgrids Enhance Security and Reliability of the Distribution Infrastructure

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 Intentional islanding***
- ***High Local Reliability***
- ***Energy during outages***

Microgrid Research and Development Test Beds

CERTS Microgrid – Test Bed

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 PV emulator and inverter; 2) a more flexible energy management system for dispatch; 3) a commercially available, stand-alone electricity storage device with CERTS controls; 4) a CERTS compatible conventional synchronous generator.

Design Characteristics

Designed for high reliability

- Insures redundancy: n + 1 sources.
- Based on autonomous local control for fast events (No central controller)
- Maximizes flexibility: uses plug-and-play peer-to-peer models; no custom engineering

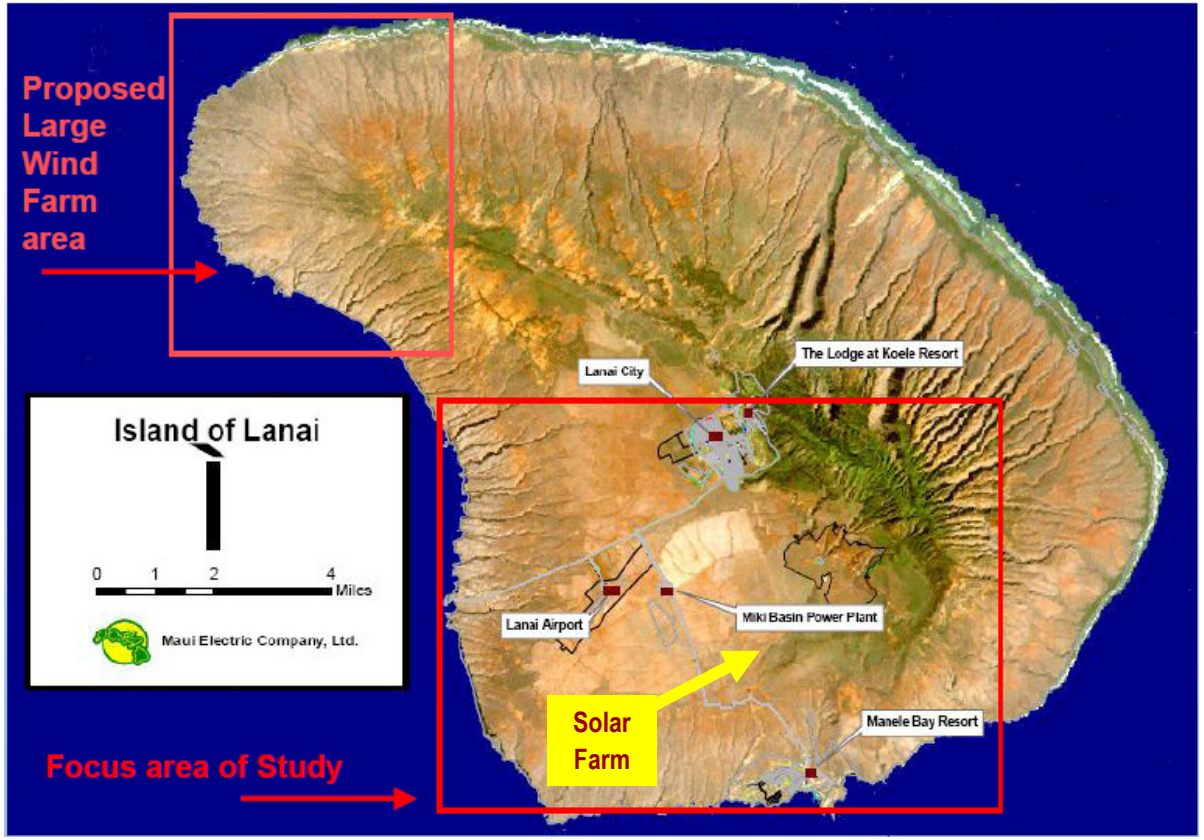
Promotes intentional islanding

- Insures stability for multi-sourced systems.
- Seamlessly separates and automatically resynchronizes with the grid.

