December 4, 2013

Office of Electricity Delivery & Energy Reliability

Results and Findings from the ARRA-Funded Smart Grid Projects

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December 3-4, 2013

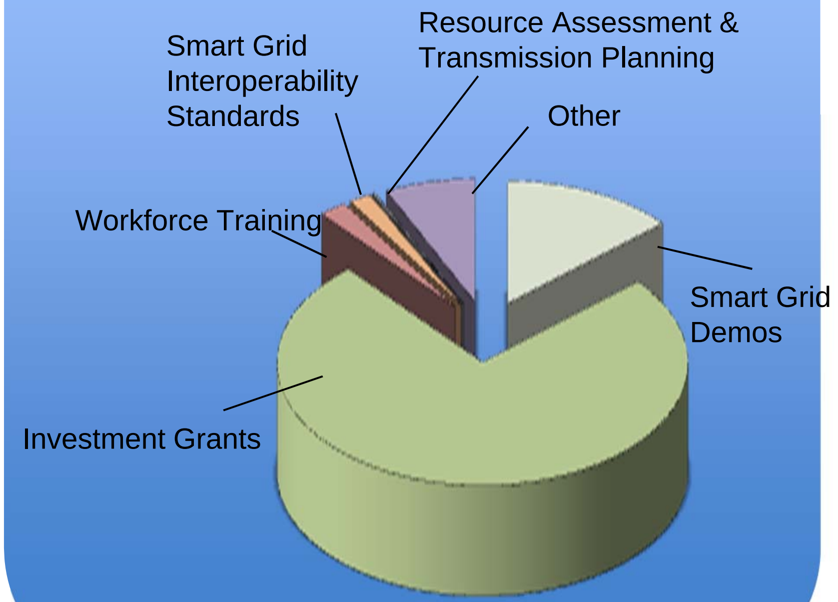
Recovery Act Smart Grid Programs

Recovery Act Smart Grid Programs

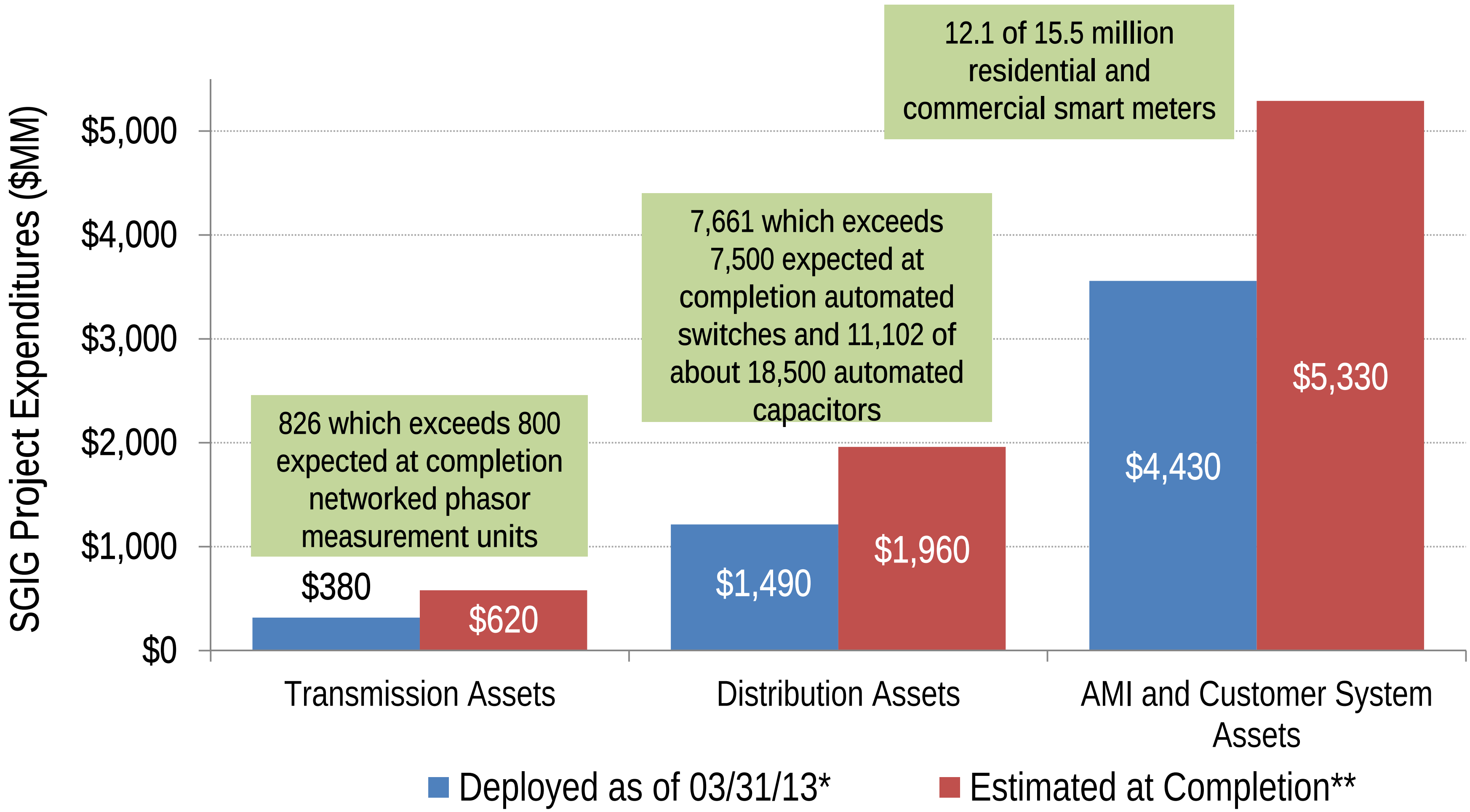
- Smart Grid Investment Grants (SGIG)*
  - $3.4 billion
- Smart Grid Regional Demonstrations (SGDP)*
  - $620 million
- Workforce Training
  - $100 million
- Interconnection-wide Transmission Planning and Resource Analysis
  - $80 million
- Interoperability Standards (with NIST)
  - $12 million
- Other
  - Technical Assistance to States ($44 million)
  - Local Energy Assurance Planning ($10 million)

