OE's Smart Grid Activities in the Distribution system

Patricia Hoffman
Assistant Secretary

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Mission

- Drive Grid Modernization and Resiliency in the Energy Infrastructure

- The formation of the Grid Technology Team is a recognition by DOE that we need to bring more resources to bear on grid modernization, coordinating effort from the Science programs, ARPA-E, and the other applied programs

Desired Outcomes from this Workshop

- Better shared understanding of the technology needs of the Distribution system
- Identification of gaps in current research
- Improved coordination across the DOE complex and with our partners

Current Status

- Significant amount of ongoing work related to the Distribution System in OE, with technology roadmaps in the research activities
  - ARRA Smart Grid grants and demonstrations
  - Smart Grid R&D
  - Microgrids
  - Energy Storage
  - Cybersecurity

- Will highlight some of the key research and demonstrations to help identify where we are in development and demonstration and where gaps may be found
  - Gap Example: the interface between buildings and the distribution system

Smart Grid Functionalities

Development characterized by seven defining *functionalities* of the smart grid

Demand response & customer participation goals

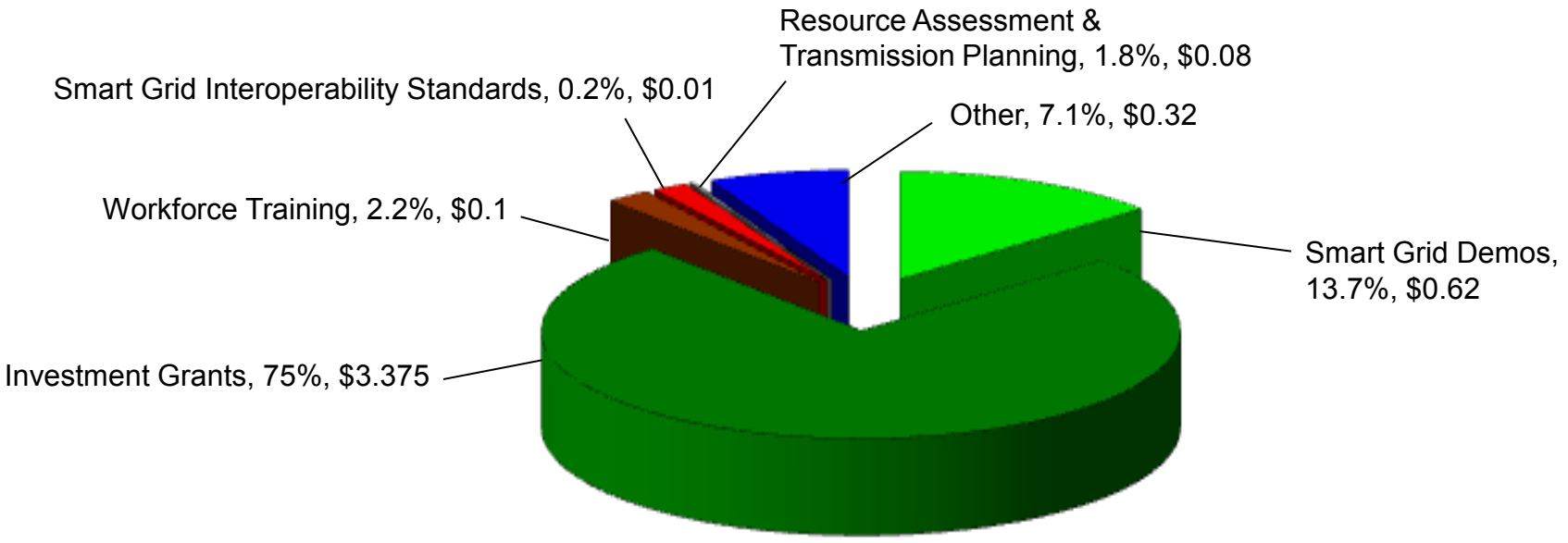
- Enables Informed Participation by Customers
- Accommodates All Generation and Storage Options
- Enables New Products, Services, and Markets

Dynamic optimization goals

- Provides the Power Quality for the Range of Needs in the 21st Century
- Optimizes Asset Utilization and Operating Efficiently
- Addresses Disturbances – Automated Prevention, Containment, and Restoration
- Operates Resiliently Against Physical and Cyber Attacks and Natural Disasters

Grid-connected distributed renewables are supporting or supported by each functionality.