Hawaii Clean Energy Initiative

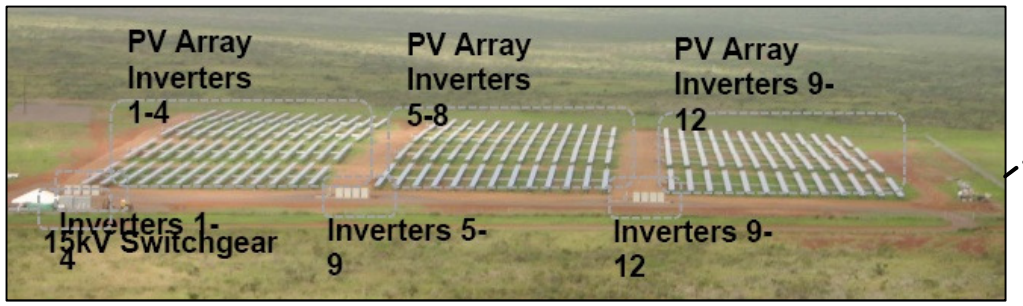
- Goal: Hawaii will supply 70% of its energy needs with clean energy by 2030
- Activities in Hawaii Will Demonstrate Impacts of High Renewable Penetration and Can be Applied to the Mainland
- Strategic Projects will help overcome technical barriers and drive State policy

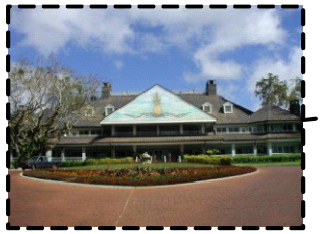
Example HCEI Project
Island of Lanai



Lana'i Grid

- Solar Array
  - Twelve 125kW SunPower Arrays
- Satcon Inverters
  - Twelve Gen1 135kW
  - IEEE 1547 range extended
  - Curtailment Control
- CHP Unit
- Energy Storage (Planned)
  - GNB Absolyte 1400 Ah Cells
  - 405kW; 750 kWh





Koehle Lodge

Well Pumps

Lanai City

Harbor

Airport

Miko Power Plant (10.4 MW)

