Smart Grid Development by the U.S. Department of Energy

Presented at Virtual Energy Forum

Dan Ton

Program Manager, Smart Grid R&D

December 1, 2011

Presentation Outline

- **Overview of Smart Grid**

  Definition, Goals, Assets, Applications, Values, Barriers

- **DOE Programs Addressing Smart Grid Barriers**

  — Recovery Act Grid Modernization Focus Areas

  — DOE Smart Grid R&D Program

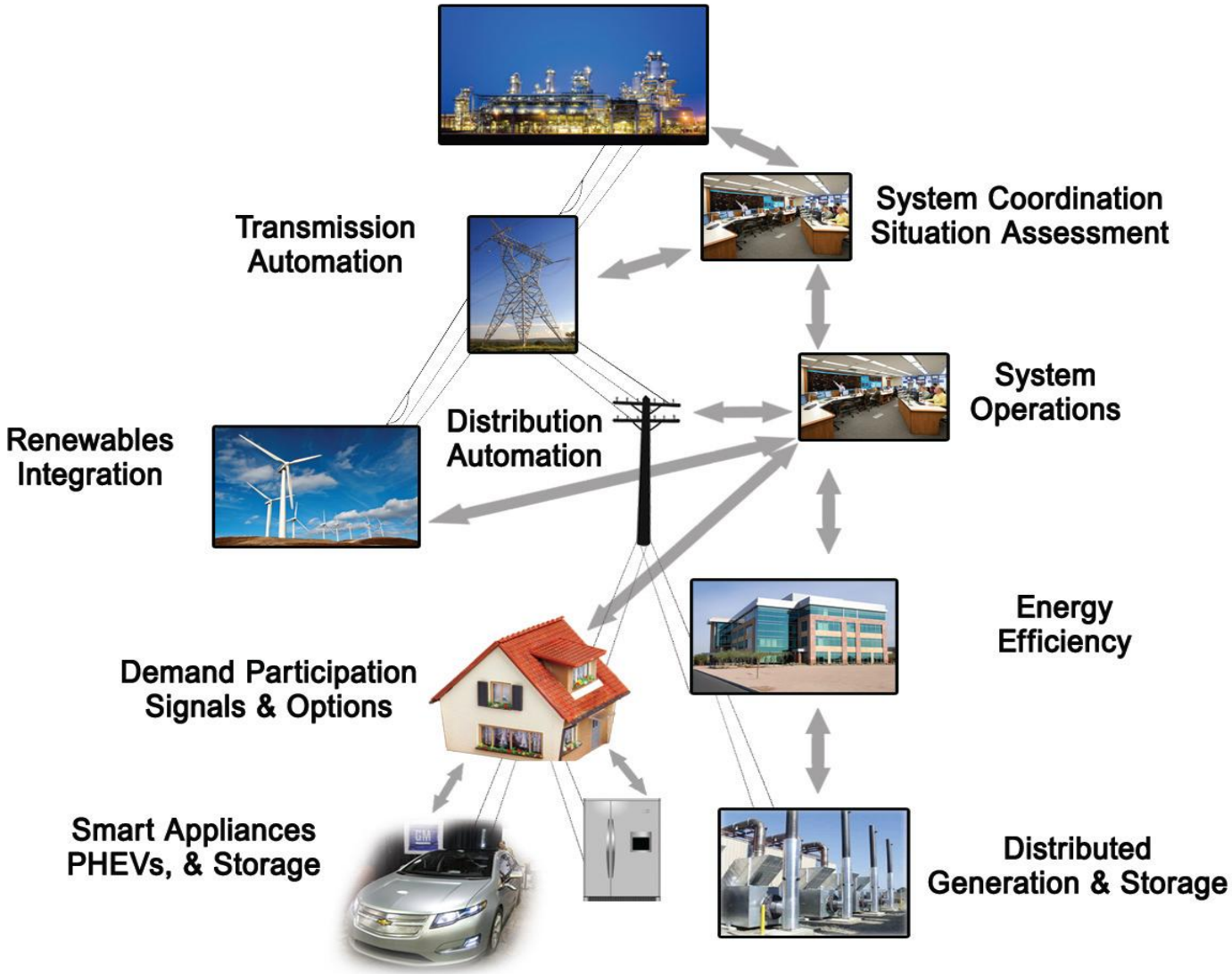
- **International Smart Grid Coordination and Collaboration**

Smart Grid: What is it?

DOE has defined seven core Smart Grid characteristics

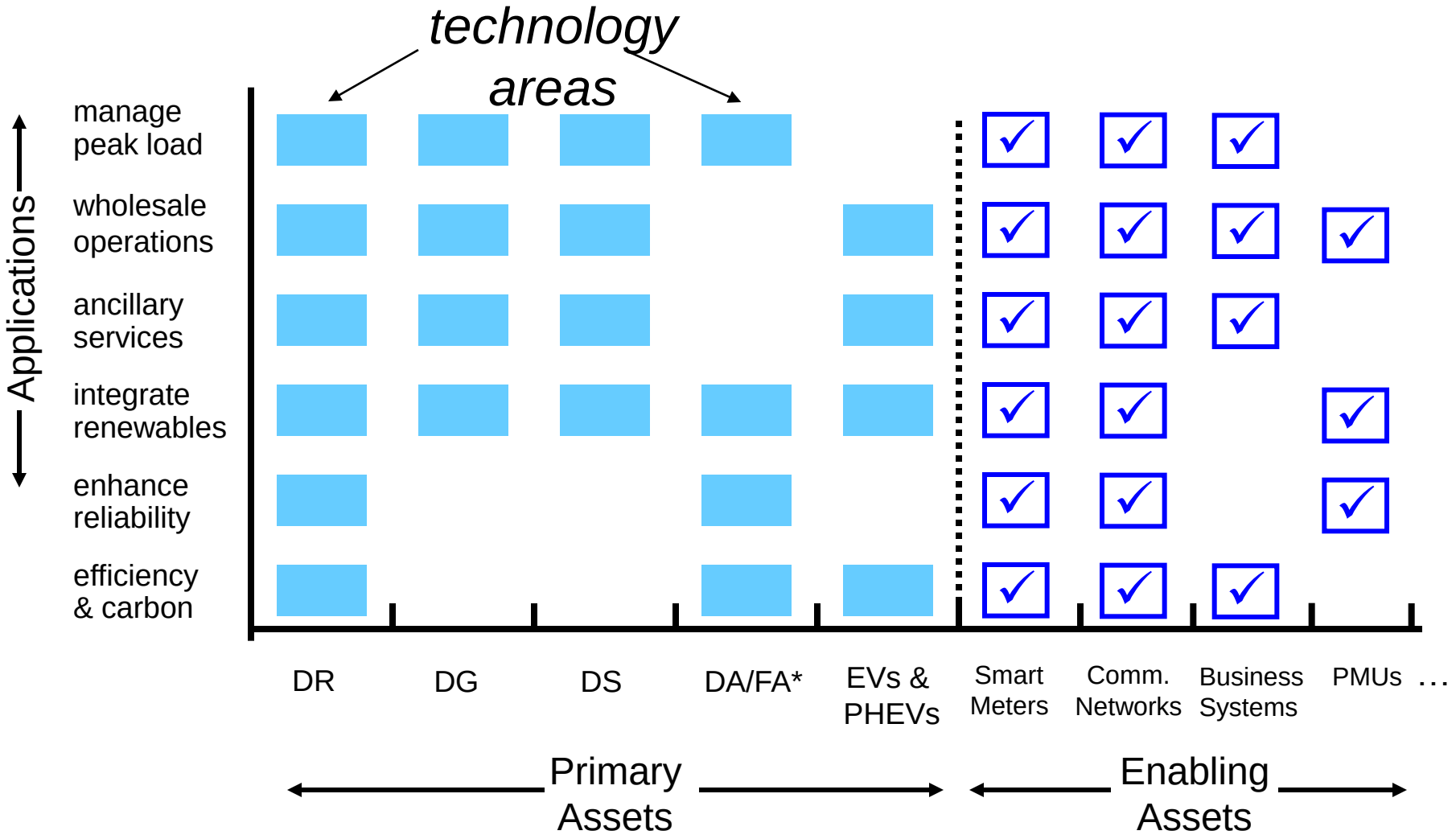
The Smart Grid Initiative is to develop and implement advanced information, communication, and control technologies, along with supportive policies, to achieve all seven characteristics.