$4.5 Billion for Grid Modernization in Recovery Act Funding



Amounts are in billion US Dollars

- **Independence and Security Act of 2007**
  - $620M for demonstration projects (Section 1304)
  - $3.375B for matching for deployment (Section 1306)

SEE: http://www.energy.gov/recovery

Smart Grid Investment Grants (SGIG)

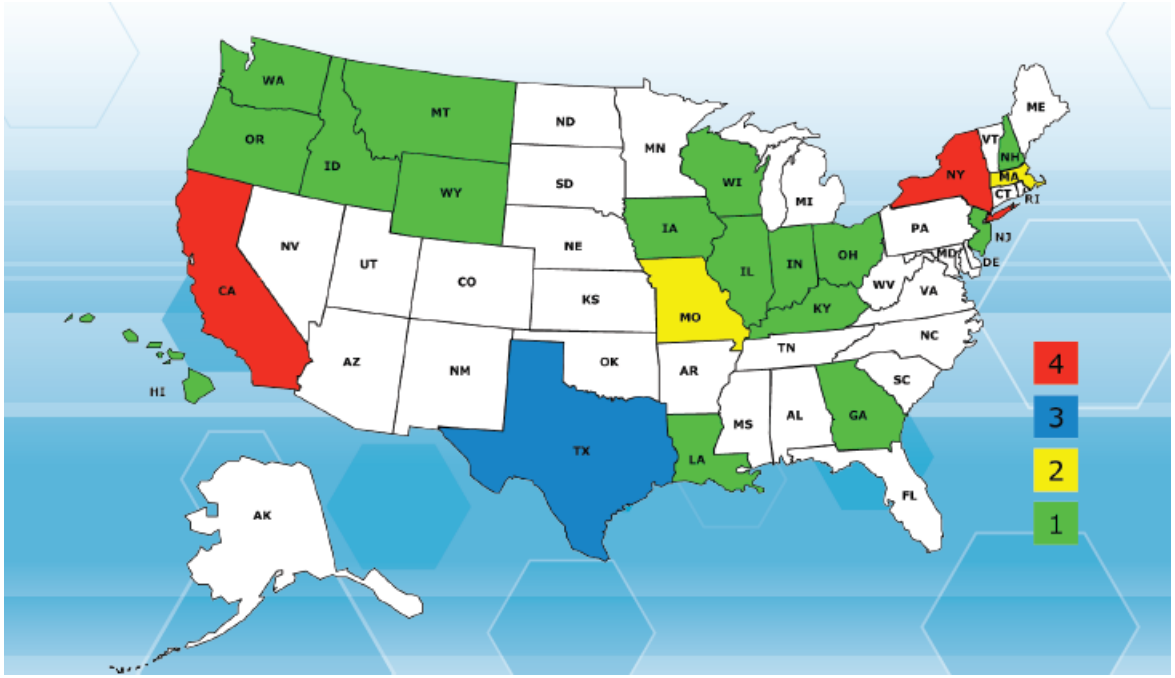
Deploying technologies for immediate commercial use supporting manufacturing, purchasing, and installation of smart grid technologies				
Customer Systems	**Advance Metering Infrastructure**	**Electric Distribution Systems**	**Electric Transmission Systems**	**Equipment Manufacturing**
				
• Displays • Portals • Energy management • Direct load controls	• Smart meters • Data management • Back office integration	• Switches • Feeder optimization • Equipment monitoring • Energy storage	• Wide area monitoring and visualization • Synchrophasor technology • Energy storage	• Energy devices • Software • Appliances

99 projects, $3.4B Federal + $4.6B Private Investments

Recovery Act: Smart Grid Regional Demonstrations

($435M Federal; $877M non-Federal)

16 Awards* Support Projects in 21 States



- ***Demonstrate*** **cutting edge SG technology (including integration of renewables)**
- **Prove ability/ ease to replicate**
- **Show benefits (with actual data)**
- **Validate business models**
- **Address regulatory and scalability issues**

*Individual project award information available at smartgrid.gov

KCP&L Green Impact Zone

(ARRA $23,940,112; Total $48,125,315)

- Project Location: Kansas City, MO
- Key Attributes
  - End-to-end solution; includes renewables (roof-top solar), storage resources, EV charging, substation and distribution automation and control, energy management interfaces, innovative customer programs and rate structures
  - Deploys fully integrated SG in economically challenged area; supports urban revitalization effort
  - The area served by KCP&L's Midtown Substation, impacts about 14,000 commercial and residential customers across ten circuits and two square miles