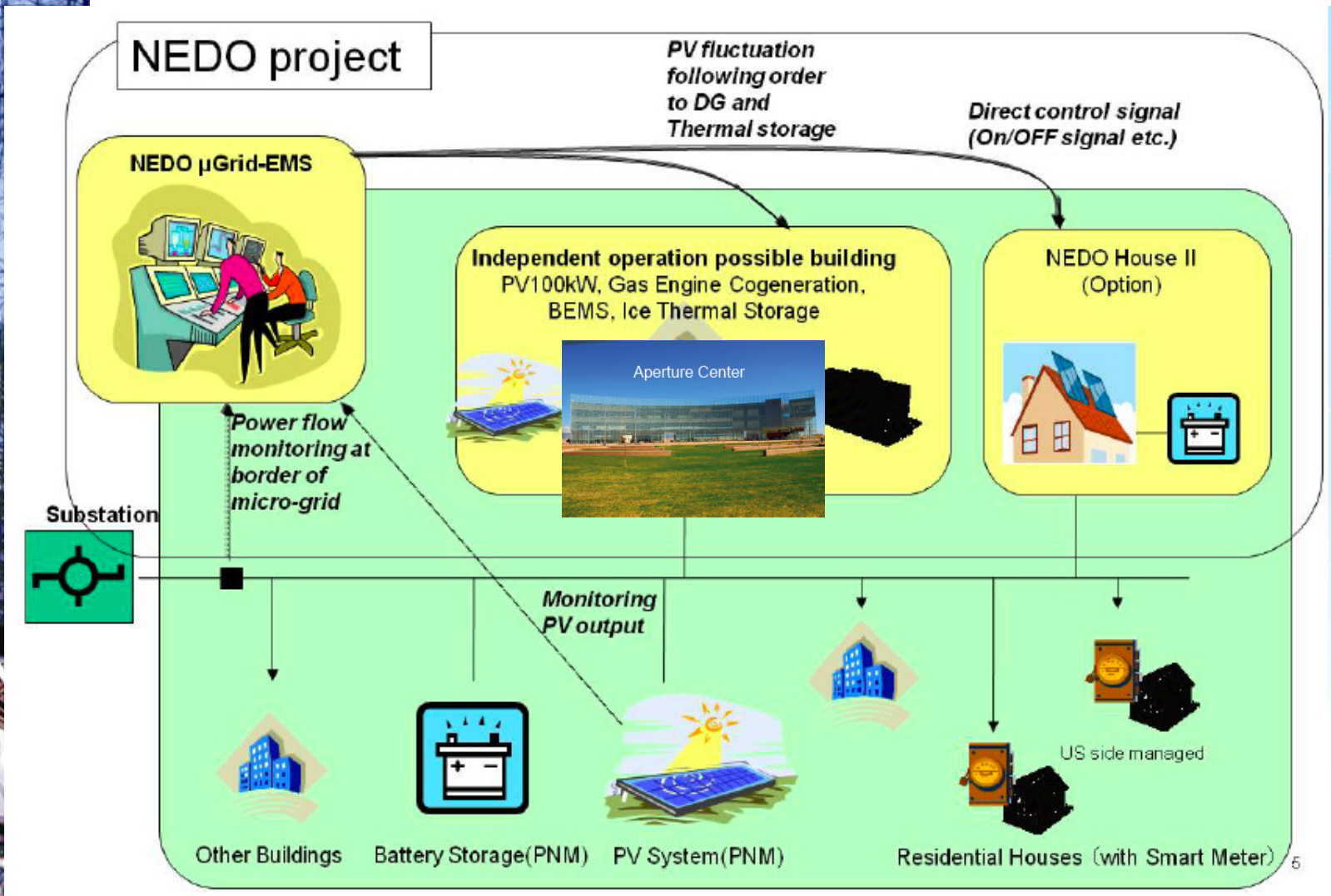
PV Plant (1.2 MW)

Proposed Battery

CHP Unit

Manele Hotel

International Team Demonstrating Microgrids with Renewables in New Mexico



Distributed Energy Controls and Communication Laboratory

OAK RIDGE National Laboratory

DECC is a unique R&D facility for testing reactive power producing distributed energy resources

- Develop, Simulate ,and Test Adaptive Controls
  - Develop adaptive controls for inverter-based distributed energy when there are multiple inverters on the same feeder.
  - Expand adaptive controls for a single inverter-based DE
- Air Conditioning Motor Stall Dynamic Study
  - Explore impact of high penetration high seasonal energy efficiency ratio (SEER) A/C units on power systems during sub-transmission faults
  - Assess impact of A/C stall on the distribution and transmission system
- Catalina Island Dynamic Study
  - Develop a dynamic model of the Catalina Island power system for studying the impacts of a high penetration of renewable energy (RE) resources and the benefits of adaptive inverter controls.
  - Show the interaction between the inverters, generators and loads as frequency and voltage change
  - Simulate the dynamic response of inverters and generators to provide real power and reactive power support, and simulate responsive loads.
  - The study will identify applicable engineering guidelines for high renewables penetration on the bulk power system.

