U.S. Department of Energy

Office of Electricity Delivery and Energy Reliability

2009 San Diego Symposium on Microgrids

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

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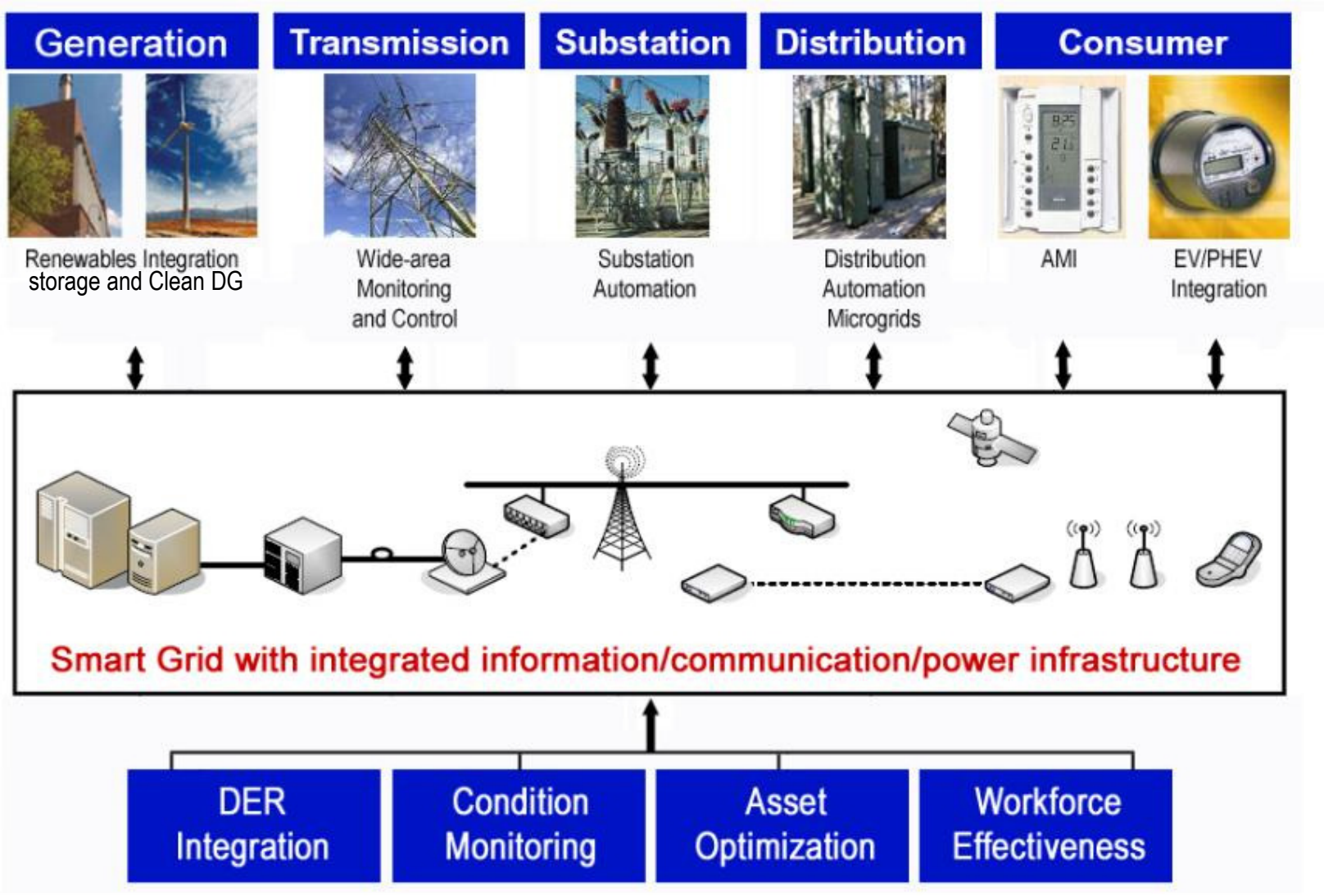
Defining the Smart Grid

SMART GRID -- integrating advances in digital and information technology into the nation's electric delivery network for enhanced operational intelligence and connectivity