Partners: City of Kansas City, Mid-America Regional Council, Siemens, OATI, Landis+Gyr, Intergraph, GridPoint, Kokam America

Center for Commercialization of Electric Technologies
Technology Solutions for Wind Integration

(ARRA $13,516,546; Total $27,419,424)

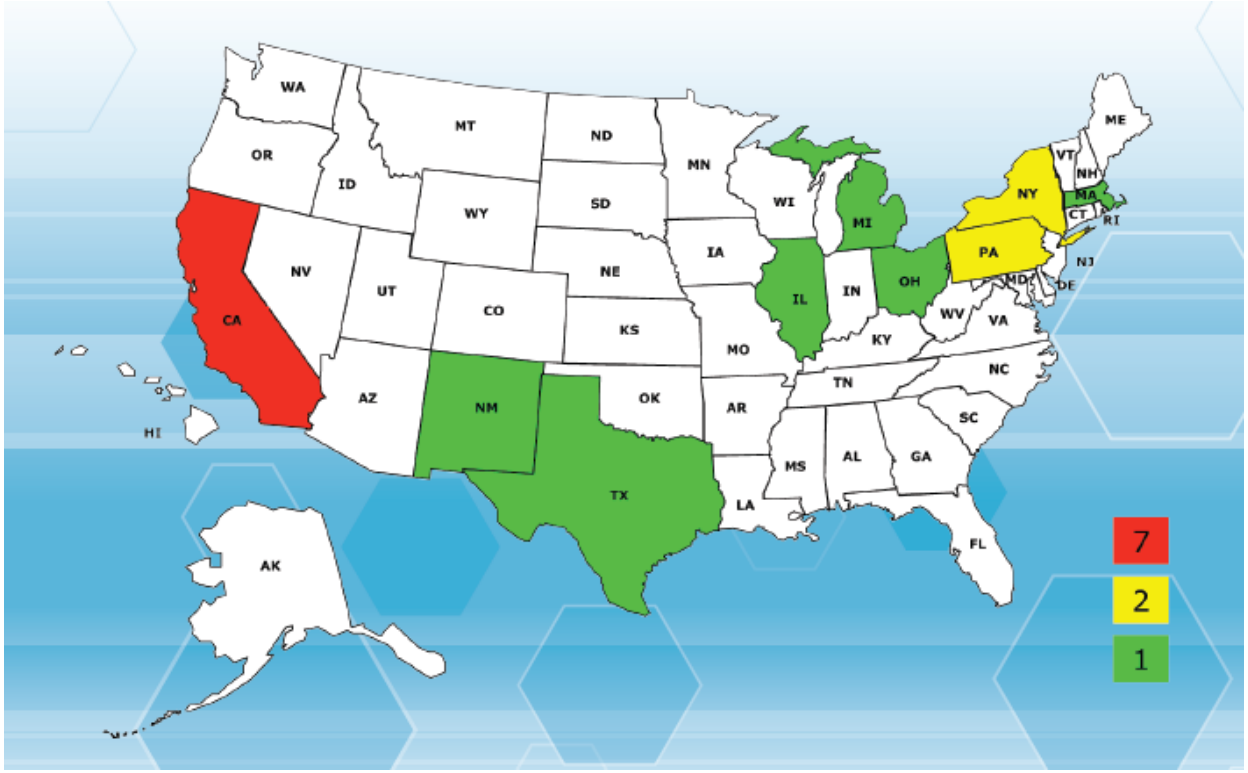
- Project Location: Houston, TX
- Key Attributes
  - Demonstrate synchrophasor technology for better grid operation when moving remote wind resources through ERCOT
  - Implement Smart Meter Texas Portal to initiate demand response events to call upon controllable loads through home area networks
  - Texas Future Community--Community-level battery storage with an innovative demand response program, smart meters, home PV system, load-interruptible DR appliances, efficient building standards and EV charging

Partners: ERCOT, AEP, CenterPoint Energy, Oncor, Sharyland Utilities, Southwest Research Institute, Direct Energy, Electric Power Group, Drummond Group, EcoEdge, Grid Point, GE, Frontier Associates, Xtreme Power, Valence, Land Tejas Developers, Montgomery County MUD 119

Recovery Act: Energy Storage Demonstrations

($185M Federal; $770M non-Federal)

16 Awards* Support Projects in 9 States



*Individual project award information available at smartgrid.gov

- Make renewable energy resources more manageable
- Balance microgrids to match generation with load
- Provide frequency regulation to balance network load and power generated
- Enable deferment of T&D investments
- Provide a more reliable power supply for high-tech industrial facilities