Microgrid Research and Development Test Beds

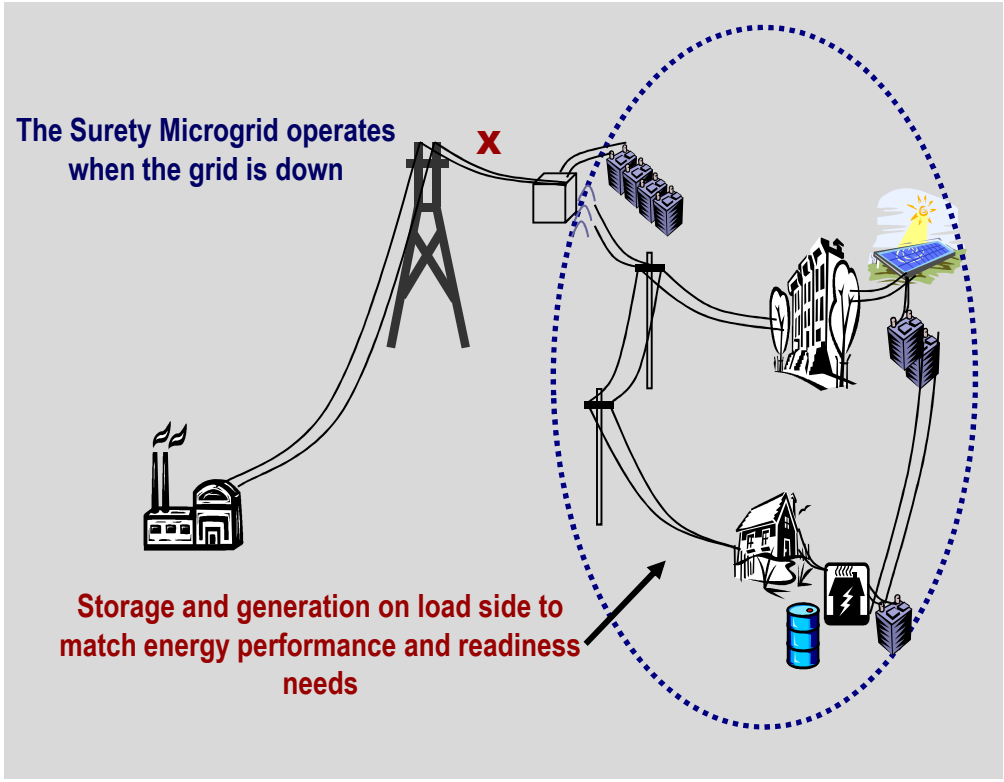
Energy Surety MicroGrids

- DOE and DOD jointly fund Sandia National Laboratory to work with military bases to develop energy surety microgrid conceptual designs
  - Electric Power Reliability Impacts Mission Performance
  - Microgrids can improve mission readiness and alleviate disruptions
- Approach and Benefits

– Identify base energy infrastructure changes to increase energy supply reliability to support base critical mission readiness

– Supports base energy security by improving utilization of on-site distributed generation resources and supports integration of renewables