Smart Grid Technology Areas



4

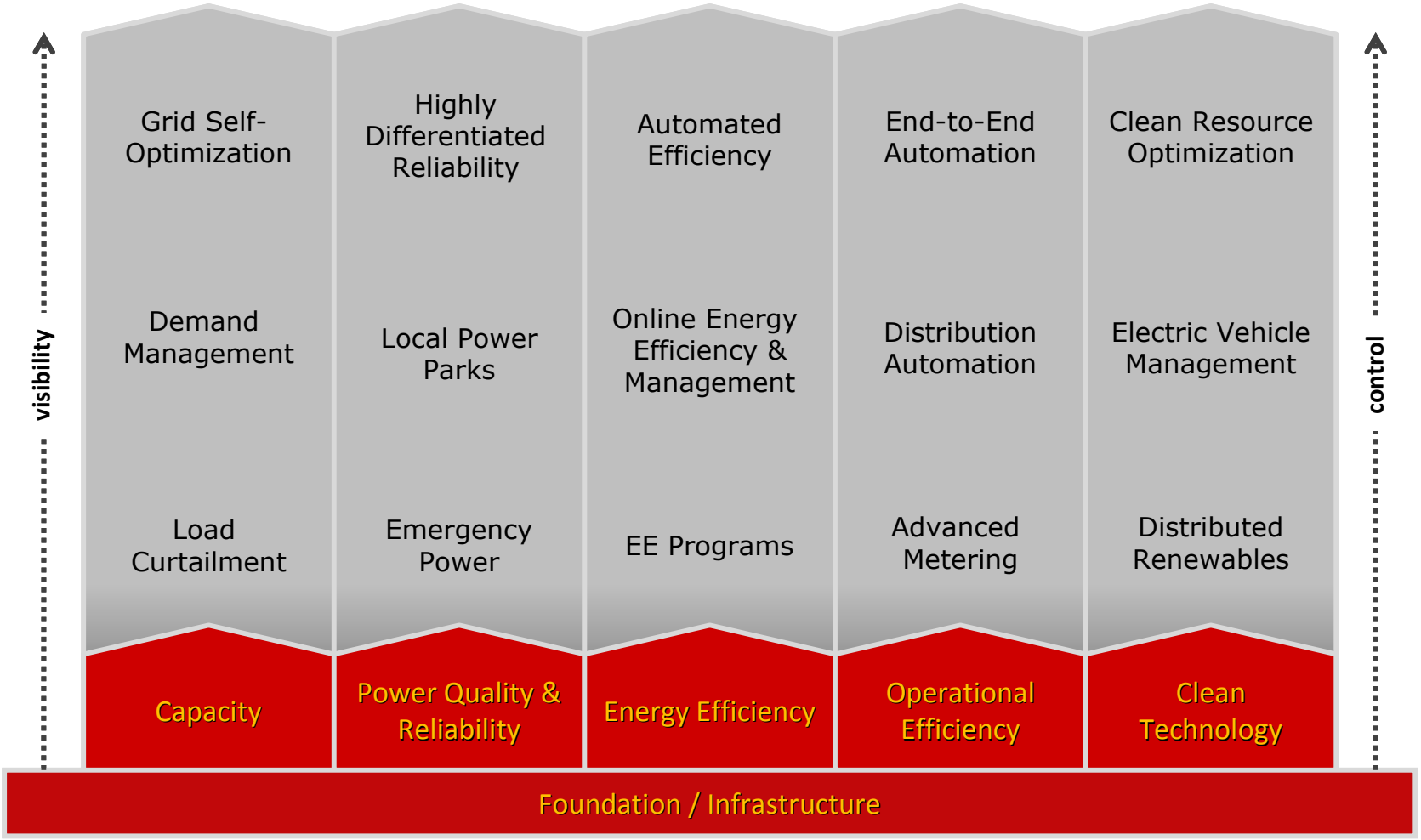
Mapping of Smart Grid Assets (Components), Applications, and Technology Areas



* DA/FA: Distribution automation/feeder automation

Assets + Applications → Value Creation

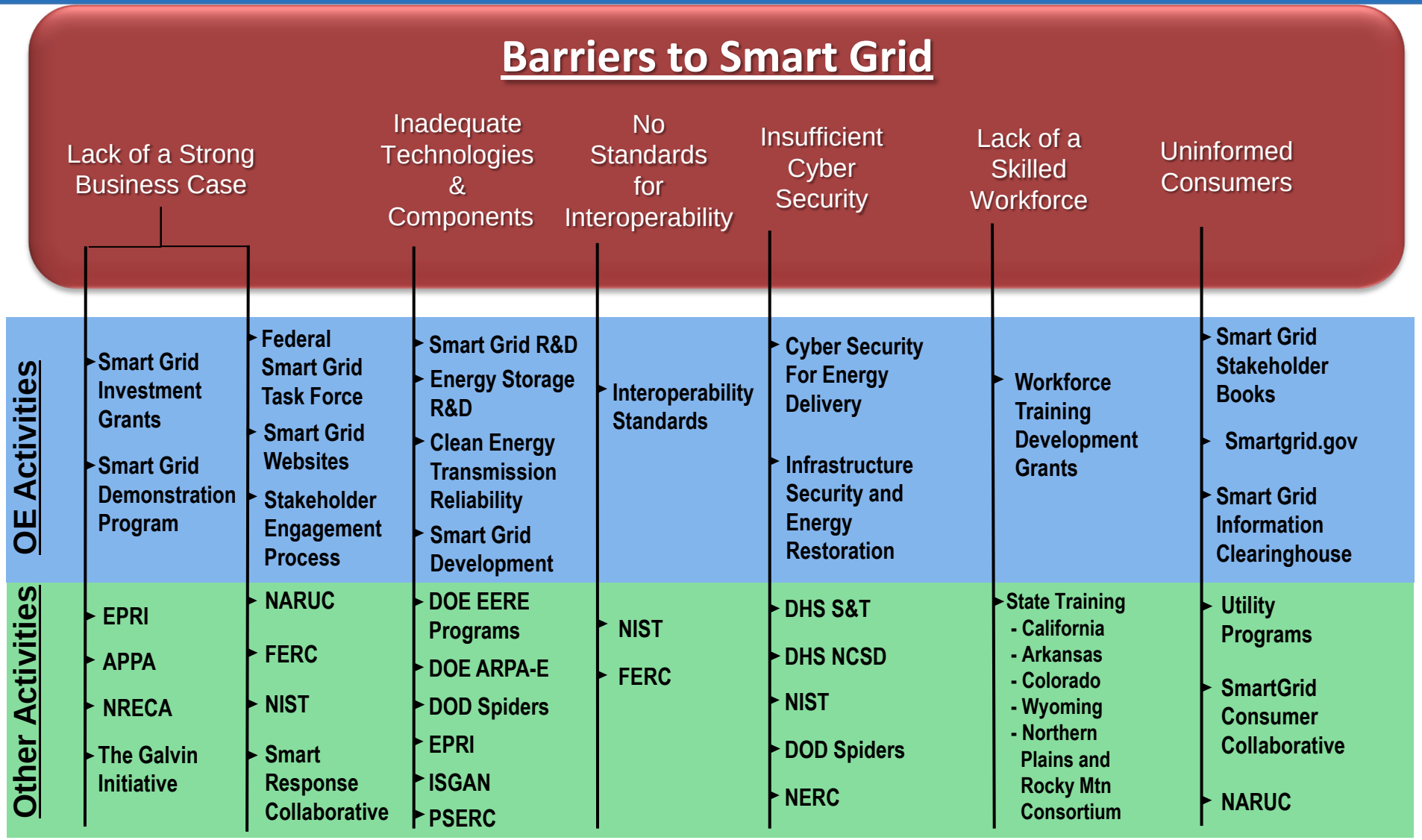
21st Century Smart Grid



Barriers to a Smart Grid

- Businesses, state regulators, and consumer advocates are unconvinced of the value of smart grid technologies due to lack of performance data on costs and benefits
- Insufficient or inadequate technologies, components, and systems to leverage IT potential of smart grid
- No established standards for interoperability of systems and components
- Insufficient cyber security for a smart grid architecture
- Lack of a skilled workforce to build, install, operate, and maintain systems and equipment
- Consumer understanding of the electrical infrastructure and opportunities enabled by smart grid technologies