Defining Microgrids

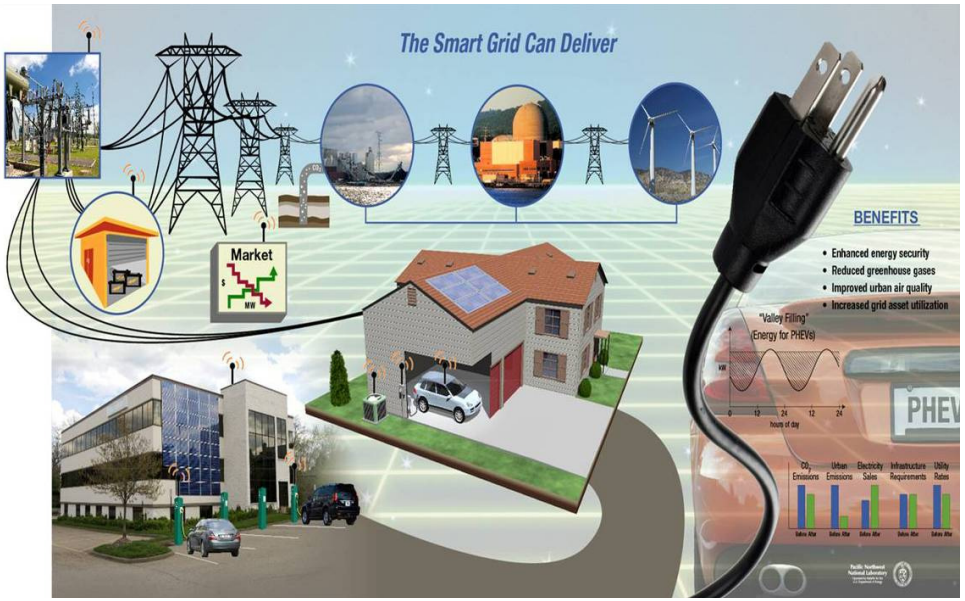
Microgrid Definition	What a microgrid is NOT
• A microgrid is an integrated energy system consisting of interconnected loads and distributed energy resources, which as an integrated system, can operate in parallel with the grid or in an intentional island mode.	• One form of technology (e.g. a microturbine 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

Microgrids Support the Seven Defining Functions of the Smart Grid

The Seven Defining Functions of the Smart Grid

- Enabling Informed Participation by Customers
- Accommodating All Generation and Storage Options
- Enabling New Products, Services, and Markets
- Providing the Power Quality for the Range of Needs in the 21st Century
- Optimizing Asset Utilization and Operating Efficiently
- Addressing Disturbances – Automated Prevention, Containment, and Restoration
- Operating Resiliently Against Physical and Cyber Attacks and Natural Disasters



Microgrids Support DOE's Goal of Grid Modernization

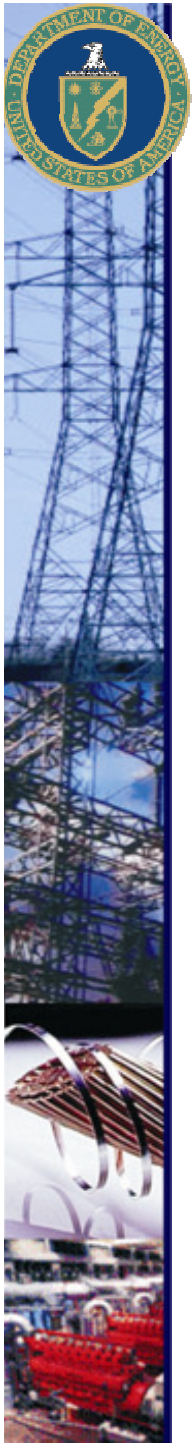
Lead national efforts to modernize the electric grid, enhance security and reliability of the energy infrastructure, and facilitate recovery from disruptions to energy supply.

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

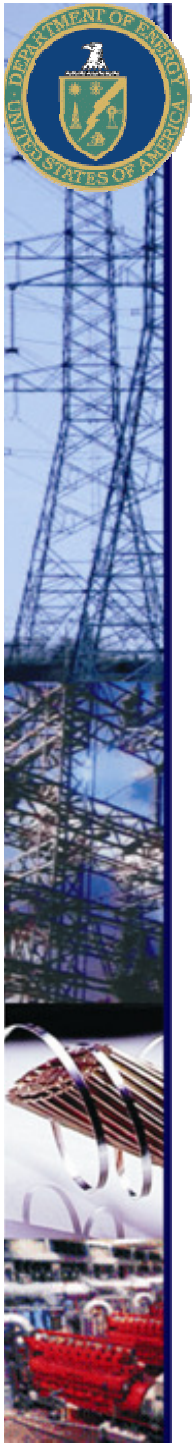
- ***Ease of CHP application***
- ***Firm intermittent resources***
- ***Arbitrage of energy price differentials***
- ***Enhance G&T by use of plug-and-play DER for peak shaving***
- ***Enhance reliability with Intentional islanding***
- ***High Local Reliability***
- ***Energy during outages***



Current Microgrid and Related Activities

- Peak Load Reduction Microgrid Projects
- Integration of Renewables
- PHEVs and Vehicle to Grid
- Hawaii Clean Energy Initiative (Microgrids with High Penetration Renewables)
- Energy Surety Microgrids (Department of Defense Microgrids for Critical infrastructure)
- Distributed Energy Controls and Communication Laboratory
- Smart Grid Metrics Development

Peak Load Reduction Microgrid Projects



Chevron Energy Solutions

What: CERTS Microgrid Demonstration

Where: Santa Rita Jail, Alameda County, California

Technologies: Microgrid technology, large-scale battery storage, photovoltaics, fuel cell, wind turbines

ATK Space Systems

What: Powering a Defense Company with Renewables

Where: Promontory, Utah

Technologies: Hydro-turbines, compressed air storage, solar thermal, wind turbines, waste heat recovery system

City of Fort Collins

What: Mixed Distributed Resources

Where: Fort Collins, Colorado

Technologies: Photovoltaics, combined heat and power, thermal storage, fuel cell, microturbines, PHEV, demand response