Originally authorized by the Energy Infrastructure Security Act 2007, EISA 1306 and EISA 1304

One-time Appropriation $4.5B of Recovery Act Funds



SGIG Deployment Status



*Number of entities: 99
Updated on September 5, 2013

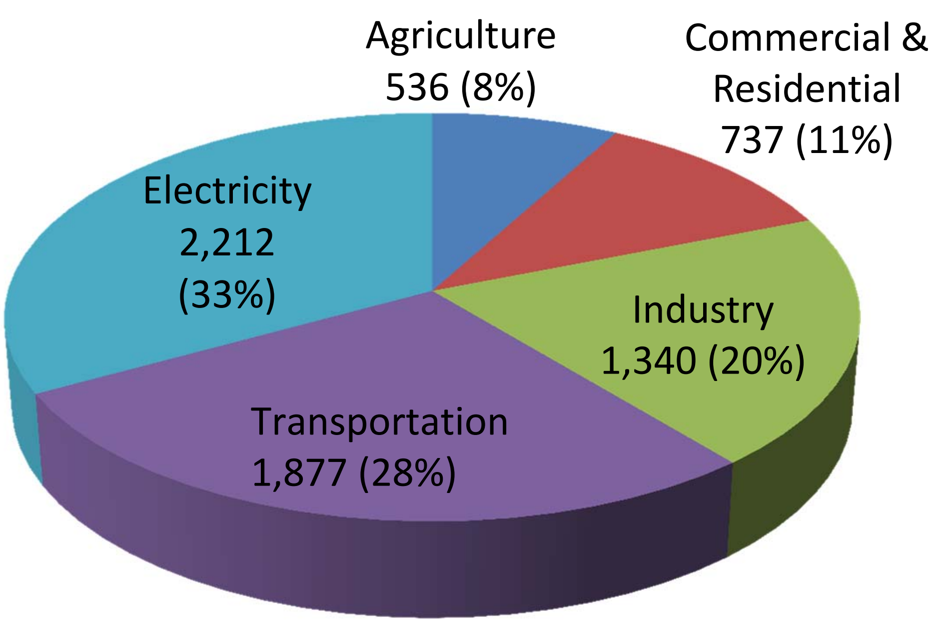
Applications and Benefits Matrix

Benefits	Smart Grid Technology Applications					
	Consumer-Based Demand Management Programs (AMI-Enabled)	Advanced Metering Infrastructure (AMI) Applied to Operations	Fault Location, Isolation and Service Restoration	Equipment Health Monitoring	Improved Volt/VAR Management	Synchrophasor Technology Applications
	• Time-based pricing • Customer devices (information and control systems) • Direct load control (does not require AMI)	• Meter services • Outage management • Volt-VAR management • Tamper detection • Back-Office systems support (e.g., billing and customer service)	• Automated feeder switching • Fault location • AMI and outage management	• Condition-based maintenance • Stress reduction on equipment	• Peak demand reduction • Conservation Voltage Reduction • Reactive power compensation	• Real-time and off-line applications
Capital expenditure reduction – enhanced utilization of G,T & D assets	✔			✔	✔	✔
Energy use reduction	✔	✔	✔		✔	✔
Reliability improvements		✔	✔	✔		✔
O&M cost savings		✔	✔	✔		
Reduced electricity costs to consumers	✔				✔	
Lower pollutant emissions	✔	✔	✔		✔	✔
Enhanced system flexibility – to meet resiliency needs and accommodate all generation and demand resources	✔	✔	✔	✔	✔	✔