OE Program Addresses Key Barriers



Recovery Act
Grid Modernization Focus Areas

Recovery Act – Grid Modernization

Programs created by statute

- Energy Infrastructure Security Act 2007:
  - Smart Grid Investment Grants (Sec. 1306)
  - Smart Grid Regional Demonstrations (Sec.1304)
- Recovery Act Directed Programs:
  - Workforce Training - $100M
  - Interconnection-wide Transmission Planning and Resource Analysis - $80M
  - Interoperability Standards - $12M

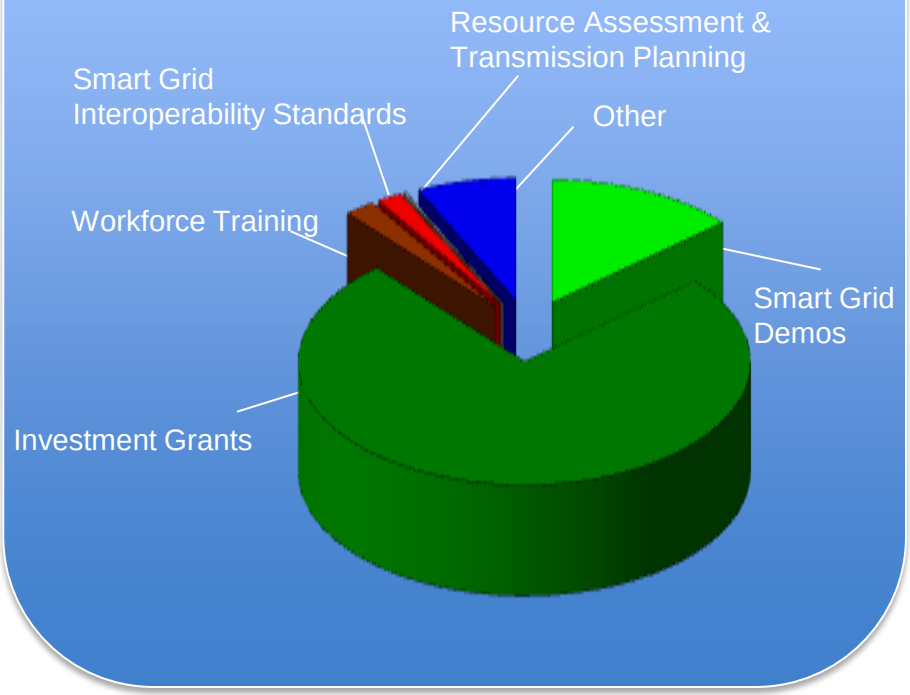
Top 10 States by Total Awarded	
State	Amt ($M)
NC	434
CA	419
TX	293
NY	276
FL	270
PA	265
MD	233
DC	213
AL	166
OH	146

Additional OE initiatives

- State & Local Energy Assurance
- State Regulatory Assistance

One-time Appropriation, $4.5B in ARRA funds

- $620M for demonstration projects
- $3.425B for deployment projects



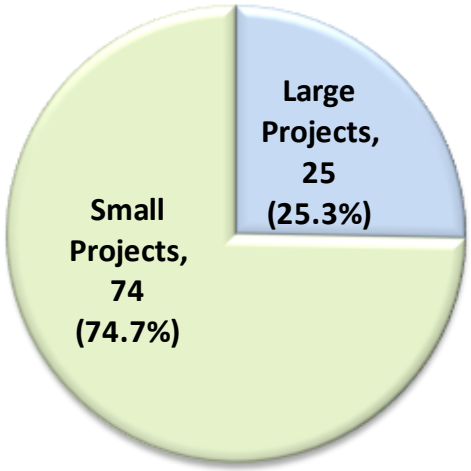
$4.5 billion obligated by end of FY10
$1.6 billion paid out to date

Recovery Act – Grid Modernization Goals

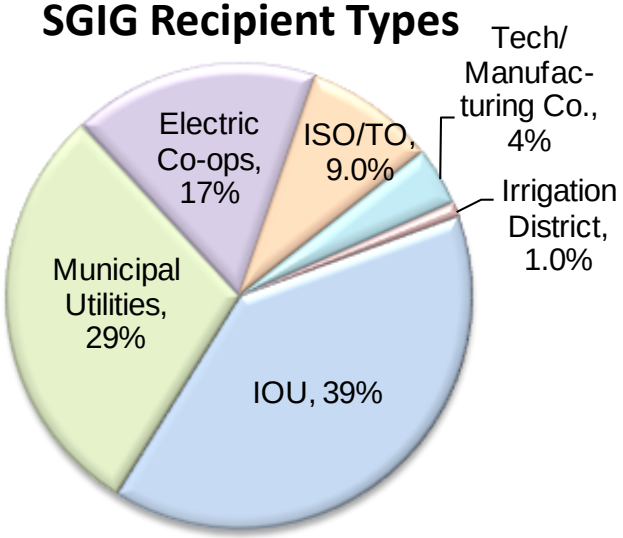
Deployment of Smart Grid Technologies	• 15.5 million smart meters • 800 Phasor Measurement Units • 6,500 Distributed Circuits
Economic Benefits	• Reductions in monthly bills for customers with smart meters and enabling technologies • Reductions in peak demand translate to less generation capacity required • Reductions in operating costs for distribution circuits with automated equipment
Reliability Benefits	• Reduction in length of power outages • Reduction in frequency and geographic scope of power outages
Environmental Benefits	• Reductions in energy wasted (line losses) in distribution circuits • Reduced emissions of CO_2, NO_X , and SO_X associated with electricity consumption of customers with smart meters and enabling technologies

Smart Grid Investment Grants (SGIG)

Number of Projects



SGIG Recipient Types

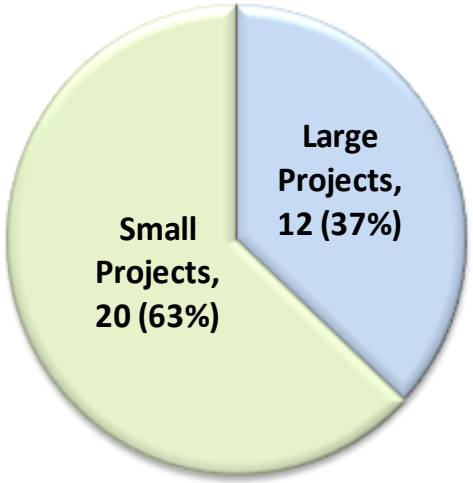


Selected Projects	
Total Funding	$7,863,897,259
Federal Share	$3,425,938,323
Total Number of Projects	99