– Document ESM Lessons Learned to benefit others



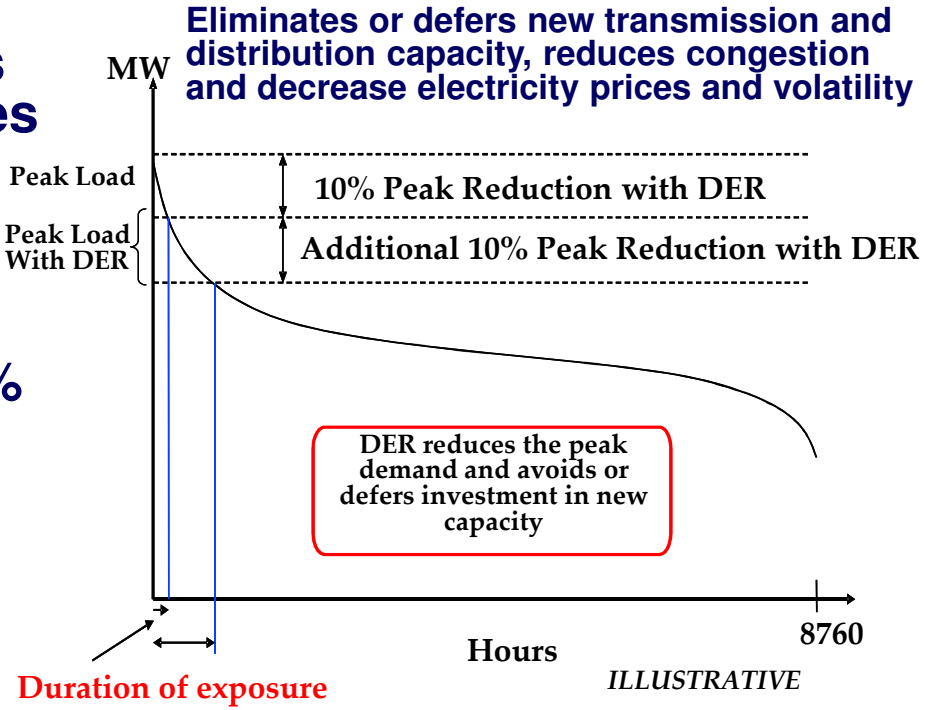
Energy Surety Microgrid Projects

- Army
  - Ft Sill*, Ft. Bliss, Ft. Belvoir*, Ft. Devens*, Ft. Carson
  - IMCOM exploring two additional sites
- Navy/Marines
  - Indian Head*, Camp Smith
  - Guam/Okinawa* in consideration
- Air Force
  - Maxwell AFB*, Kirtland AFB*, Schriever AFB, Vandenberg AFB
- PACOM/NORTHCOM proposing SPIDERS JCTD in Hawaii and Colorado

▪* Indicates OE/DoD Funded
▪All others FEMP funded

Peak Load Reduction Microgrid Projects

- Projects are either microgrids or are developing technologies that will advance microgrids
- Objective: To encourage 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 and services
- 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)



Benefits

- ✓Increases grid reliability
- ✓Addresses vulnerability of critical infrastructure
- ✓Helps manage peak loads and defers T&D investment
- ✓Lowers emissions and utilizes fuel resources more efficiently
- ✓Helps customers manage energy costs

Peak Load Reduction Microgrid Projects

- **Chevron Energy Solutions**—CERTS Microgrid Demo at the Santa Rita Jail - large-scale energy storage, PV, fuel cell
- **SDG&E**—Beach Cities 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
- **ConEd**—Interoperability of Demand Response Resources - demand response, PHEVs, fuel cell, combustion engines, intelligent islanding, dynamic reconfiguration, and fault isolation

ARRA
Smart Grid Demonstration Program

- 32 projects/$620 million to demonstrate advanced Smart Grid technologies and integrated systems that will help build a smarter, more efficient, more resilient electrical grid