Renewable and Distributed Systems Integration for Peak Load Reduction (RD&D program)

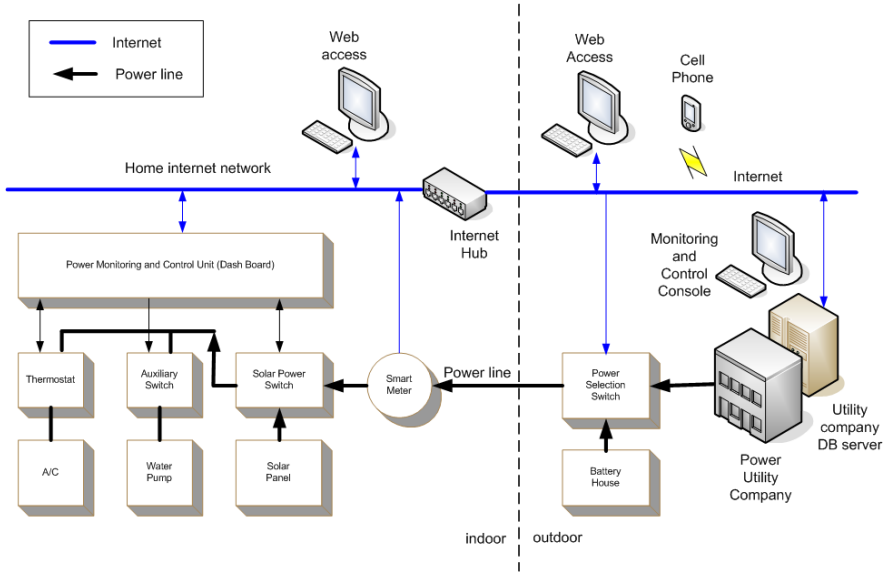
- **Chevron Energy Solutions**—CERTS Microgrid Demo at the Santa Rita Jail - large-scale energy storage, PV, fuel cell
- **SDG&E**—Beach Cities Microgrid - demand response, storage, outage management system, automated distribution control, AMI
- **U of HI**—Transmission Congestion Relief, Maui - intermittency 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

University of Nevada

Dramatic Residential Demand Reduction in the Desert Southwest

- Project Goals
  - 65% decrease in peak demand on electric feeder into low energy housing development
  - Optimized grid management of distributed assets
    - Photovoltaic systems
    - Substation battery storage
    - Advanced meter infrastructure
    - Price responsive and direct load control
  - Development of intelligent agents within consumer gateway connected to advanced meter infrastructure
- 5 years; $7M Fed, $13.9M Non-Fed
- Partners: Nevada Power Co., Pulte Homes, GE Ecomagination