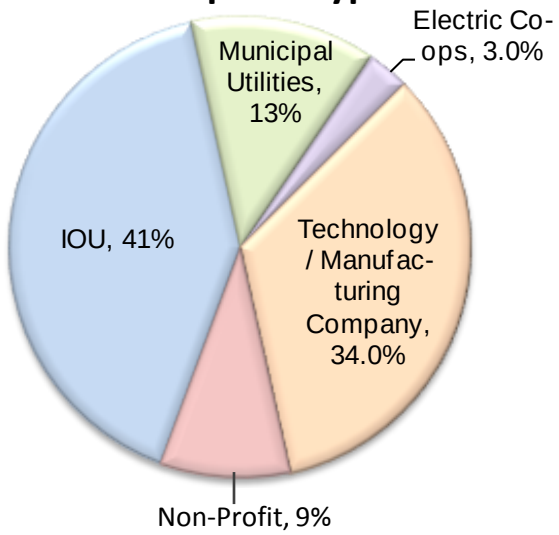
- **Deployment of current technological components for immediate commercial use**
- **Support of manufacturing, purchasing, and installation of smart grid technologies**
- **Large projects: $20M-$200M**
  Small projects: $394K-$20M
  (Federal share)
- **3-year projects**

Smart Grid Demonstration Program (SGDP)

Number of Projects



SGDP Recipient Types

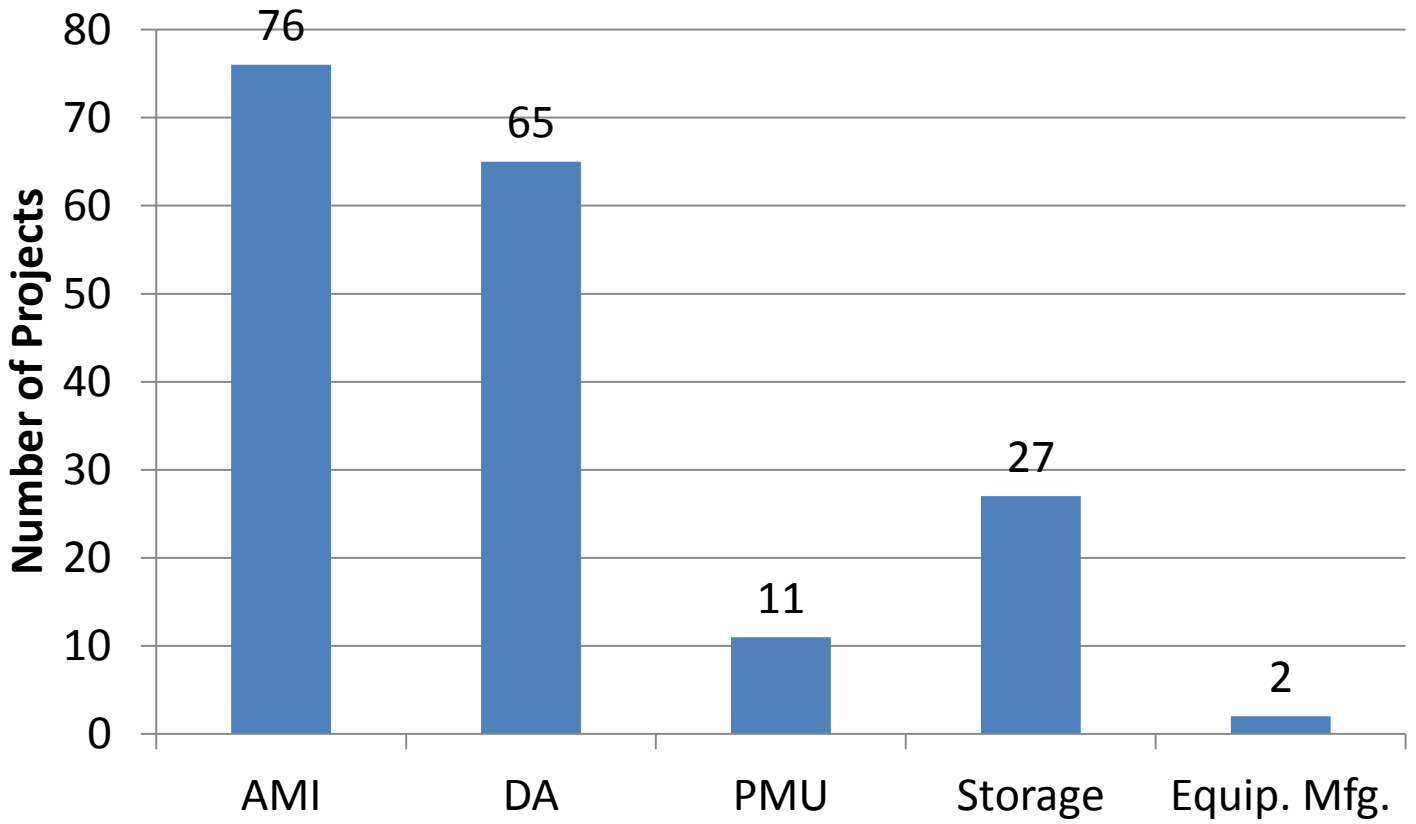


Selected Projects	
Total Funding	$1,647,637,256
Total Federal Funding	$620,027,274
Total Number of Projects	32

- **Demonstrate emerging technologies (including energy storage) and alternative architectures**
- **Validate business models**
- **Address regulatory and scalability issues**
- **Large projects: $20M-$89M**
  Small projects: $720K-$20M
  (Federal share)
- **4-year projects (average)**