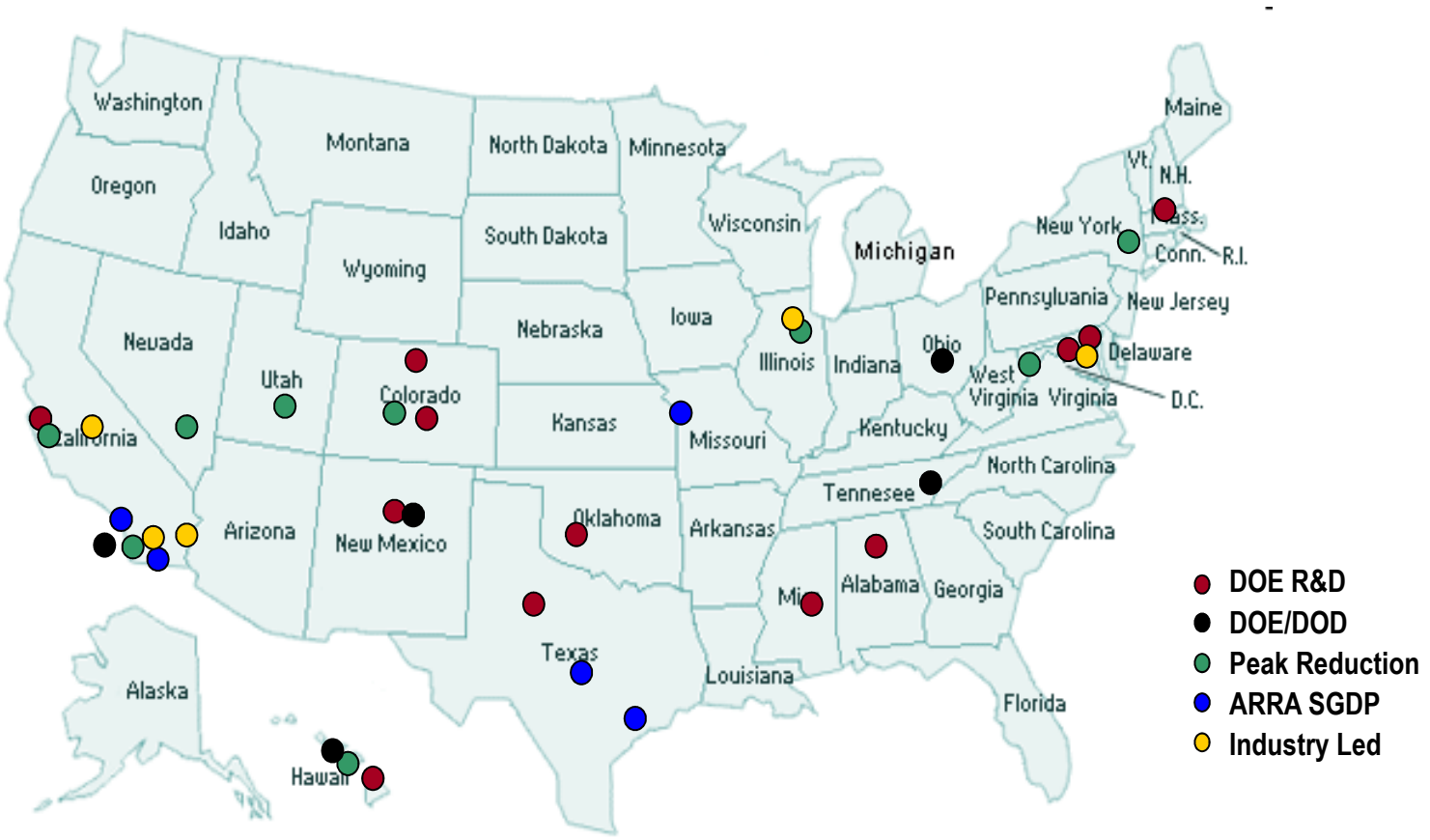
- Projects include large-scale energy storage, smart meters, distribution and transmission system monitoring devices, and a range of other smart technologies, and will act as models for deploying integrated Smart Grid systems on a broader scale

- These demonstration projects will further our knowledge and understanding of what works best and delivers the best results for the Smart Grid

ARRA Smart Grid Demonstration Projects Microgrid Technologies

- **Los Angeles Dept of Water and Power**—Fully integrated SG – demand response, consumer energy use data/behavioral studies, PHEV
- **Kansas City Power and Light**—Green Impact Zone – urban end to end SG, roof-top solar, storage, EV charging, distribution automation, customer programs and energy management interfaces
- **Pecan Street Project**—Brownfield redevelopment – mixed use development with green building initiatives, EV charging and V-2-G, PV, customer energy management, distribution optimization
- **Center for Commercialization of Electric Technologies**—Technology Solutions for Wind Integration and Texas Future Community – community energy storage, demand response programs, load interruptible appliances smart meters, residential PV, green building standards, EV charging
- **Southern California Edison**—Irvine Smart Grid Demo – end to end SG from transmission to customer devices, looped distribution topology, societal/environmental efficiencies

Current Microgrid Landscape

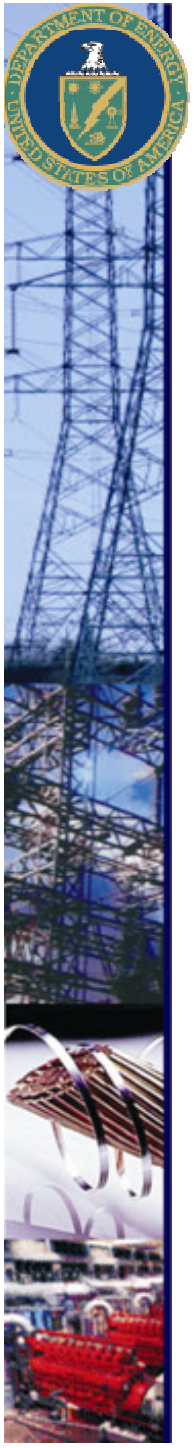


Federal programs, institutions, and the private sector are increasing microgrid development and deployment. The number of successfully deployed microgrids will verify the benefits and decrease implementation risks further expanding the market for microgrids.