Illinois Institute of Technology

What: The Never-Failing Perfect Power Prototype

Where: Illinois Institute of Technology, Chicago, Illinois

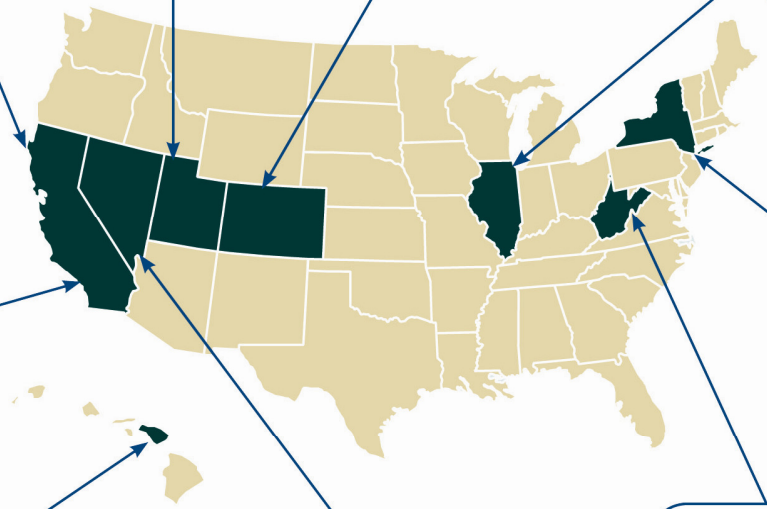
Technologies: Advanced meters, intelligent perfect power system controller, gas fired generators, demand response controller, uninterruptable power supply, energy storage

SDG&E

What: Beach Cities Microgrid

Where: San Diego, California

Technologies: Demand response, energy storage, outage management system, automated distribution control, advanced metering infrastructure



Consolidated Edison

What: Interoperability of Demand Response Resources

Where: New York City, New York

Technologies: Demand response, PHEVs, fuel cell, combustion engines, intelligent islanding, dynamic reconfiguration, fault isolation

University of Hawaii

What: Transmission Congestion Relief

Where: Maui, Hawaii

Technologies: Intermittency management system, demand response, wind turbines, dynamic simulations modeling

University of Nevada, Las Vegas

What: "Hybrid" Homes - Dramatic Residential Demand Reduction

Where: Las Vegas, Nevada

Technologies: Photovoltaics, advanced meters, in-home dashboard, automated demand response, energy storage

Allegheny Power

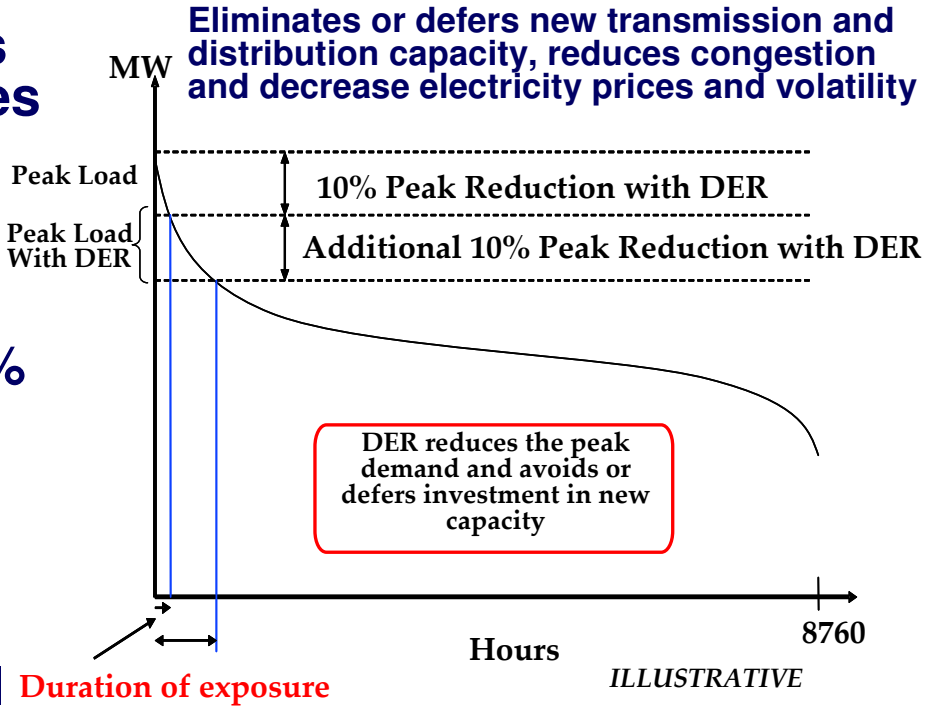
What: West Virginia Super Circuit - Dynamic Feeder Reconfiguration

Where: Morgantown, West Virginia

Technologies: Biodiesel combustion engine, microturbine, photovoltaics, energy storage, advanced wireless communications, dynamic feeder reconfiguration

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)