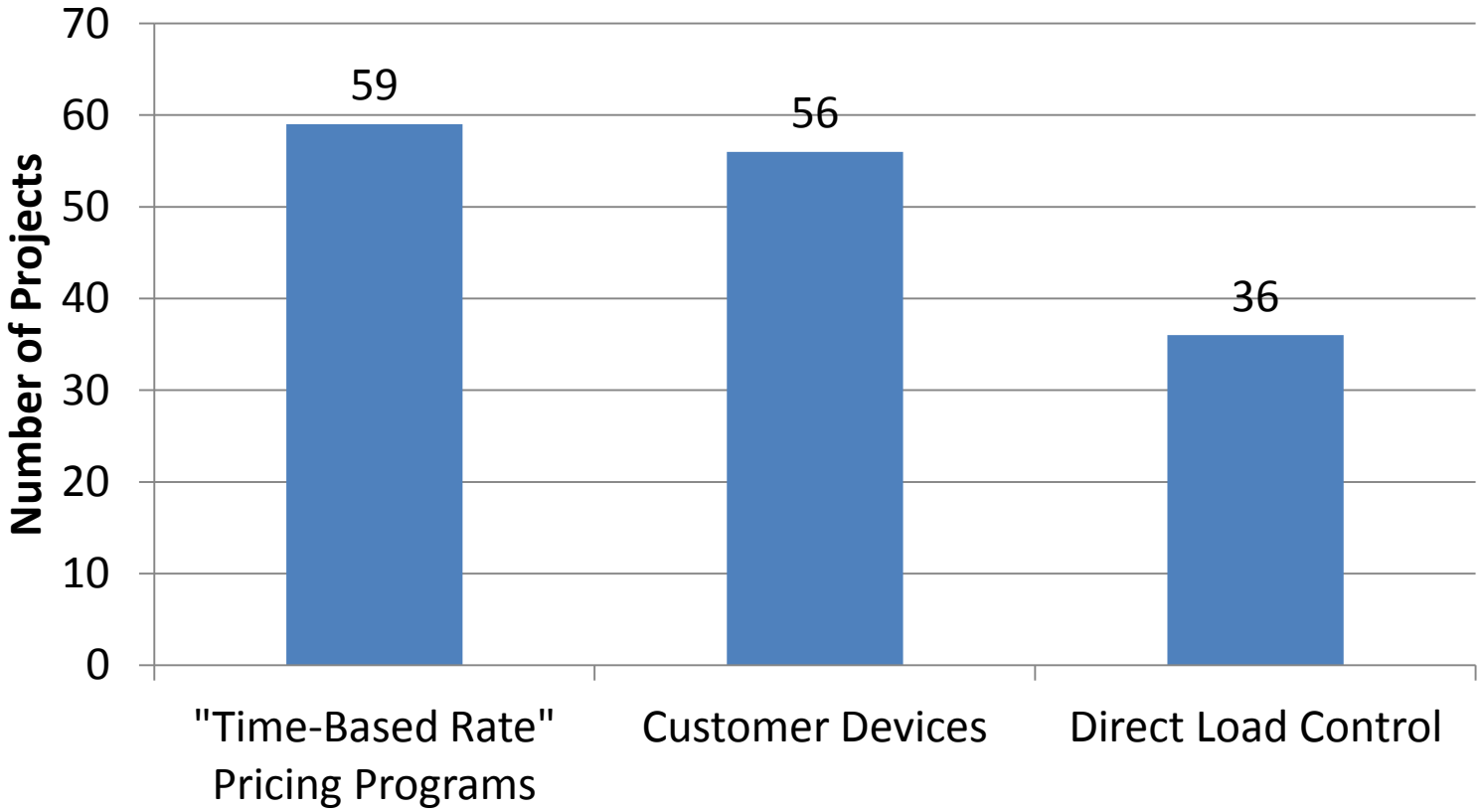
Distribution of Projects by Technology

131 total projects in the SGIG and SGDP programs, with some projects installing multiple technologies



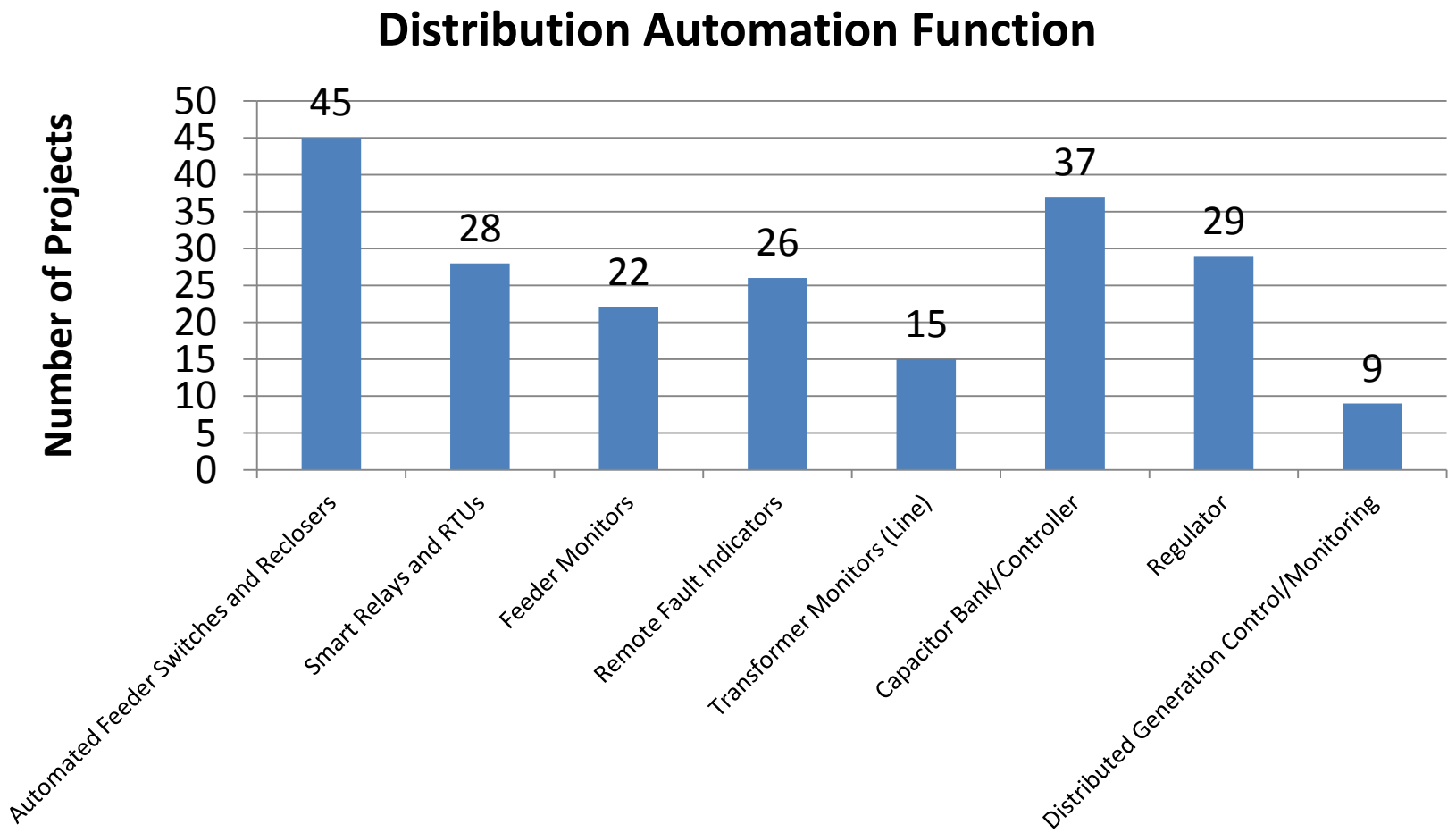
Distribution of AMI Projects & Customer Engagement

76 projects have AMI and some type of customer program, most being pilot activities engaging a limited segment initially



Note: Project components are NOT mutually exclusive

SGIG: Distribution Automation



Recovery Act - Transmission

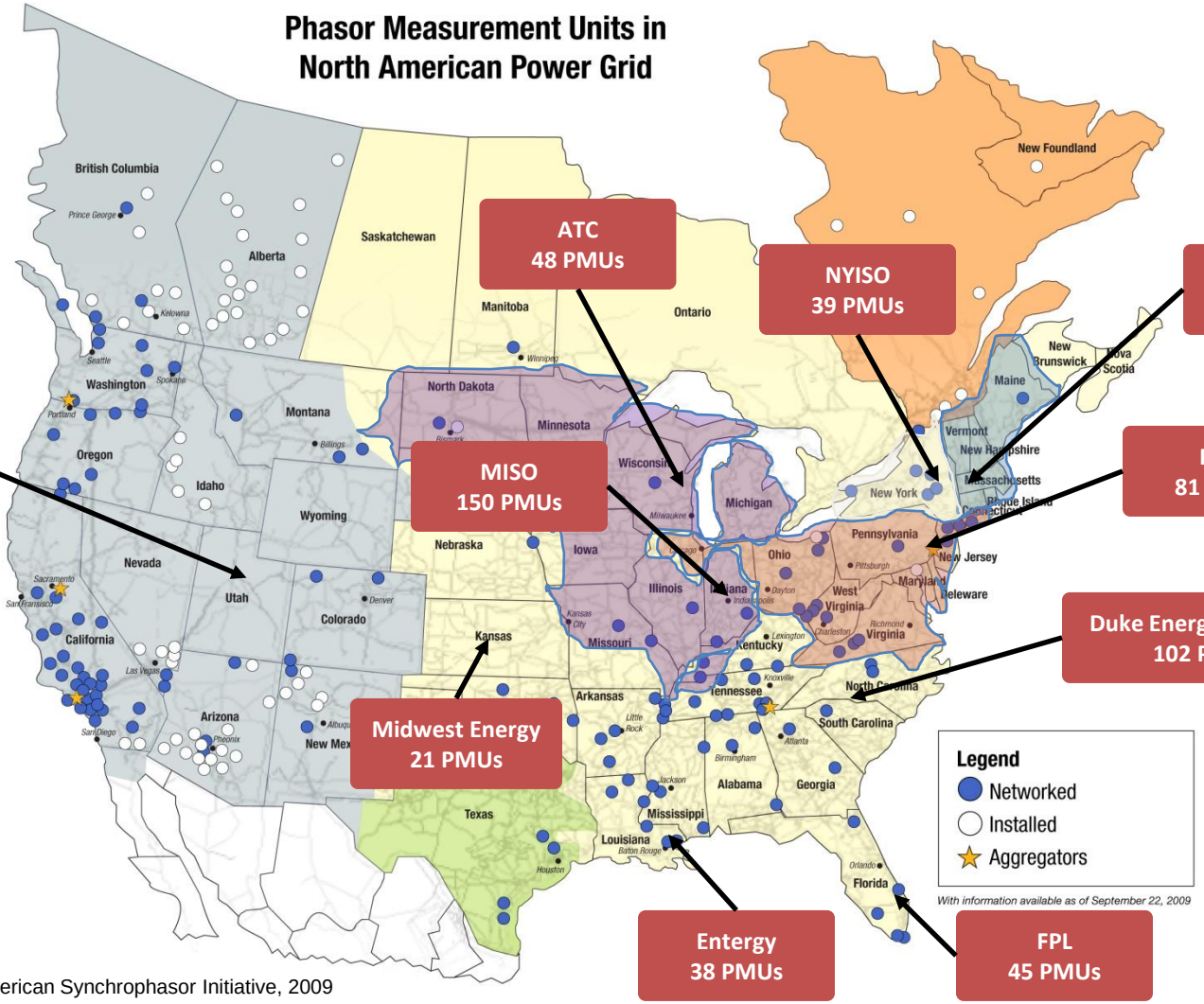
$308M ($153M Federal) dedicated to 10 Transmission Projects