Greenhouse Gas Emissions

Electricity generation accounts for 40% of total national energy use and 33% of greenhouse gas emissions

Million Metric Tons of CO2 Equivalent



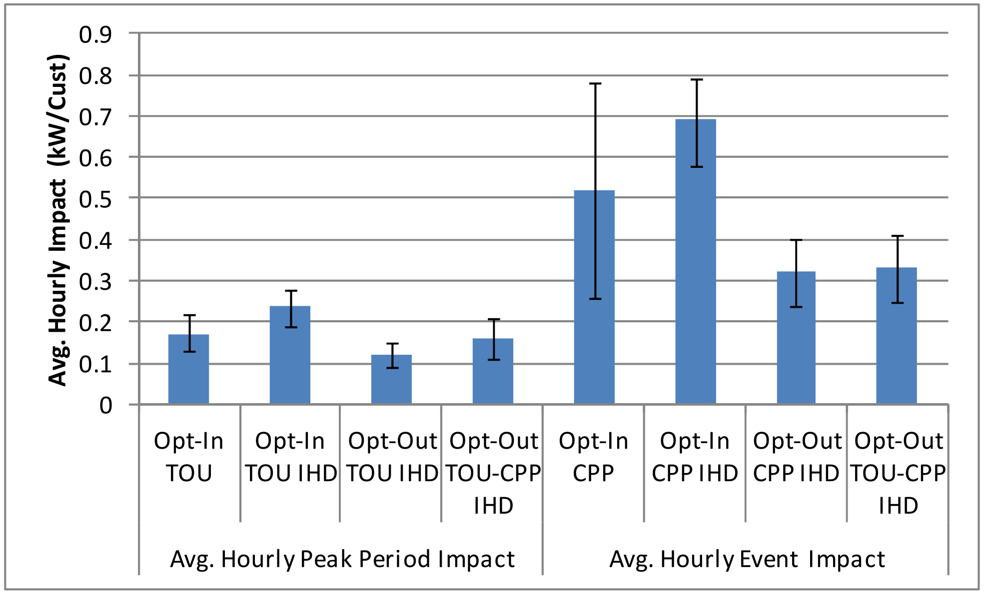
Sources: EIA. Monthly Energy Review August 2013 and EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks

Administration GHG Reduction Goal:

17% below 2005 levels by 2020

- Reducing carbon pollution from power plants
- Accelerating clean energy leadership
- Building a 21st Century transportation sector
- Cutting energy waste in homes, businesses and factories
- Reducing other greenhouse gas emissions
- Federal leadership

CBS Project at SMUD

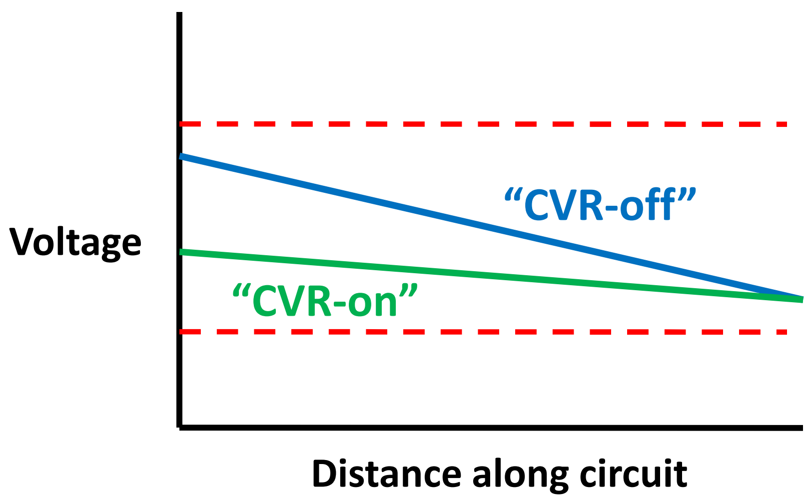


	TOU (¢/kWh)	Block w/CPP (¢/kWh)	TOU w/CPP (¢/kWh)
Base/Off-Peak <700 kWh	8.5	8.5	7.2
Base/Off-Peak >700 kWh	16.6	16.7	14.1
Peak	27.0	n/a	27.0
Critical Event	n/a	75.0	75.0
No. of Critical Events	n/a	12	12

- Study results show a 0.12-0.24 kW avg. reduction per customer during peak period is possible, with reductions 2-3X greater for event-based CPP
- Acceptance rates much higher for Opt-Out (>93%) than Opt-In (16-18%) but attrition rates were minimal in ALL cases (0-2% for Opt-In and 2-4% for Opt-Out)
- If CPP or TOU offered to 100,000 customers, results indicate aggregate event day load impact would be MUCH bigger for Opt-Out (30.7 and 16.6 MW, respectively) than Opt-In (12.6 and 6.7 MW, respectively)