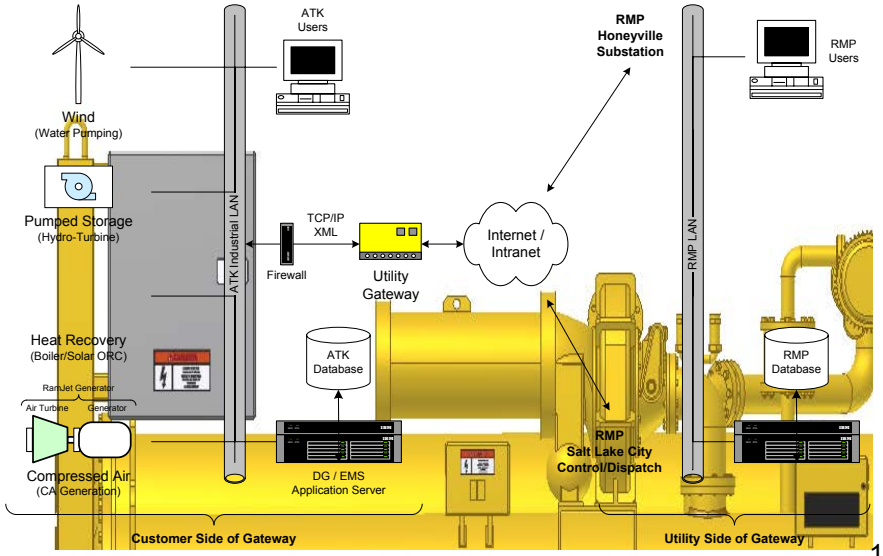


ATK Launch Systems

Integrated Automated DG Demonstration

- Project Goal

  Develop and demonstrate a diverse system of renewable distributed generation technologies that are integrated into an intelligent system-wide automation system with two-way communications to the utility and that will produce a verifiable on-demand reduction of at least 15 percent of substation load with no disruption of facility operations
- Project Partners: Rocky Mountain Power, P&E Automation
- 5 years; $1.6M Fed, $2M Non-Fed
- Project location: Promontory facility
- Project Components: compressed air gen + wind + heat recovery + concentrated solar + steam & hydro turbines + controls
- Major Milestones
  - Design and test renewable distributed generation systems controls
  - Design and test the utility/customer gateway
  - Engineer and install 2.6 MW of diverse, renewable, distributed generation
  - Demonstrate system operations
  - Measure and validate savings and systems benefits



Chevron USA

CERTS Microgrid Demonstration With Large-Scale Energy Storage and Renewables at Santa Rita Jail

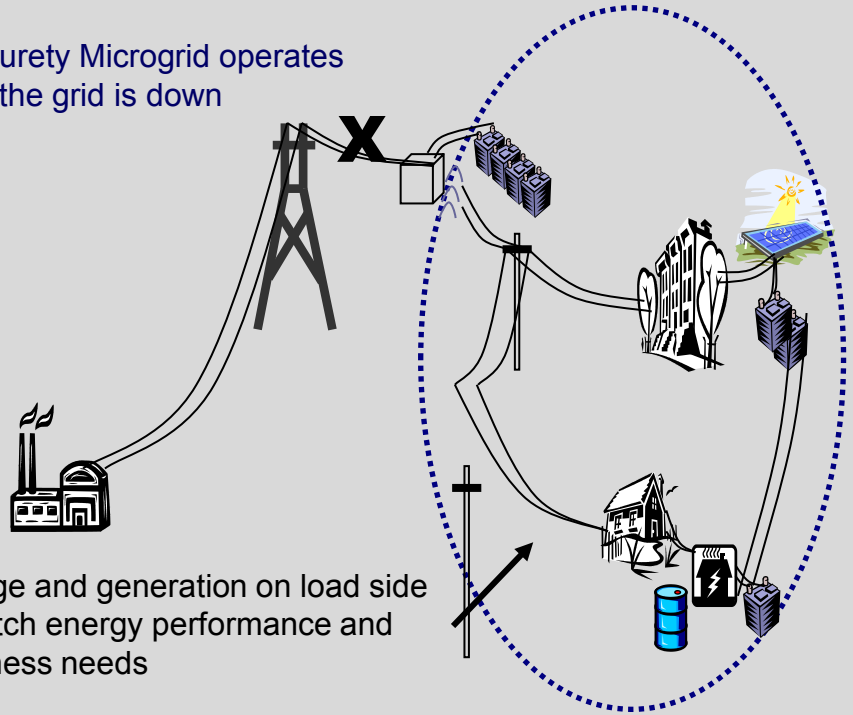
- Project Goals
  - Reduce utility grid peak loads while enabling the autonomous operation of distributed resources during service interruptions
  - Improve grid reliability, serve to increase grid efficiency and security, and meet critical customer power quality and reliability requirements
  - During normal grid-connected operations, the system will reduce the peak demand on the utility's distribution feeder by over 15 percent
- Project Partners: VRB Power Systems, SatCon Power Systems, Energy & Environmental Economics Inc., LBNL, University of Wisconsin, Alameda County, Pacific Gas & Electric Company, Stratgen Consulting
- 3 year contract length; Fed $6M, $6M Non-Fed
- Project location: Santa Rita Jail in Alameda County, CA
- Project components: controls + storage + PV + fuel cell + back-up diesel generators + wind

Energy Surety MicroGrids

OE/DoD jointly developing energy surety microgrid conceptual designs for military bases

- Increase energy supply reliability to support base critical mission readiness
- Improve utilization of on-site distributed generation resources and supports integration of renewables