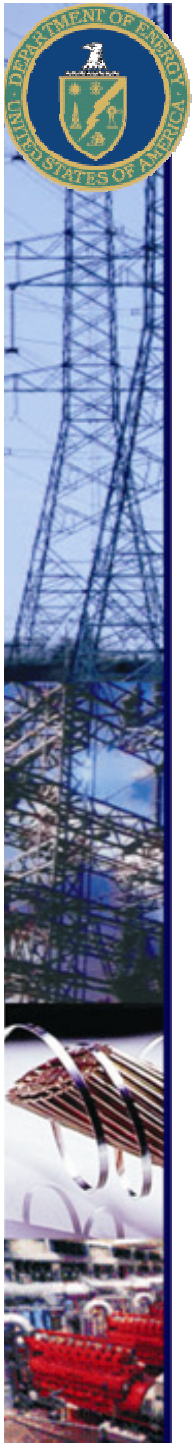


Benefits

- ✓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

Integration of Renewables

- Technology research & development – both prime movers and their integration technologies
- Helping utility planners & operators learn from their peers and national experts what changes they need to make as renewables are added
- Implementing three Energy Policy Act of 2005 mandates that can reduce transmission uncertainty
- Supporting transmission analysis under American Recovery and Reinvestment Act of 2009
- Providing best practice assistance to States that wish to change their electricity policies
- Encouraging regional coordination & thinking among States on State Electricity Policies

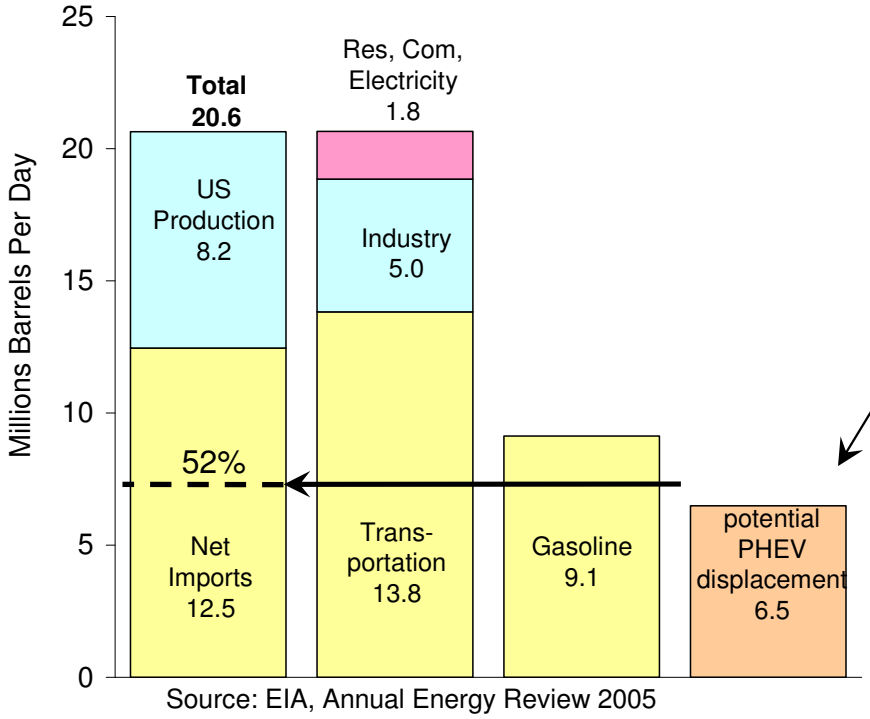


PHEVs and Vehicle to Grid

- University of Delaware: The project will pilot-test, collect, and analyze data from five V2G-enabled electric vehicles operating in a “real world” setting. The vehicles will be used daily in an existing fleet and data generated by them will be recorded and analyzed.
- Pacific Northwest National Laboratory: completed a PHEV analysis that focused on the maximal technical potential of the U.S. electric grid to support the electrification of the U.S. light duty vehicle fleet using PHEV technology.
- Pacific Northwest National Laboratory: Influence the development of transportation-based battery chargers to accommodate load leveling, mobile transportation billing, ancillary grid services, energy storage, and other anticipated needs of the evolving smart grid

Preparing for PHEVs

- **The idle capacity** of the U.S. grid **could supply 73%** of the energy needs of today's cars, SUVs, pickup trucks, and vans (158 million vehicles)…
- **without adding generation or transmission** if vehicles are charged off peak
- Smart Chargers – enabled by the Smart Grid – will help manage this new energy device to avoid any unintended consequences on the infrastructure