Applying Volt/VAR Optimization to Improve Energy Efficency

Conservation voltage reduction (CVR) reduces customer voltages along a distribution feeder for lowering peak demands and overall energy consumption



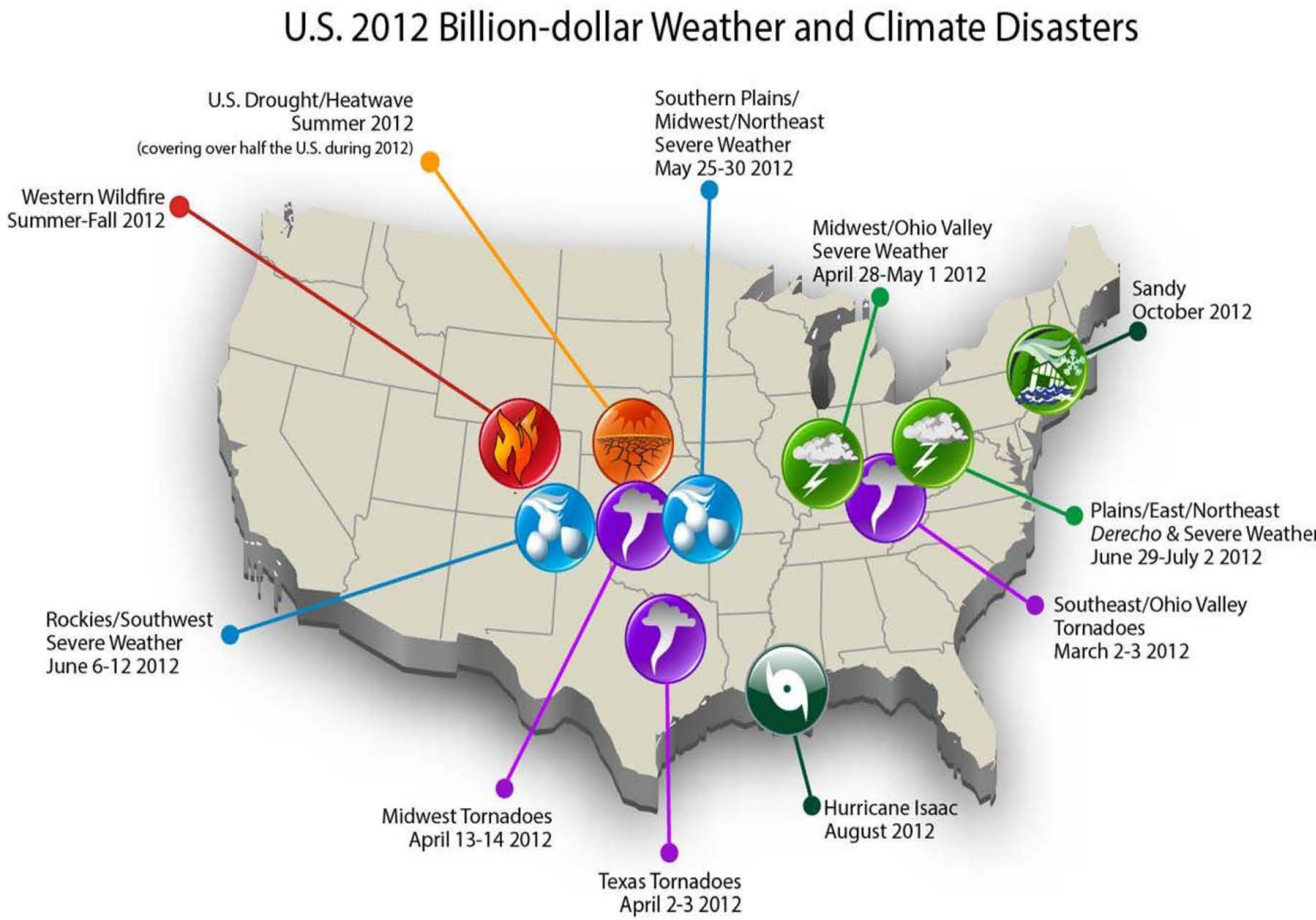
OG&E:

- **Control algorithm set voltage levels at the substation**
  - **Applying smart meter data**
  - **Capability turned on when power price exceeds $0.22/kWh**
- **Achieved 8 MW reduction from application of VVC technology on 50 circuits during Summer 2011**
- **Goal – 74 MW reduction over 400 circuits by 2017 (SGIG contributes to 16 MW)**

PNNL 2010 GRID-LAB-D Analysis:

National deployment of CVR provides a 3.0% reduction in annual energy consumption for the electricity sector. 80% of this benefit can be achieved from 40% of feeders.