- **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**

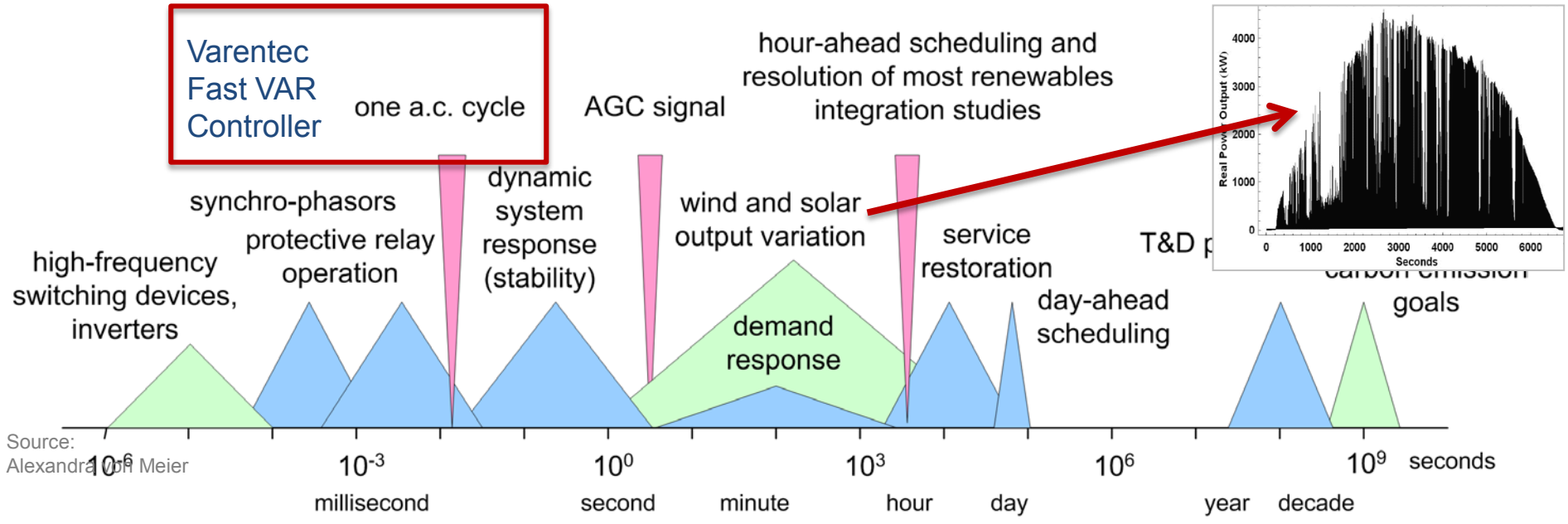
Developing Fast Responding Voltage Control (Under High Penetration of Renewables)

Today – Slow Voltage Control

- Generators & electromechanical switches
- Centralized LTC & Cap Banks (latency)
- Poor dynamic response
- **STATCOMs (fast) > $150 / kVAr**

Future - Varentec Dynamic Voltage Control

- Swarm of fast, distributed controllers
- Decentralized fast local control <1 sec
- Networked, fail-normal, secure
- **Cost point of less than $40/kVAr**



DOE SG Targets: enable RPS Mandates while maintaining stability/reliability of the grid
Alignment: dynamic control hardware plus new algorithms support DOE SG objectives

Distribution Automation Projects

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

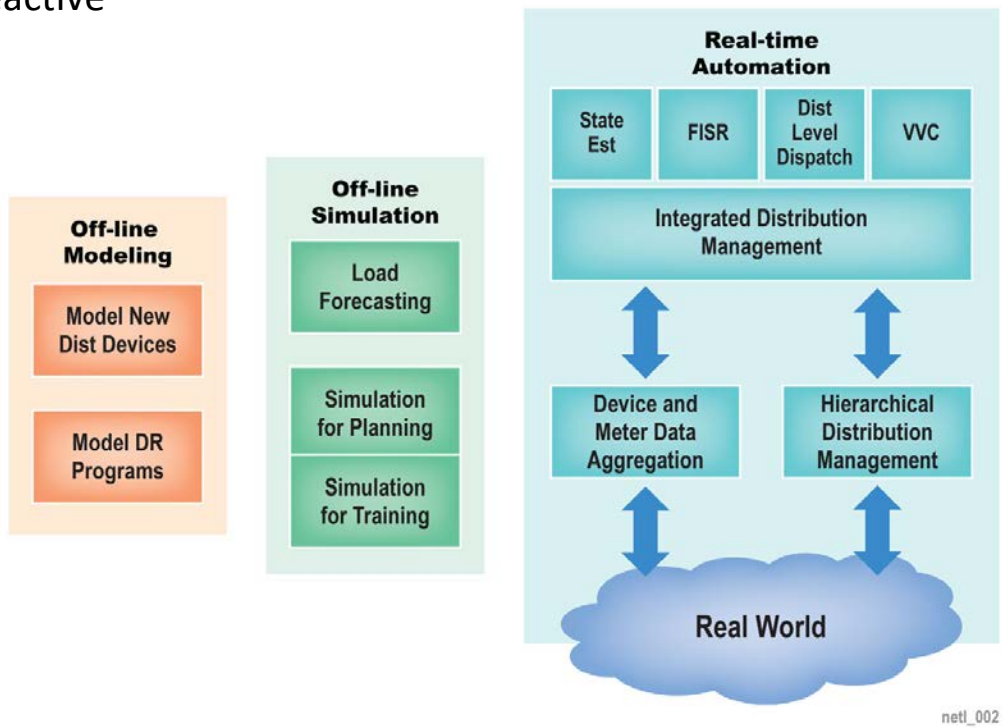
Varentec: Utilize an advanced circuit topology with integration of energy storage, to deliver fast response voltage regulation and dynamic reactive power compensation