Source: EIA, Annual Energy Review 2005

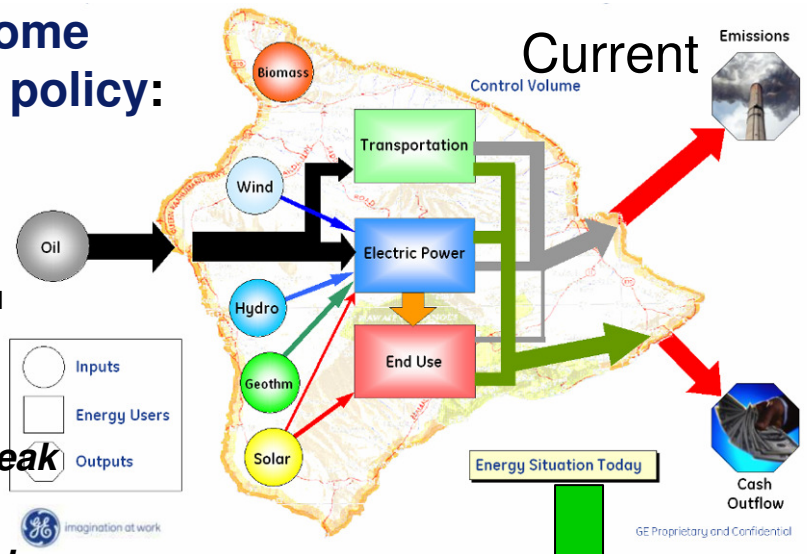
- Potential to displace 52% of net oil imports (6.7 MMbpd)
- More sales + same infrastructure = downward pressure on rates
- Reduces CO_2 emissions by 27%
- Emissions move from tailpipes to smokestacks (and base load plants) … cheaper to clean up
- Introduces vast electricity storage potential for the grid

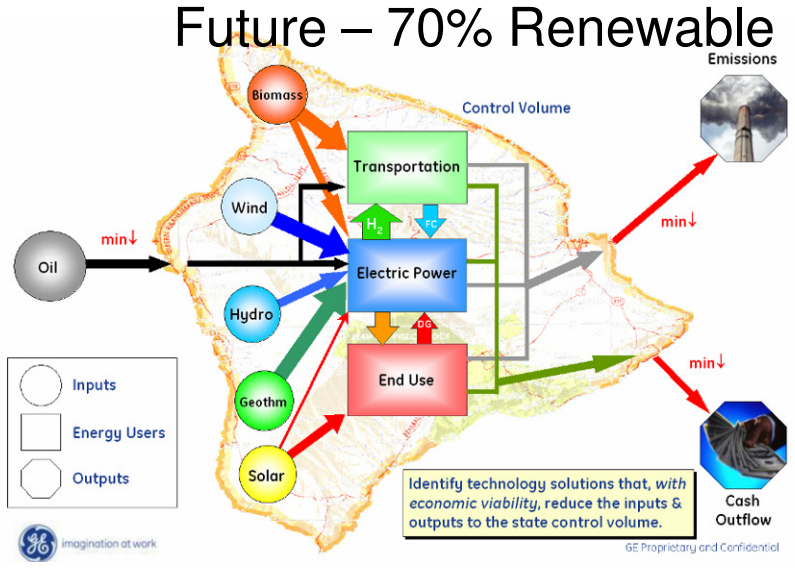
Activities in Hawaii Will Demonstrate Impacts of High Renewable Penetration and Can be Applied to the Mainland

Goal: Hawaii will supply 70% of its energy needs with clean energy by 2030

Strategic Projects will help overcome technical barriers and drive State policy:

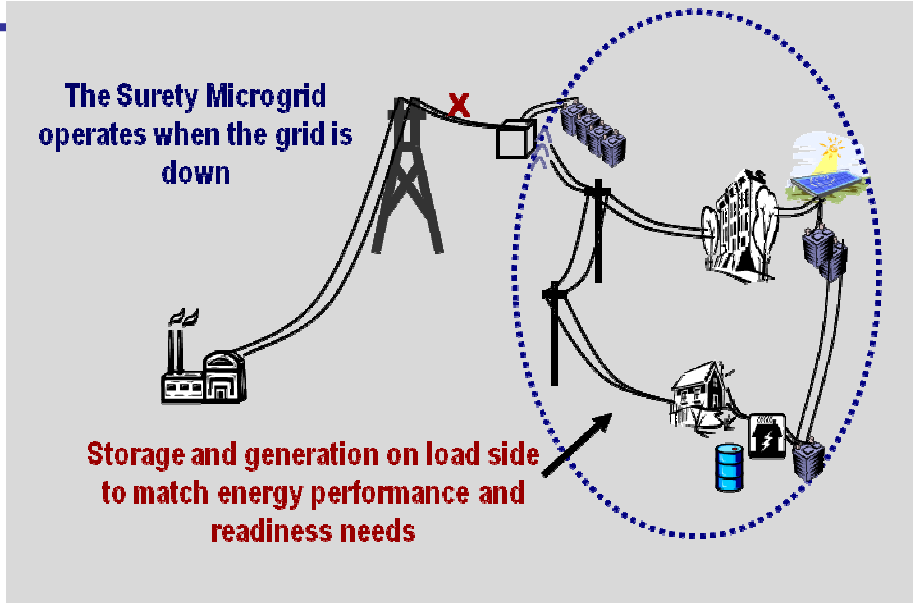
- ***Hawaii Clean Energy Initiative***
  - Grid Stability Solutions for Variable Renewables on Kauai
  - Optimizing Energy Efficiency and Renewables for Military Housing on Oahu
  - Lanai High Penetration Renewable Energy Grid
  - Regulatory and Policy Support
- ***Use of distributed resources to reduce peak power (minimum of 15% reduction) on distribution feeder or substation) - Distribution Management System for peak load reduction***
  - Develop and demonstrate a distribution automation solution that aggregates DG, energy storage, and demand response technologies in a distribution system to achieve both T&D level benefits at the Maui Lani Substation
- ***Hawaii Distributed Energy Resource Technologies for Energy Security***
  - HNEI, GE, and local utilities, are developing detailed models of the energy infrastructure for each of the major Hawaiian Islands using GE's proprietary software. To date, models have been validated for the Big Island and Maui and are now under development for the islands of Oahu and Kauai