- American Transmission Company (PMU)
- American Transmission Company (SCADA)
- Duke Energy Carolinas
- Entergy Services
- Midwest Energy
- Midwest ISO – 9 transmission utility partners
- ISO New England – 7 transmission utility partners
- New York ISO – 8 transmission utility partners
- PJM Interconnection – 12 transmission utility partners
- Western Electricity Coordinating Council – 18 transmission utility partners

By 2013, over 900 networked phasor measurement units (PMUs) will be installed, providing nearly complete coverage of the transmission system.

Recovery Act – PMU Deployment

The SGIG program is supporting the deployment of 804 phasor measurement units (PMUs) across the US.



SGIG Total 804 PMUs

Source: Map from North American Synchrophasor Initiative, 2009

Recovery Act - Energy Storage

$586 million in private investment from $185 million in federal funds
➔ Better than 3:1

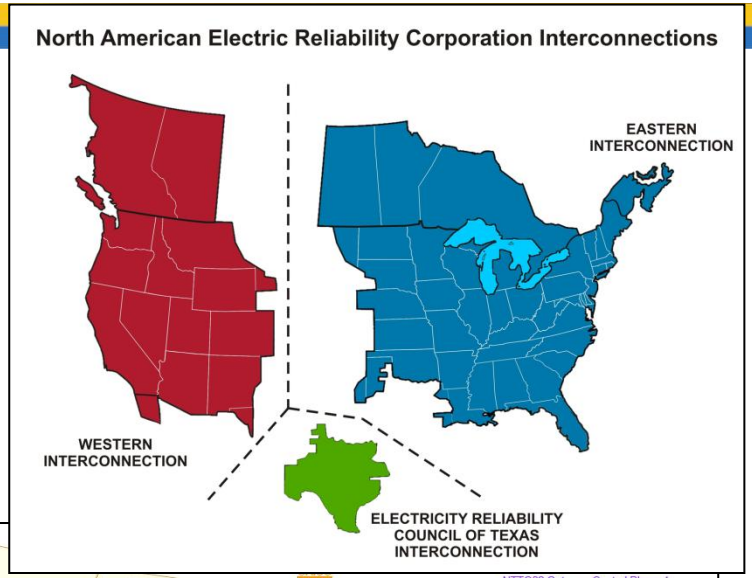
Energy Storage Regional Demonstration Projects Include

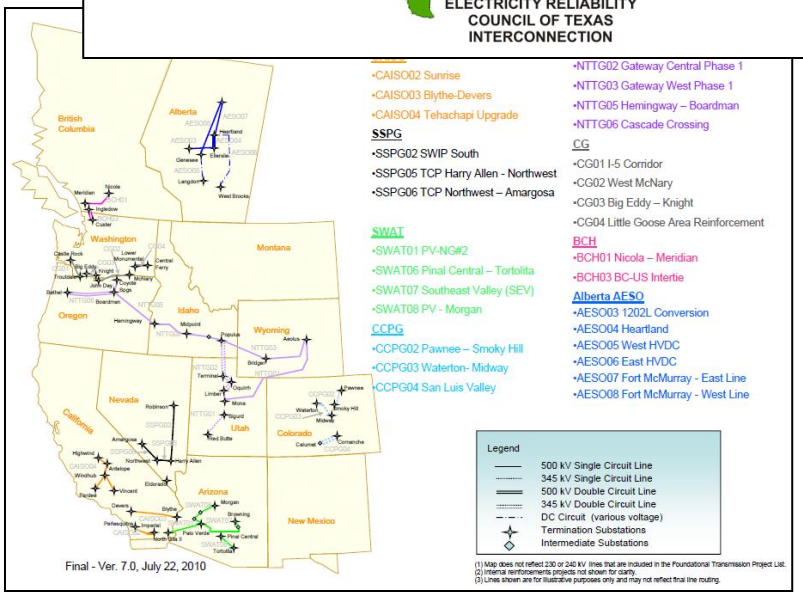
- Large Battery Systems (3 projects, 53MW)
- Compressed Air (2 projects, 450MW)
- Frequency Regulation (20MW)
- Distributed Projects (5 projects, 9MW)
- Technology Development (5 projects)

20 Li-Ion community energy storage units on Detroit Edison grid

Recovery Act - Transmission Planning

- Consensus scenarios for future electricity supplies and analyzing environmental and other considerations that will be incorporated into transmission plans
- Long-term resource and transmission planning studies in 2011, with update in 2013
- The knowledge and perspective gained from this work will inform policy and regulatory decisions in the years to come and provide critical information to electricity industry planners, states, and others to develop a modernized, low-carbon electricity system
- Time horizon expanded to 20 years for planning
- First time environmental stakeholders included in process





Recovery Act - Workforce Training

- Recipients of the Recovery Act funds will provide training in demand response, distributed generation, energy utilization/optimization, and cost simulations.
- $100 million in Recovery Act funds was being offered to 54 workforce training programs. Target benefits include:
  - Up to 175,000 technicians, staff, and management positions filled with qualified personnel
  - Skilled workforce educated in energy conservation and renewable energy
  - Increased investment in advanced laboratory equipment, faculty development, and academic research
  - Increased skills and pay rates for technicians and displaced workers
  - Increased awareness of cybersecurity issues

Smart Grid Benefit Analysis:
DOE Smart Grid Computational Tool (SGCT)

The SGCT is an analysis tool that identifies the benefits of a SG project and guides the user through an analysis which quantifies those benefits.

The SGCT characterizes smart grid (SG) projects by identifying what technology will be installed and what functionality that technology will enable.

Based on the characterization of a project, it identifies the economic, reliability, environmental, and security benefits the SG project will yield.

The SGCT uses user-entered data to calculate the monetary value of benefits and prepares graphs and tables that compare the costs and benefits to help determine the project's overall value.

The SGCT can also perform a sensitivity analysis.