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

Simulation and Modeling

Boeing: Distribution Management System for secure interoperability capabilities with legacy and new services for a self-healing, highly automated system.

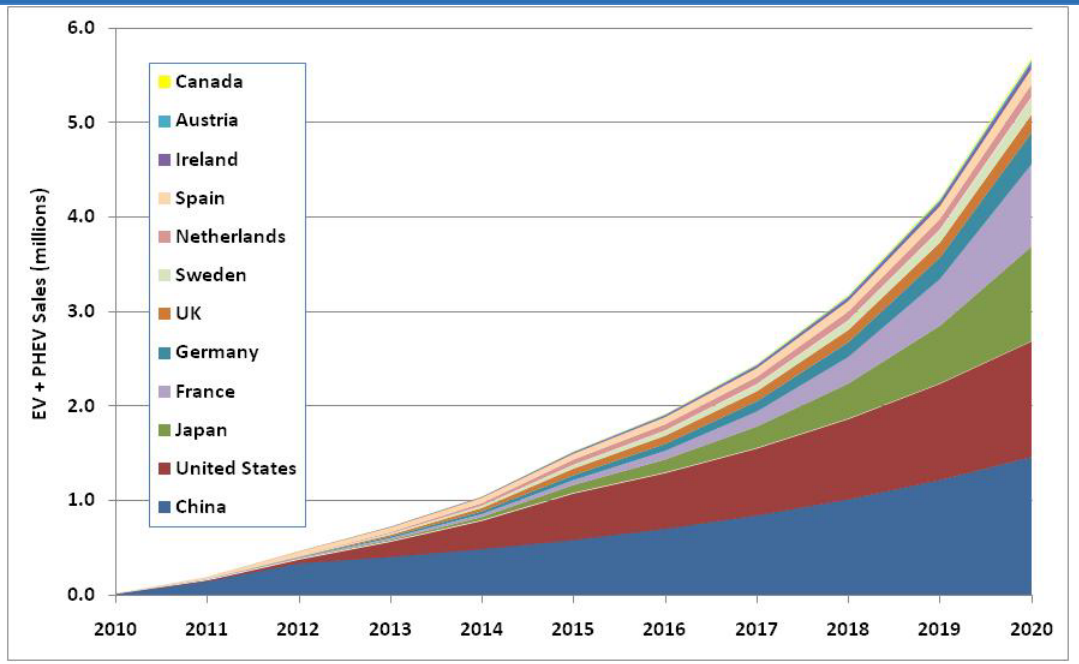
Alstom: The e-*terra* IDMS platform will define, design and prototype an innovative platform for consumer enablement and integration of DER.



PEV Integration

- **Objective**: 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)

Projects:

- **Delta Products** – residential EV charges based on low cost secure wireless networks
- **Siemens** – flexible charging control for power quality and reliability at distribution grid
- **GE** – design and infrastructure for commercial chargers for fleets
- **Eaton** – commercial chargers with two way communications

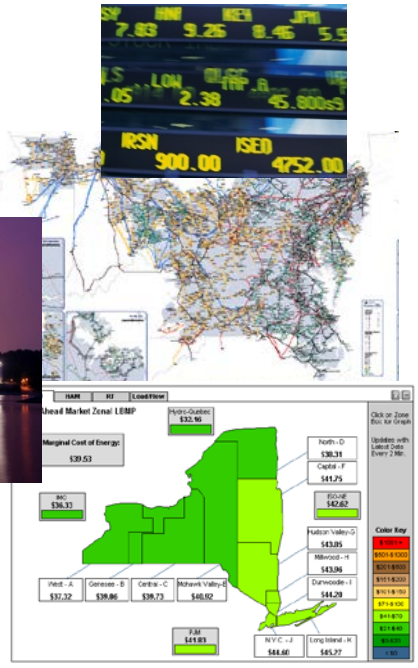
GridLAB-D: A Unique Tool for Designing and Studying Smart Grids