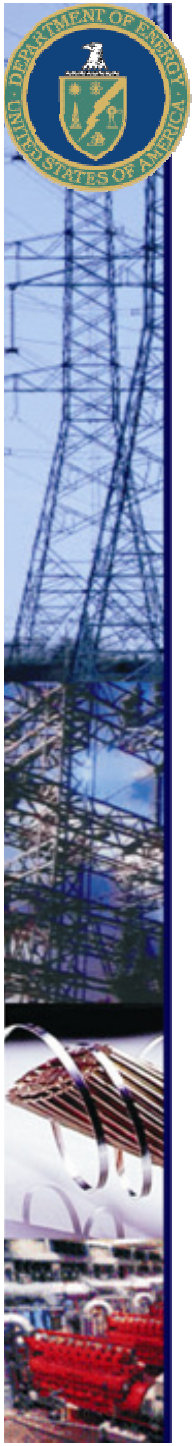


Energy Surety MicroGrids

- DOE and DOD jointly fund Sandia National Laboratory to work with military bases to develop energy surety microgrid conceptual designs
- 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
  - Reduces dependence on fossil fuels – supports integration of renewables into on-base power supply infrastructure
  - Improvements on critical mission capability based on condition and availability of energy supplies at critical facilities



- Projects are cost shared between DOE and the DOD site – most projects about $120K for five month effort
- Focus on assisting 5-6 military bases in FY09



Distributed Energy Controls and Communication Laboratory

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

Balance Load and Generation
- Several types of responsive load
- Load can even supply regulation
- Reduce transmission congestion

Voltage Regulation
- Local, adaptive control that works with utility control
- Improved standards, relaying and modeling

High Penetration of Renewables
- Large aggregations, large Balancing Areas, statistical methods of planning and forecasting load and generation

Variability of Renewables
- Regulation from responsive load and storage
- Rapid regulation now available is better

Cost
- Improve efficiency with voltage regulation and responsive load
- Optimize costs with the market

Emissions
- Emissions will be reduced by using responsive load instead of generation

DECC Technologies in Catalina Island Renewable Integration Project

SCE using DECC adaptive voltage regulation algorithms to demonstrate use of distributed renewable generation and supporting advanced power electronics to serve 15% or more of Catalina Island's electrical demand and facilitate successful and reliable integration of future additional renewables, on Catalina and mainland electrical systems

Developing Smart Grid Metrics

20 metrics further defined in Smart Grid System Report

Area/Regional/Nat'l Coordination

- Dynamic Pricing
- Real-time Data Sharing
- DER Interconnection
- Regulatory Policy

Distributed Energy Resource Tech

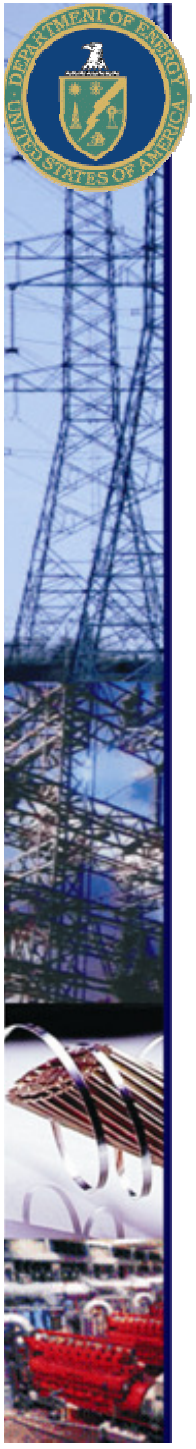
- Load Participation
- Microgrids
- DG & Storage
- Electric Vehicles
- Grid-responsive Load
- T&D Reliability

Delivery (T&D) Infrastructure

- T&D Automation
- Advanced Meters
- Advanced Sensors
- Capacity Factors
- Generation/T&D Efficiency
- Dynamic Line Rating
- Power Quality