The SGCT can calculate the value of specific benefits*

Benefit Category	Benefit Sub-category	Benefit
Economic	Improved Asset Utilization	Optimized Generator Operation (utility/ratepayer) Deferred Generation Capacity Investments (utility/ratepayer) Reduced Ancillary Service Cost (utility/ratepayer) Reduced Congestion Cost (utility/ratepayer)
	T&D Capital Savings	Deferred Transmission Capacity Investments (utility/ratepayer) Deferred Distribution Capacity Investments (utility/ratepayer) Reduced Equipment Failures (utility/ratepayer)
	T&D O&M Savings	Reduced Distribution Equipment Maintenance Cost (utility/ratepayer) Reduced Distribution Operations Cost (utility/ratepayer) Reduced Meter Reading Cost (utility/ratepayer)
	Theft Reduction	Reduced Electricity Theft (utility/ratepayer)
	Energy Efficiency	Reduced Electricity Losses (utility/ratepayer)
	Electricity Cost Savings	Reduced Electricity Cost (consumer)
Reliability	Power Interruptions	Reduced Sustained Outages (consumer) Reduced Major Outages (consumer) Reduced Restoration Cost (utility/ratepayer)
	Power Quality	Reduced Momentary Outages (consumer) Reduced Sags and Swells (consumer)
Environmental	Air Emissions	Reduced Carbon Dioxide Emissions (society) Reduced SO_X, NO_X, and PM-10 Emissions (society)
Security	Energy Security	Reduced Oil Usage (society) Reduced Wide-scale Blackouts (society)

*Methodological Approach for Estimating the Benefits and Costs of Smart Grid Demonstration Projects, EPRI, January 2010.

Smart Grid R&D Program

Smart Grid R&D Program

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.

*** MYPP available at:**
http://www.smartgrid.gov/sites/default/files/oe_mypp.pdf

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

Smart Grid Characteristics and R&D Program Goals

7 Characteristics

- Power Quality for 21st Century
- Self Healing
- Resilient against Attacks and Disasters
- Customer Participation
- Integrate All Generation & Storage Options
- New Markets and Operations
- Asset Optimization and Operational Efficiency

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

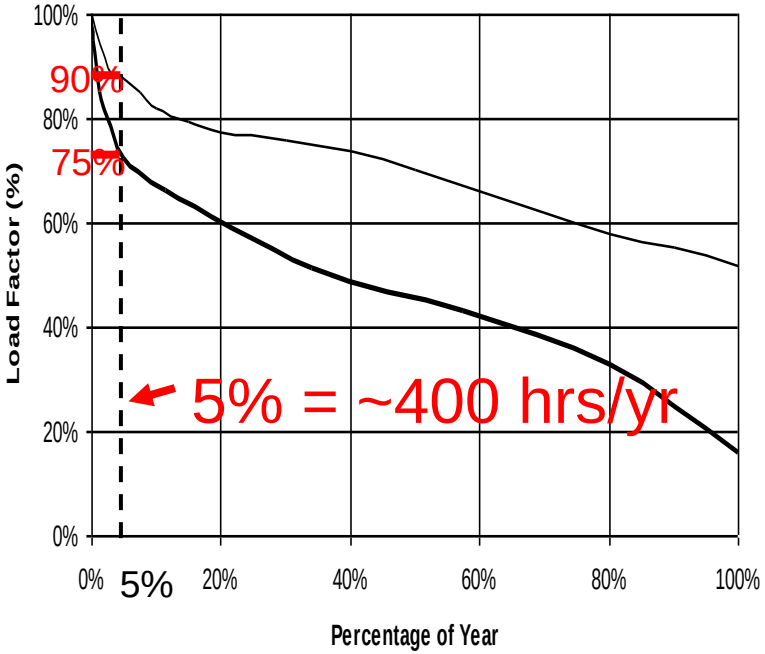
>98% reduction in outage time of required loads

20% load-factor improvement

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



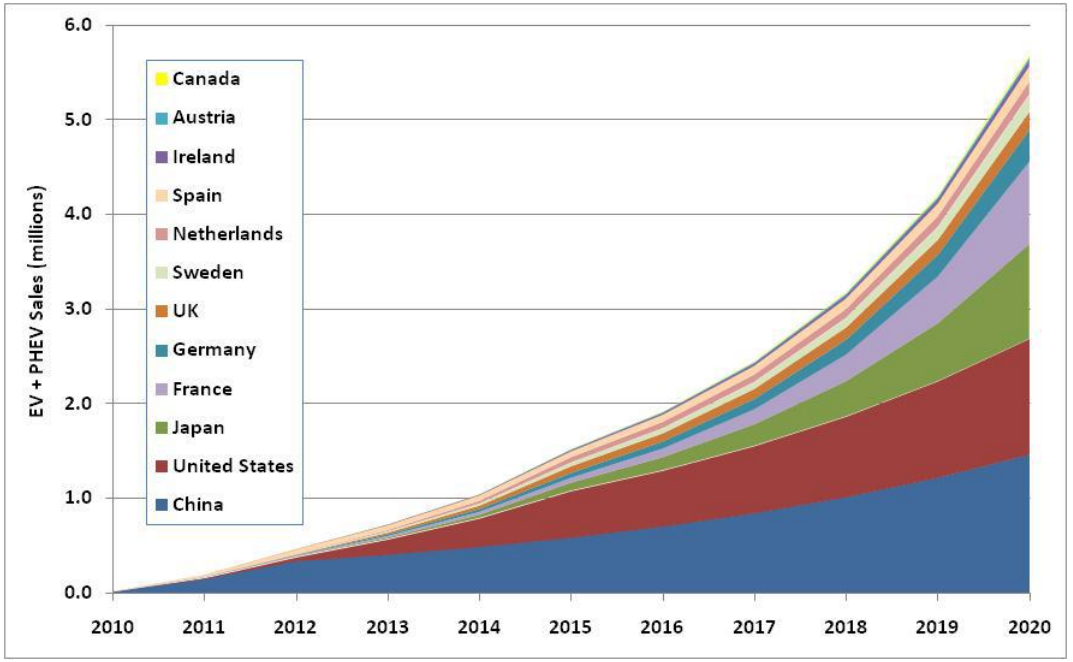
25% of distribution & 10% of generation assets (transmission is similar), worth 100s of billions of US dollars, are needed less than 400 hrs/year!

PEV Integration

FY 2011 Smart Grid-Capable EVSE FOA

- Reduce current costs of commercially available EVSE (residential and non-residential), with smart grid capabilities, by 50% in 3 years

- **Key features:** Bi-directional communications; Human machine interface for applications to provide local user input/output; PEV load management & smart controls; Conformance to interoperability, cyber security, and safety standards



Source: Transforming Global Markets for Clean Energy Products, IEA (2010)

Announcement of selections for award pending

Distribution Automation – FY 2010 FOA Awards

Advanced Communications and Controls

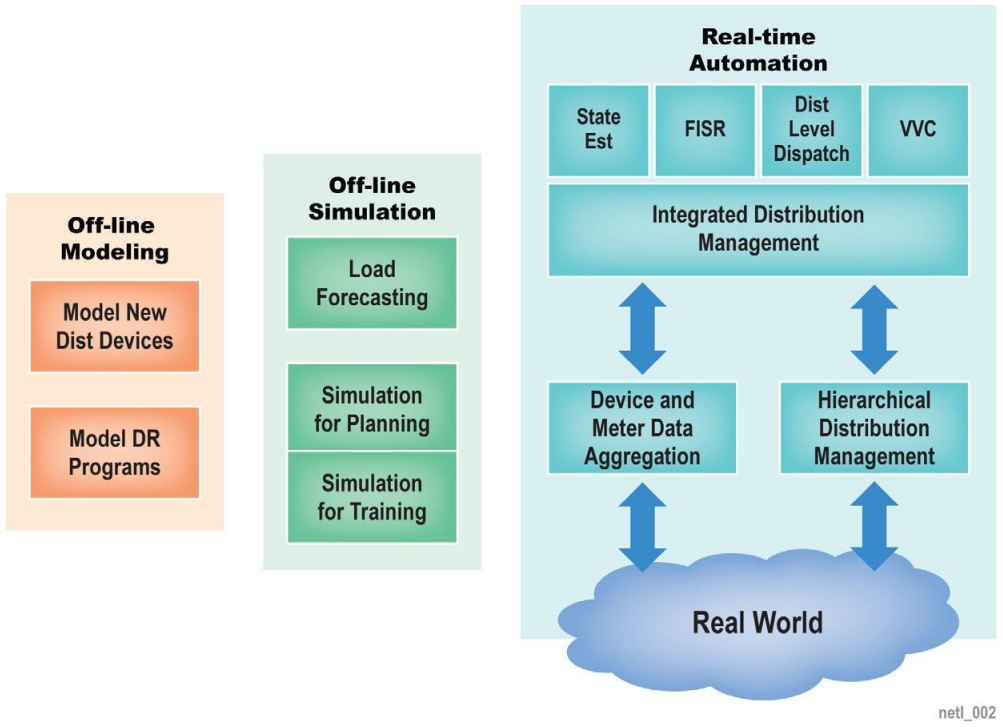
On-Ramp Wireless: Develop a wide area wireless distribution grid sensor and faulted circuit indicator system capable of monitoring underground and other hard-to-reach distribution circuits