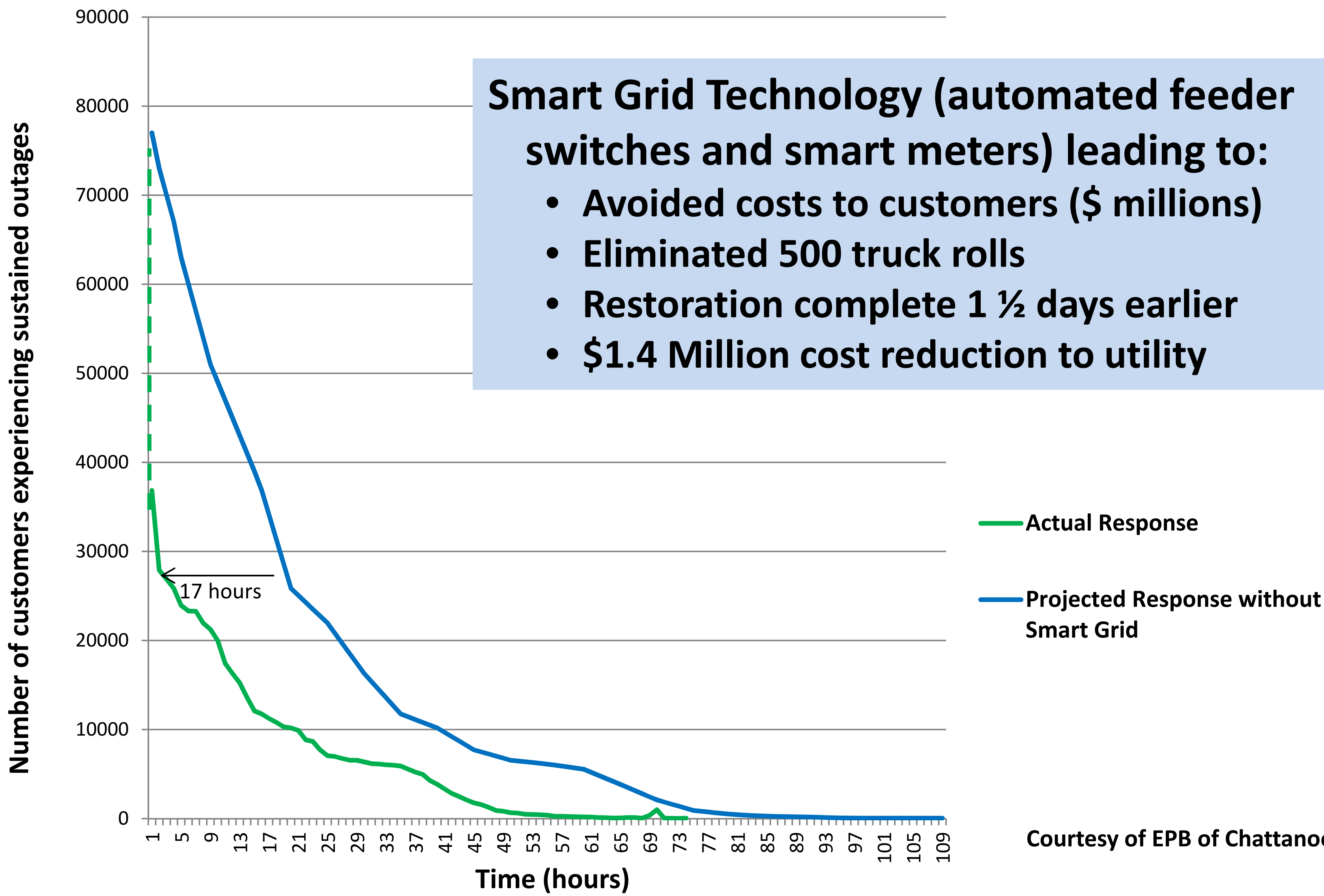
Recent Weather Patterns



July 5, 2012 Storm Response

Smart Grid Technology (automated feeder switches and smart meters) leading to:

- **Avoided costs to customers ($ millions)**
- **Eliminated 500 truck rolls**
- **Restoration complete 1 ½ days earlier**
- **$1.4 Million cost reduction to utility**



Courtesy of EPB of Chattanooga

Value of Service

One utility has installed 230 automated feeder switches on 75 circuits in an urban area. From Apr 1 – Sep 30 2011:

SAIDI improved 24%; average outage duration decreased from 72.3 minutes to 54.6 minutes (or by 17.7 minutes).