Information Networks/Finance

- Cyber Security
- Open Architecture/Standards
- Venture Capital

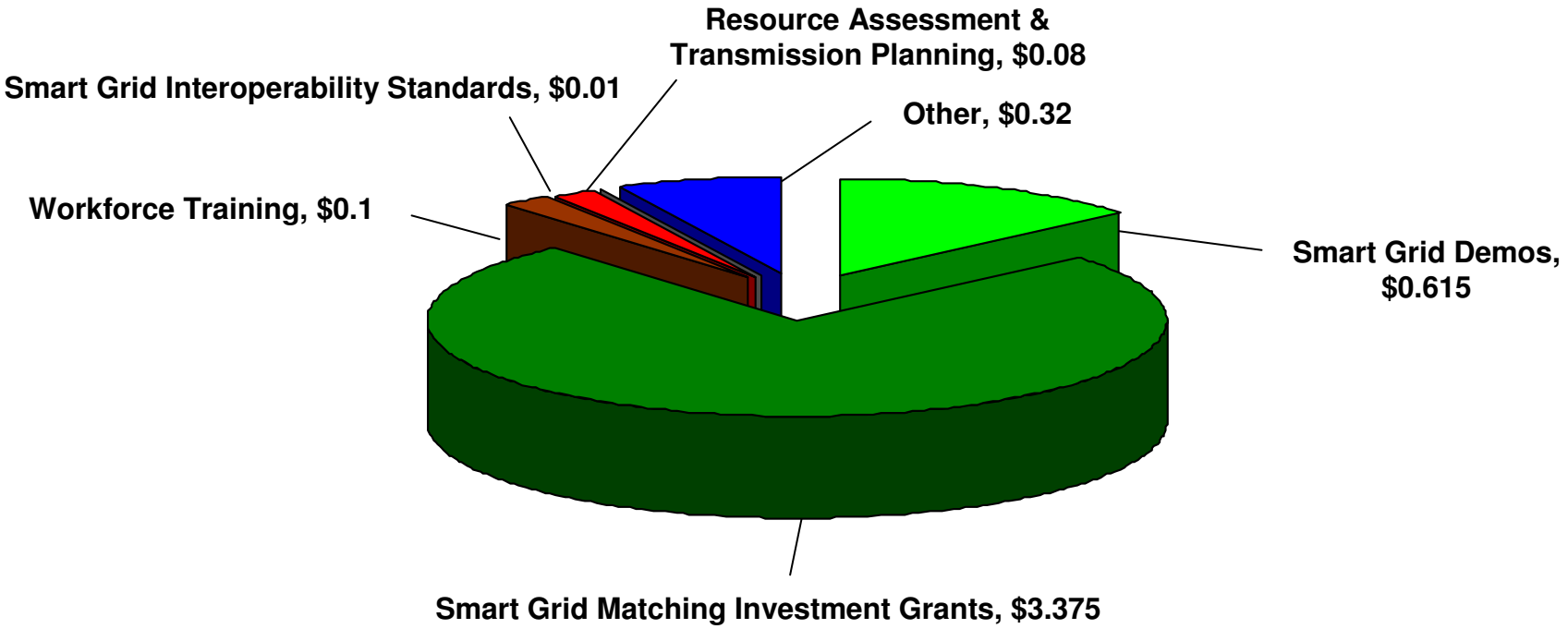


Future Microgrid and Related Activities

- Award projects funded through the American Recovery and Reinvestment Act of 2009
  - Smart Grid Investment Grants (Oct)
  - Smart Grid Demonstration Projects (Dec)
- Smart Grid Technology Roadmap Workshop
  - In conjunction with industry, identify key smart grid technology areas/barriers and RD&D pathways for overcoming the barriers
  - Areas identified and defined will be the basis for future R&D

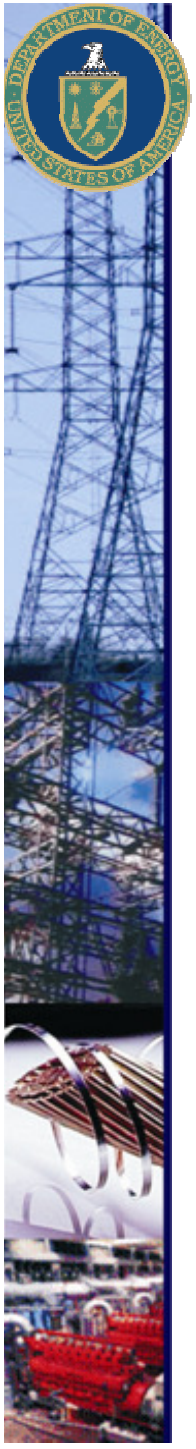
$4.5B for Electricity Delivery in Recovery Act Funding

- **Smart Grid:** These funds support the implementation of the Smart Grid program authorized by the Energy Independence and Security Act of 2007
  - $615M for smart grid demonstration projects (Section 1304)
  - $3.375B for matching grants for smart grid deployment (Section 1306)



Amounts are in billion US Dollars

For more details see http://www.energy.gov/recovery

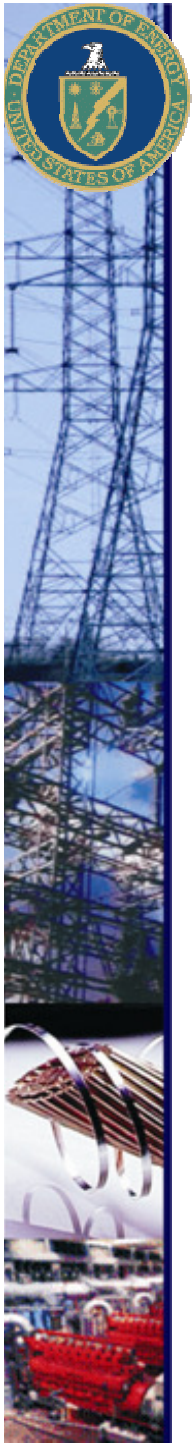


OE Recovery Act Program Status

- **Regional and Interconnection Transmission Analysis and Planning:** Supports long-term, coordinated interconnection transmission planning across the country; focuses on dialogue and collaboration among states within an interconnection on how best to meet the area's long-term electricity supply needs
  - $60M solicitation released June 15, 2009; deadline August 14, 2009
  - $20M for supporting transmission and demand analysis to be performed by DOE's national laboratories and the North American Electric Reliability Corporation (NERC)