ABB: Develop a real-time distribution feeder performance monitoring, advisory control, and health management system for enhanced asset utilization and grid reliability

Integrated Distribution Management System

Seamless integration of AMI & demand response, customer-owned DER, fault location, isolation, & restoration, volt/VAR control, & dynamic reconfiguration for distribution automation

- Boeing Distribution Management System
- Alstom's *e-terra* integrated distribution management system



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 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.

National Lab Team on SPIDERS

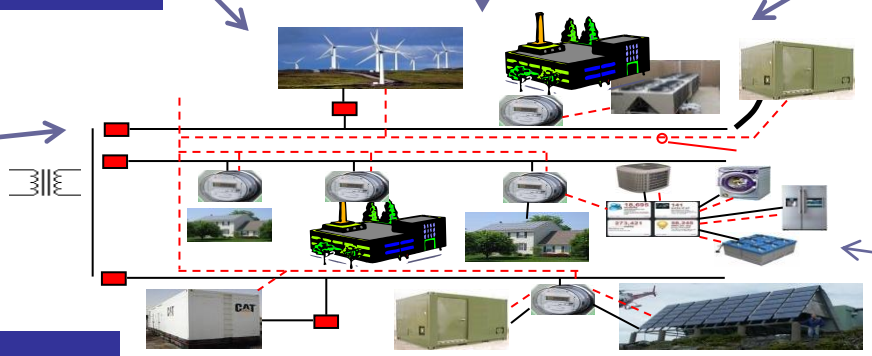
(Smart Power Infrastructure Demonstration for Energy, Reliability, and Security)

Microgrid (SNL)
- Advanced Metering Infrastructure
- Substation & Distribution Automation
- Two-Way Communications & Control
- Adaptive Relaying

Cyber Security (INL)
- Virtual Secure Enclave
- Live Action Network
- Secure Distributed Monitors
- Situational Awareness

Dynamic Control (SNL, ORNL)
- Load Control Systems
- Islanding Control System
- Energy Management System
- Seamless Grid Synchronization

Assistant Technical Manager (SNL)



Energy Secure Installation

Assistant Transition Manager (PNNL)

Demand Side Management (NREL, ORNL)
- Energy Efficiency Technologies
- Dynamic Voltage Regulators
- Smart Sockets
- Automated Load Shedding

Operational Test Agency (PNNL)

Energy Storage (NREL)
- Vehicle-to-Grid
- Hydrogen
- Batteries

Renewable Integration (NREL)
- Photovoltaic
- Wind
- Fuel Cells
- Biofuel

Smart Grid Interconnection & Interoperability Standards

In close work with the NIST Smart Grid Interoperability Standards Program

GridWise Architecture Council

- Develop and disseminate smart grid interoperability related methods, tools, and education
- Leadership and participation in the NIST Smart Grid Interoperability Panel
- Annual Grid-Interop forums on smart grid interoperability

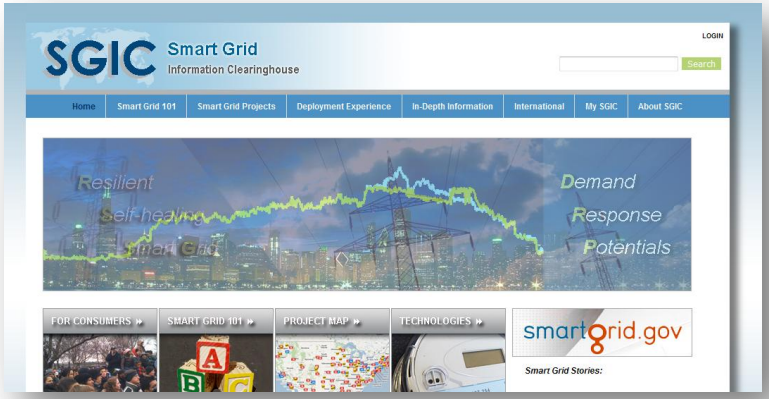
Interoperability & Interconnection Standards

- **IEEE P2030** Series: Smart Grid Interoperability – development of interoperability Guides for smart grid components and the overall system
- **IEEE 1547** Series of Interconnection Standards - development and harmonization of Interconnection and integration standards for DER
- **Interoperability Conformance Testing**: Establish test procedures and capabilities

Information Resources

Smart Grid Information Clearinghouse

- Smart grid project summaries (with focus on non-ARRA projects), use cases, and business cases for the U.S. and internationally
- >200 & >50 smart grid projects in the U.S. and overseas; >1,000 smart grid-related documents and multimedia (use cases, c/b analyses, business cases, legislation & regulation, standards, and technologies)



Smartgrid.gov

- ARRA smart grid project summaries and other Federal program activities
- Reporting of ARRA SGIG & SGDP projects (progress, metrics and benefits, consumer behavior studies) and provision of analysis results to the public

International Smart Grid Coordination & Collaboration

International Smart Grid Action Network (ISGAN)

Bringing high-level government attention and action to accelerate world-wide development and deployment of smarter electricity grids

ISGAN…

- Facilitates dynamic knowledge sharing, technical assistance, peer review and, where appropriate, project coordination
- Sponsors activities that accelerate smart grid deployment and address knowledge gaps
- Builds on the momentum of and knowledge created by the substantial investments being made in smarter grids globally
- Fulfills a key recommendation in the Smart Grids Tech. Action Plan
- Leverages cooperation with the International Energy Agency, Global Smart Grid Federation, and other relevant stakeholders

ISGAN Scope

- Five key topic areas
- Core emphasis on sharing of knowledge and lessons learned
- Projects may cover several topics areas

Four Foundational Projects

1. • **"Global Smart Grid Inventory"**
   of enabling programs and policies
2. • **Smart Grid Case Studies**
   using a common framework and metrics
3. • **Benefit/Cost Methodologies**
   (bottom-up & top-down) and related policy toolkits to assess smart grid investments
4. • **Synthesis of Insights for High-level Decision Makers**
   (e.g., CEM Ministers) from ISGAN and other related projects

- Recognized that ISGAN is not the only entity developing an "inventory"
- Several such efforts underway regionally
  - ENARD Annex V
  - ASGI
  - EEGI
  - EC-directed (JRC)
  - Etc.
- Although different drivers for each, there are opportunities for cooperation

Others Projects and Collaboration
Proposed or Under Consideration

Smart Grid International Research Facility Network (SIRFN)

Coordination with the ENARD IA
(Electricity Networks, Analysis, Research & Development)

Continuing dialog with private sector and other stakeholders
(e.g., Global Smart Grid Federation, ADB, SGIP)

Engagement with other international efforts
(e.g., the US-EU Energy Council and APEC Smart Grid Initiative)

Joint Projects with the DSM IA

Contact Information

Dan T. Ton
Program Manager, Smart Grid R&D
Office of Electricity Delivery and Energy Reliability
U.S. Department of Energy
(202) 586-4618
Dan.ton@hq.doe.gov

For more information:

OE: www.oe.energy.gov

Smart Grid: smartgrid.gov