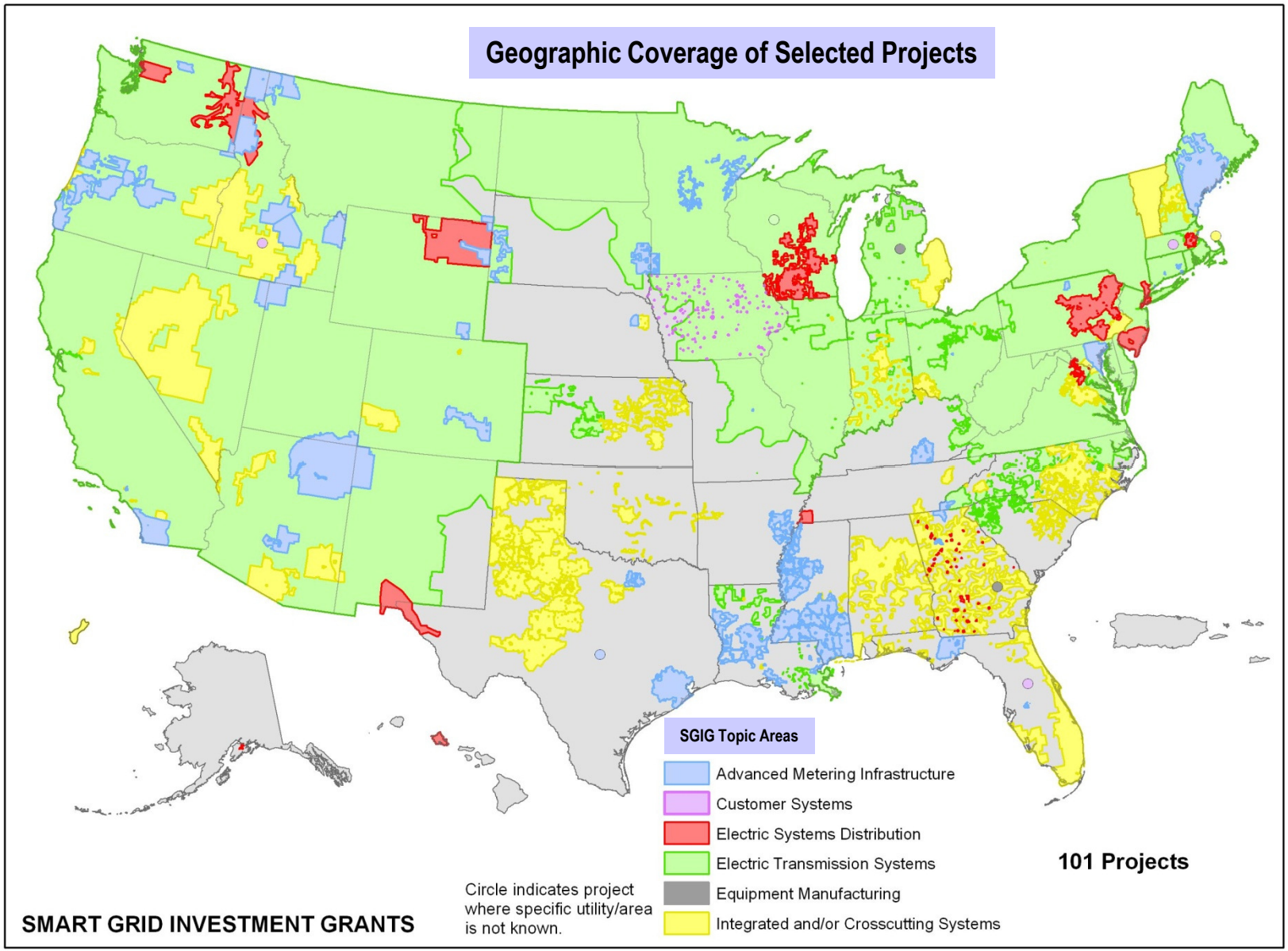
ARRA: Smart Grid Investment Grants

(100 projects: $3.4B Federal; $4.7B non-Federal)