Estimated Avg. Customer Interruption Costs US 2008$ by Customer Type and Duration						
Customer Type	**Interruption Cost Summer Weekday**	**Interruption Duration**				
		Momentary	**30 mins**	**1 hr**	**4 hr**	**8 hr**
Large C&I	Cost Per Average kWh	$173	$38	$25	$18	$14
Small C&I	Cost Per Average kWh	$2,401	$556	$373	$307	$2,173
Residential	Cost Per Average kWh	$21.6	$4.4	$2.6	$1.3	$0.9

Sullivan J, Michael, 2009 *Estimated Value of Service Reliability for Electric Utility Customers in the US*, xxi

VOS Improvement Δ = Δ SAIDI x Customers Served x Avg Load x VOS Coefficient

VOS Estimate for SAIDI Improvement on 75 feeders from Apr 1 to Sep 30 2011					
Customer Class	**Δ SAIDI**	**Customers Served within a Class**	**Average Load (kW) Not Served**	**VOS Coefficient ($/kWh)**	**Δ VOS**
Residential	17.7 mins (0.295 hrs)	107,390	2	$ 2.60	$ 164,736
Commercial		8,261	20	$ 373.00	$ 18,179,477
Industrial		2,360	200	$ 25.00	$ 3,481,325
Total		**118,011**			**$ 21,825,537**

AMI Improvements in Operational Efficiencies

Results from 15 projects due to automation of metering service tasks and reductions in labor hours and truck rolls

Smart Meter Capabilities	O&M Savings	% Reduction
• Remote meter reading • Remote service connections/disconnections	Meter Operations Cost	13-77
	Vehicle Miles	12-59

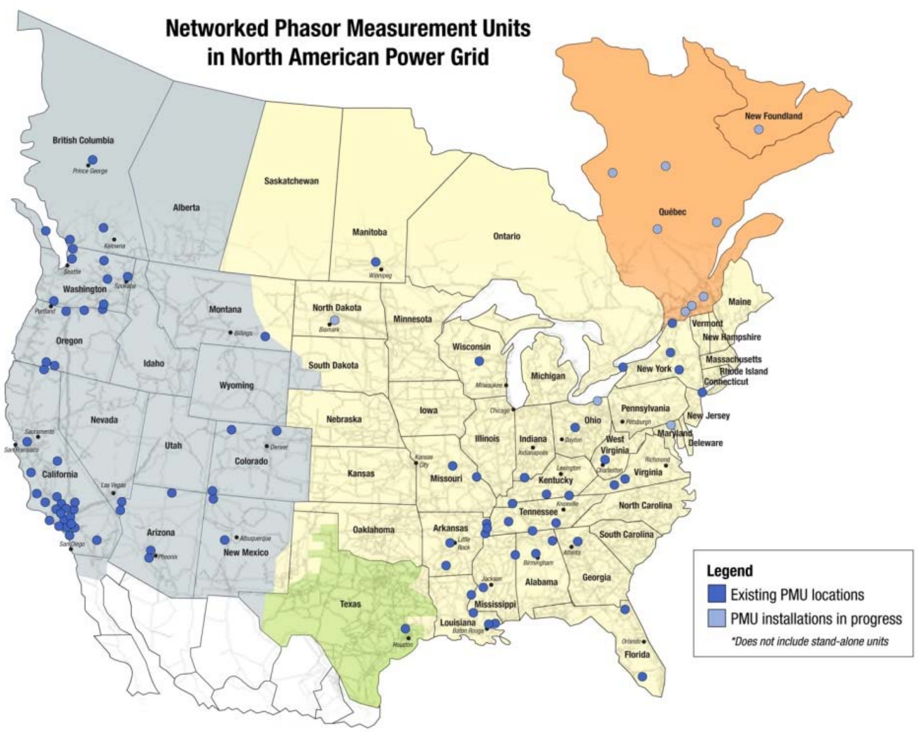
Future SGIG examples to provide information on other benefits

Smart Meter Capabilities	Expected Benefits
• Tamper detection and notification	Enables potential recovery of ~1% of revenues that may be lost from meter tampering
• Outage detection and notification	Enables faster restoration (e.g., PECO avoided 6,000 truck rolls following Superstorm Sandy and accelerated restoration by 2-3 days)
• Voltage and power quality monitoring	Enables more effective management of voltages for conservation voltage reductions and other VVO applications