Unifies models of the key elements of a smart grid:

Power Systems

Loads

Markets

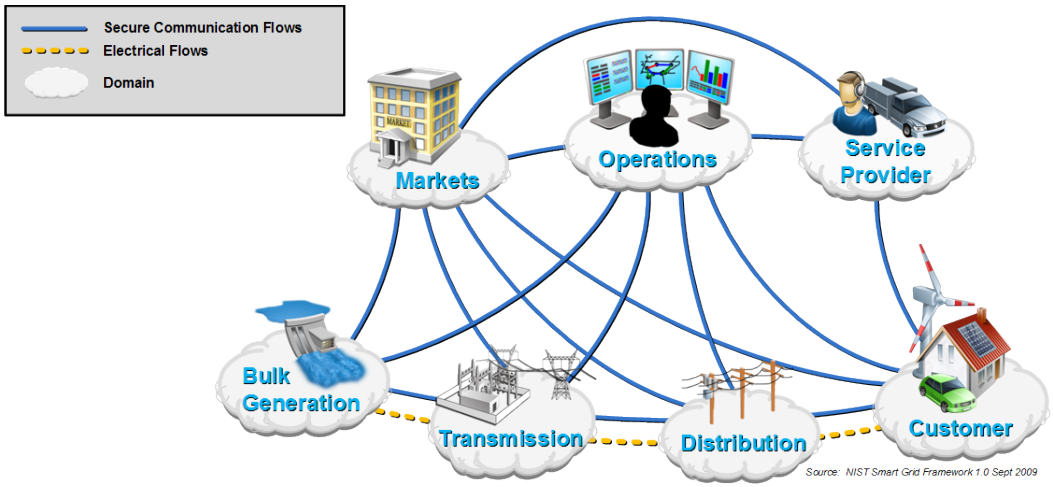


- ✓ Smart grid analyses
  - field projects
  - technologies
  - control strategies
  - cost/benefits
- ✓ Time scale: sec. to yrs
- ✓ Open source
- ✓ Contributions from
  - government
  - industry
  - academia
- ✓ Vendors can add or extract own modules

- GridLAB-D is a DOE-funded, open–source, time-series simulation of all aspects of operating a smart grid from the substation level down to loads in unprecedented detail
- Simultaneously solves:
  - Unbalanced, 3-phase power flow (radial or network), w/explicit control strategies
  - End use load physics, voltage-dependency, behavior & control in 1000s of buildings
  - Double-auction retail supply/demand markets

Standards – Key Aspect of US Policy

DOE provided $12 million in Recovery Act funds to NIST to support carrying out its responsibility, stipulated under the US 2007 Energy Independence and Security Act, *"to coordinate development of a framework that includes protocols and model standards for information management to achieve interoperability of smart grid devices and systems…"*



Standardized architectural concepts, data models, and protocols are essential to achieve interoperability, reliability, security, and evolvability

- Congress directed that the framework be "flexible, uniform, and technology neutral"
- Use of these standards is a criterion for federal Smart Grid Investment Grants
- Input to federal and state regulators

Cybersecurity for Energy Delivery Systems Program

Assess and Monitor Risk

Develop security metrics, as well as tools and methodologies for measuring and assessing both static and real-time security states to support risk management decision making

- Develop the Cybersecurity Maturity Model

Develop and Implement New Protective Measures

Harden legacy and next-generation energy delivery system architectures with security tools and procedures to be more resilient to a cyber incident

National SCADA Test Bed (NSTB)

Partner with control system vendors to discover and mitigate SCADA vulnerabilities in next-generation systems prior to deployment

Manage Incidents

Focus on detection, containment, remediation, recovery and restoration, and post incident analysis/forensics to be prepared for an incident once it occurs

Sustain Security Improvements

Collaborate between industry, academia, and government to advance cybersecurity

- Support the Energy Sector Control Systems Working Group to develop, implement, and update the *Roadmap to Secure Control Systems in the Energy Sector*

Summary

- Considerable efforts underway in many aspects of grid modernization
- Significant lessons from the ARRA and other demonstrations underway, including identification of future needs
- Understanding how to efficiently and effectively integrate all aspects of this complex, dynamic system will require constant vigilance and creative solutions as the demands on the electricity system continue to increase