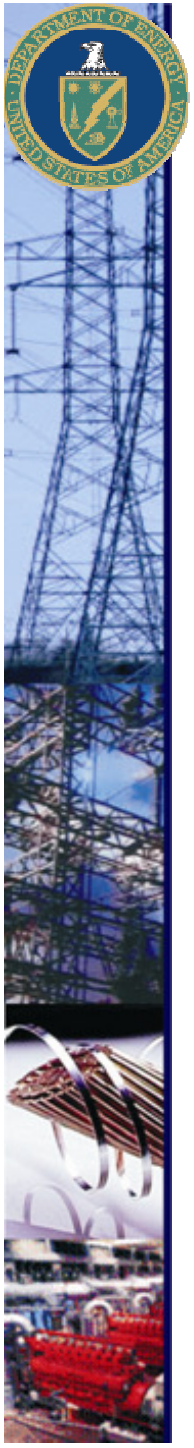
Smart Grid Systems and Equipment	Numbers of Units (self-reported estimates)	Improvements	Impacts
Networked Phasor Measurement Units	877	• *Near-nationwide coverage* • *6X the 166 existing networked PMUs*	***Enhanced situational awareness and electric system reliability and resiliency***
Smart Transformers	205,983	• *Enables preventative maintenance*	
Automated Substations	671	• *5% of 12,466 transmission and distribution substations in U.S.*	
Load Control Devices	176,814	• *Enables peak demand reductions*	***1444 MWs of peak demand reduction per year*** (self-reported estimates)
Smart Thermostats	170,218	• *Enables peak demand reductions*	
Smart Meters	18,179,912	• *13% of the 142 million customers in the U.S.*	***Transformational changes in consumer behavior and energy consumption***
In-Home Display Units	1,183, 265	• *Enables customer empowerment*	
PHEVs / Charging Stations	12 / 100	• *Accelerates market entry*	***Begins the path toward energy independence***



Geographic Coverage of Selected Projects



Oct 13, 2009



Microgrids in the News

THE HILL

Microgrids are key to future energy strategy

By Guy Warner - 05/04/10 03:17 PM ET

Business Wire
A Berkshire Hathaway Company

Microgrid Markets and Opportunities —A High Growth Element of the Emerging Smart Grid

June 10, 2010

SMART GRID NEWS.COM

Microgrids: Why Some Utilities See a Threat Where Others See Opportunity

By Peter Asmus October 29, 2009

The Washington Post

Pareto Energy to build 'microgrid' for Howard University

Monday, July 5, 2010

FAST COMPANY.COM
Where ideas and people meet

Why the Microgrid Could Be the Answer to Our Energy Crisis

By Anya Kamenetz July 1, 2009

POWER-GEN WORLDWIDE

Microgrids key to the Smart Grid's evolution

SBI Energy Report:
www.sbireports.com

TECHPULSE360
Business and Innovation in Silicon Valley

The Micro Grid As Smart Grid Of The Future, Sophisticated Software Under Development

April 13, 2010

PikeResearch
Cleantech Market Intelligence

Microgrids: Islanded Power Grids and Distributed Generation for Community, Commercial, and Institutional Applications

Report Released 4Q 2009

Information Sources

Office of Electricity Delivery and Energy Reliability Web Site
http://www.oe.energy.gov

Smart Grid Web Site
http://www.smartgrid.gov

Sandia National Laboratory – Energy Systems
http://www.sandia.gov/ERN/fuel-water/index.html