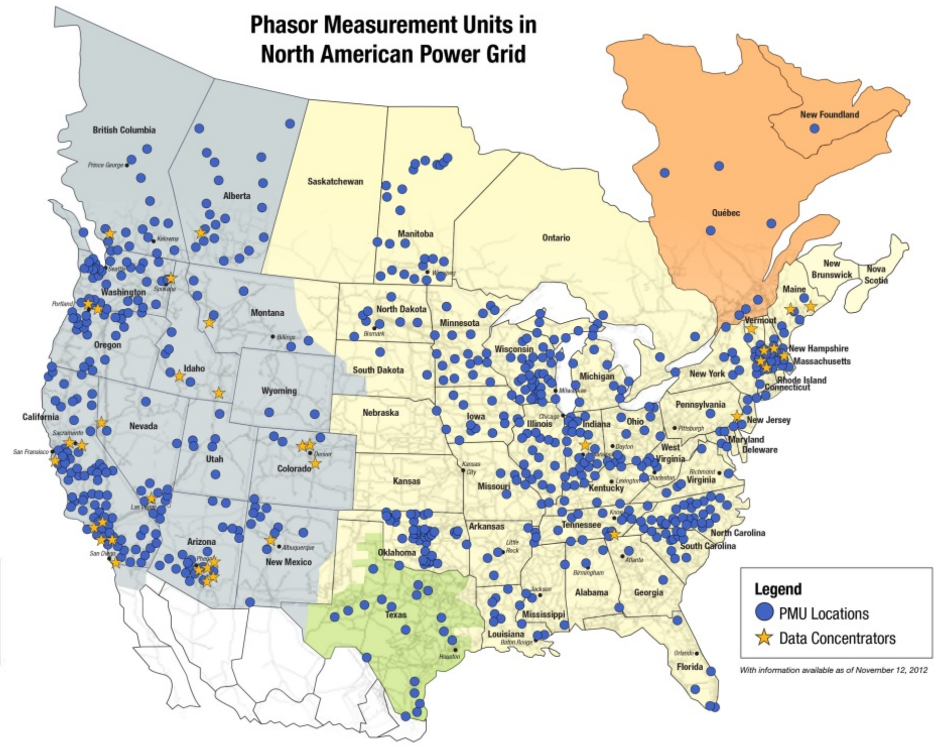
Synchrophasor Technology for Transmission System Operations

DOE and NERC/NASPI are working together closely with industry to enable wide area time-synchronized measurements that will enhance the reliability of the electric power grid through improved situational awareness and other applications

April 2007

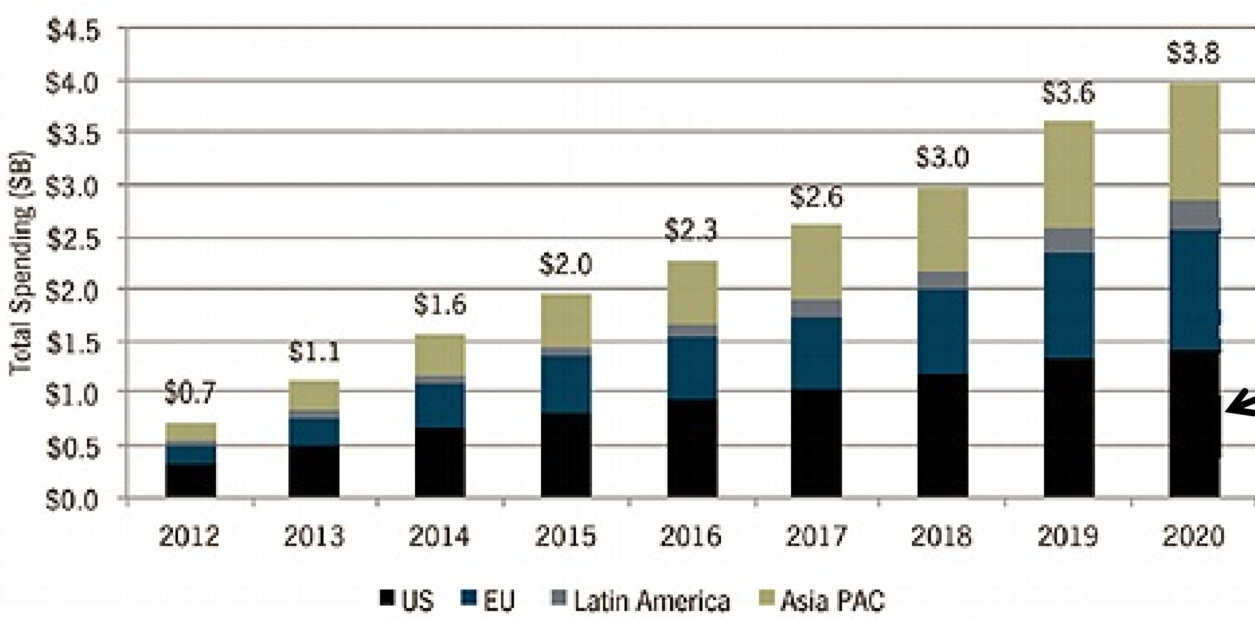


November 2012



Growth in Utility Data Analytics

FIGURE: Global Utility Analytics Spending, 2012-2020

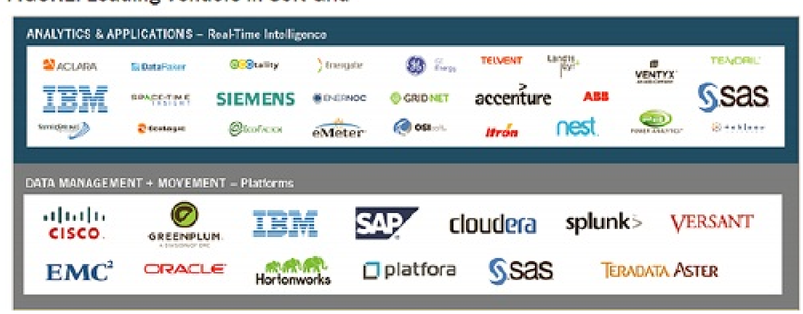


Spending in US at $1.4 billion in 2020

Provides utilities ability to track, visualize and predict:

- Asset management
- Outage management
- Mobile workforce management
- Customer behavior
- Power flow management (real-time balancing)

FIGURE: Leading Vendors in Soft Grid



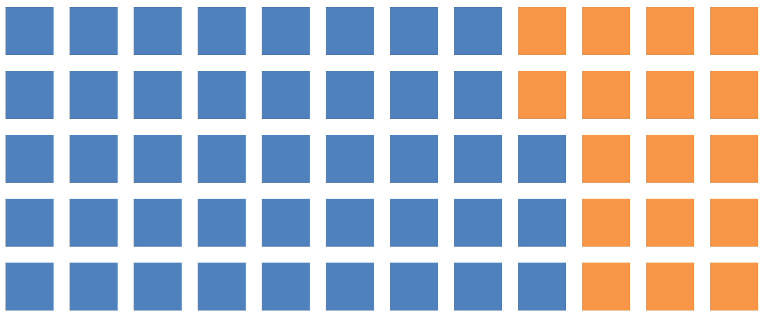
Source: "The Soft Grid 2013-2020: Big Data & Utility Analytics for Smart Grid," GTM Research

Grid Modernization Investments

SGIG projects *accelerate* industry investment to achieve a modern grid

ARRA Spending **$7.8 billion with cost share to be spent through 2015**

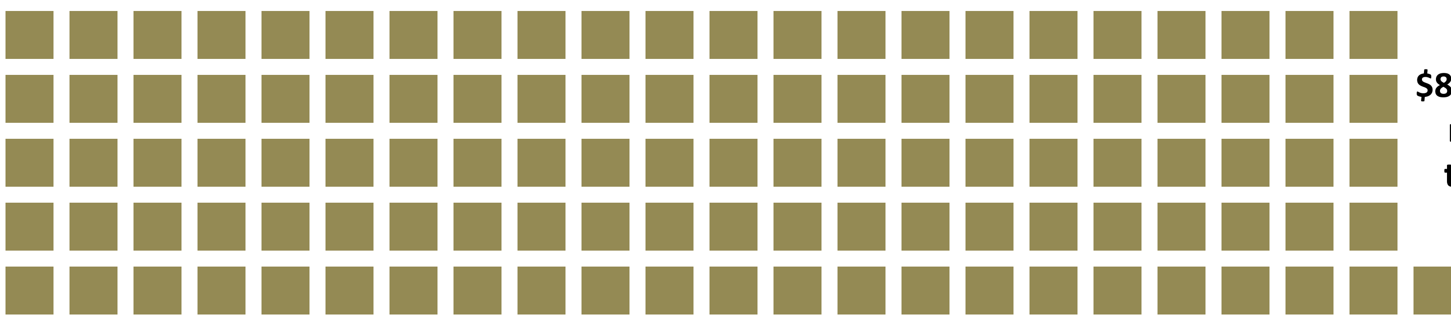
EPRI Estimate



$338 - $476 billion needed through 2030

EPRI. Estimating the costs and benefits of the smart grid: A preliminary estimate of the investment requirements and the resultant benefits of a fully functioning smart grid. EPRI, Palo Alto, CA; 2011.

Brattle Group Estimate



$880 billion needed through 2030

Chupka, M.W. Earle, R., Fox-Penner, P., Hledik, R. Transforming America's power industry: The investment challenge 2010 – 2030. Edison Electric Institute, Washington D.C.,: 2008.

For More Information

Contact: joseph.paladino@hq.doe.gov

Websites: www.oe.energy.gov
www.smartgrid.gov

Reports:

SGIG Progress Report (July 2012)
Peak Demand Reductions – Initial Results (December 2012)
AMI O&M Savings – Initial Results (December 2012)
Reliability Improvements – Initial Results (December 2012)
Voltage Optimization – Initial Results (December 2012)
Economic Impact (April 2013)
Customer Enrollment Patterns in Time-Based Rate Programs (June 2013)
Synchrophasor Technologies and Their Deployment in Recovery Act Smart Grid Programs (August 2013)

All reports are downloadable from:

http://www.smartgrid.gov/all/news/department_energy_releases_smart_grid_impact_reports