- **Assistance to State Electricity Regulators:** Funding to support state public utility commissions and their key role in regulating and overseeing new electricity projects; can be used by states and public utility commissions to hire new staff and retrain existing employees to accelerate reviews of the large number of electric utility requests expected under the Recovery Act
  - $46M solicitation released June 15, 2009; deadline August 31, 2009

- **State Energy Assurance Capabilities:** Available for state governments to improve emergency preparedness plans and ensure the resiliency of the country's electrical grid
  - $39.5M solicitation released June 15, 2009; deadline July 30, 2009



Smart Grid Investment Grant Program

Overview

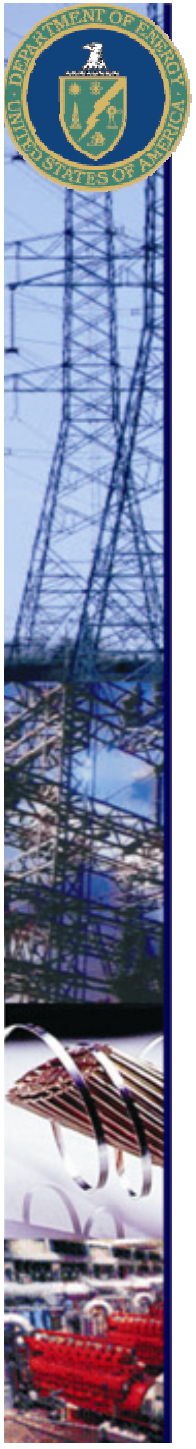
- Competitive, merit-based solicitation; more than 600 applications expected
- Covers electric transmission & distribution technologies, customer systems, equipment manufacturing, Advanced Metering Infrastructure (AMI), and Integrated Systems

Eligibility and Funding

- Applications expected from eligible entities such as electric utilities, load serving entities, appliance and equipment manufacturers, and IT vendors
- National Laboratories and Federally Funded Research and Development Centers are NOT eligible
- Expected project awards range from $100,000 to $20,000,000 for Phasor Measurement Units (PMU) projects; $500,000 to $200,000,000 for others
- Funding provided for up to 50% of qualified investments requested by grant applicants

Anticipated Schedule

Activity	Date
Notice of Intent (NOI)	April 16, 2009
Funding Opportunity Announcement (FOA)	June 25, 2009
FOA Closes	August 6, 2009
Project Awards	October 2009
FOA – Round 2, if necessary	November, 2009
FOA – Round 3, if necessary	March, 2010
All Funds Obligated	September 2010



Smart Grid Demonstration Program

Overview

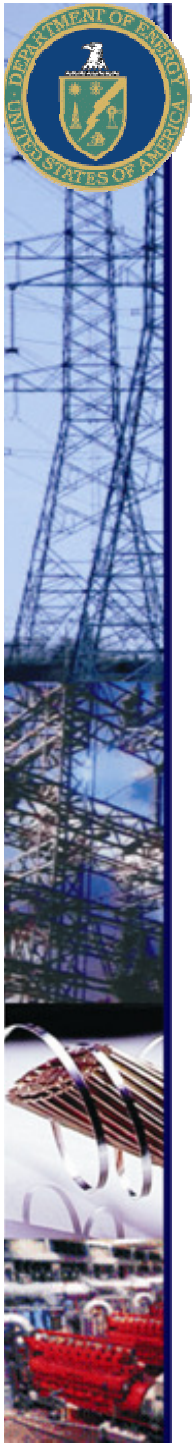
- Competitive, merit-based solicitation; several hundred proposals expected
- Covers electric transmission, distribution, and customer-side projects at a scale that can be replicated across the country
- Scope includes (1) Regional smart grid demonstrations, (2) Energy storage demonstrations

Eligibility and Funding

- Expect applications from all types of organizations including state and local agencies, universities, electric utilities, equipment manufacturers, and project developers
- Other Federal agencies, certain non-profits that engaged in lobbying activities after December 31, 1995 are NOT eligible
- Approximately $615,000,000 in Federal funds available
- Applicant's cost share must be at least 50% of the total allowable costs
- Expect to fund: 8-12 regional demonstrations, 12-19 energy storage projects

Anticipated Schedule

Activity	Date
Draft Funding Opportunity Announcement (FOA)	April 16, 2009
Funding Opportunity Announcement	June 27, 2009
FOA Closes	August 26, 2009
Project Awards	December, 2009



Where Can I find Information on All of This Information?

Smart Grid Information Clearinghouse

Serves as a central repository for smart grid project information, applications, requirements, performance, costs and benefits, and standards implementation. Includes RDSI and other smart grid demonstration projects, as well as all ARRA smart grid projects

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

Clearinghouse Web Site
Coming Soon

Smart Grid Web Site
Coming Soon