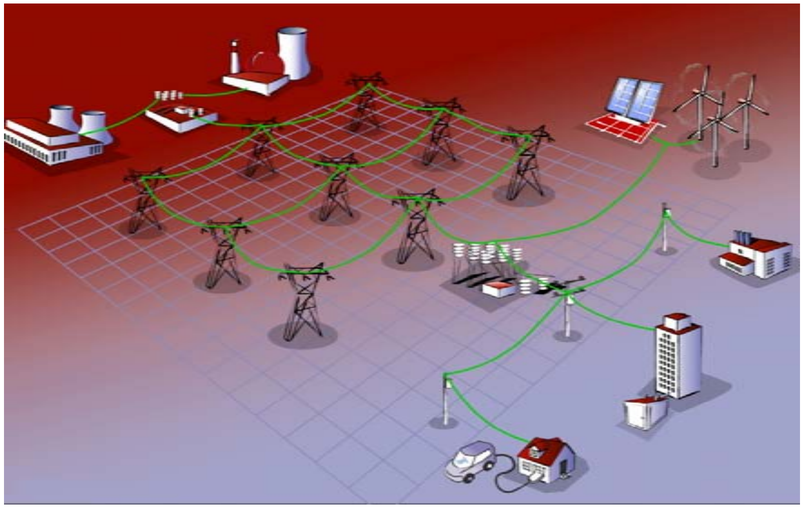
NATIONAL ENERGY TECHNOLOGY LABORATORY



Success Stories in DOE's ARRA Smart Grid Program

Steve Bossart, Senior Energy Analyst

Smart Grids & Microgrids for Government & Military Symposium

October 24-25, 2013, Arlington, VA

U.S. DEPARTMENT OF ENERGY

Topics

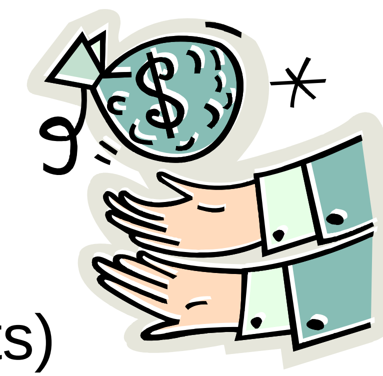
- OE ARRA Smart Grid Program
- OE ARRA Smart Grid Progress
- Case Studies/Success Stories
- Life After ARRA Smart Grid

DOE OE ARRA
Smart Grid Program

Smart Grid ARRA Activities

American Recovery and Reinvestment Act ($4.5B)

- Smart Grid Investment Grants (99 projects)
  - $3.4 billion Federal; $4.7 billion private sector
  - > 800 PMUs covering almost 100% of transmission
  - ~ 8000 distribution automation circuits
  - > 15 million smart meters

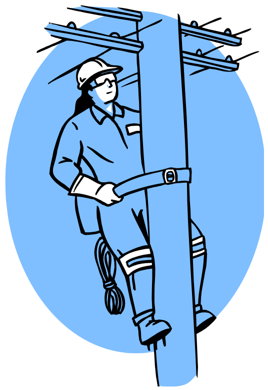


- Smart Grid Demonstration Projects (32 projects)
  - $685 million Federal; $1 billion private sector
  - 16 storage projects
  - 16 regional demonstrations

Smart Grid ARRA Activities (continued)

Additional ARRA Smart Grid Activities

- Interoperability Framework by NIST ($12M)
- Transmission Analysis and Planning ($80M)
- State Electricity Regulator Assistance ($49M)
- State Planning for Smart Grid Resiliency ($52M)
- Workforce Development ($100M)

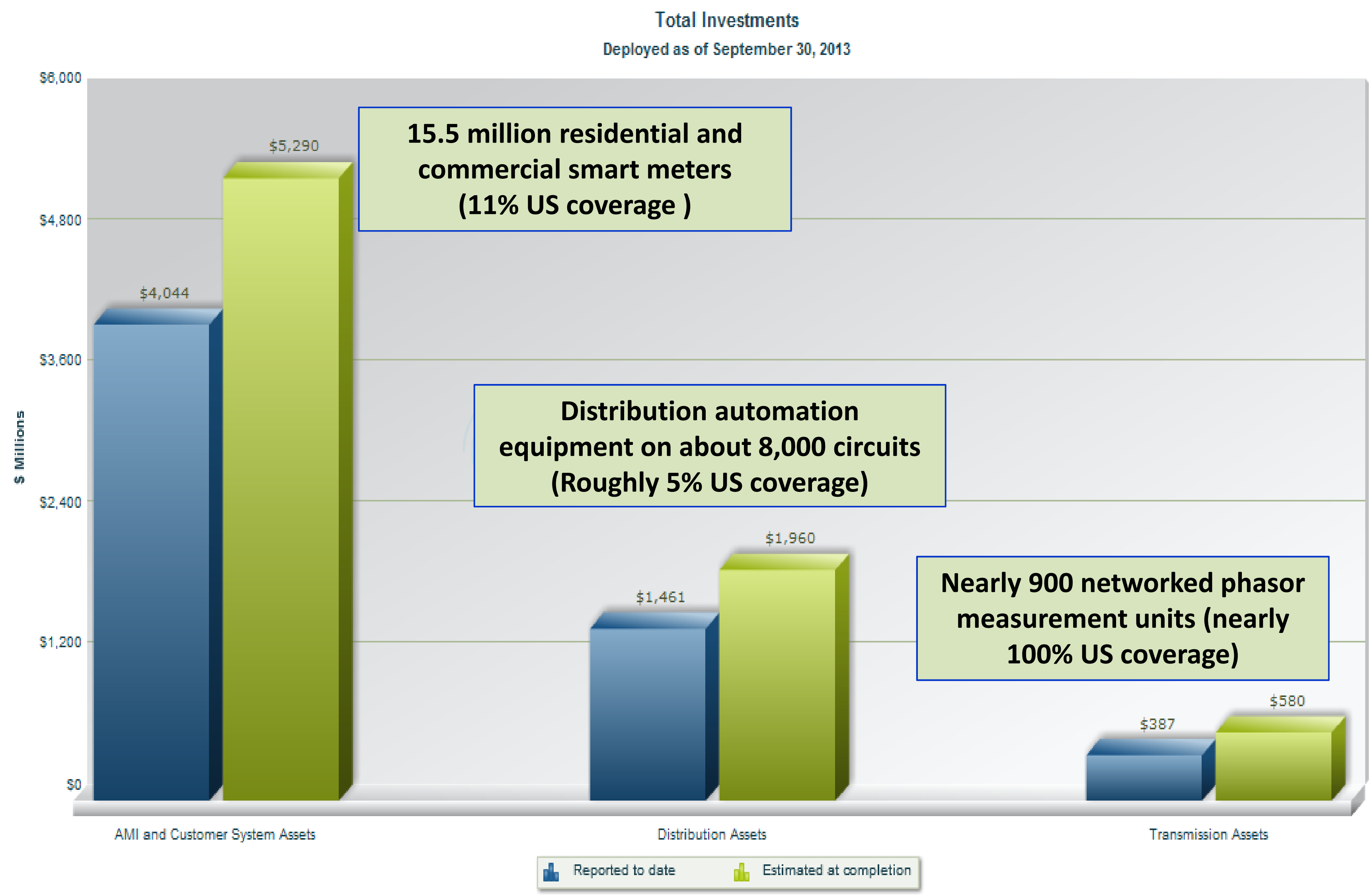


Technology Deployment

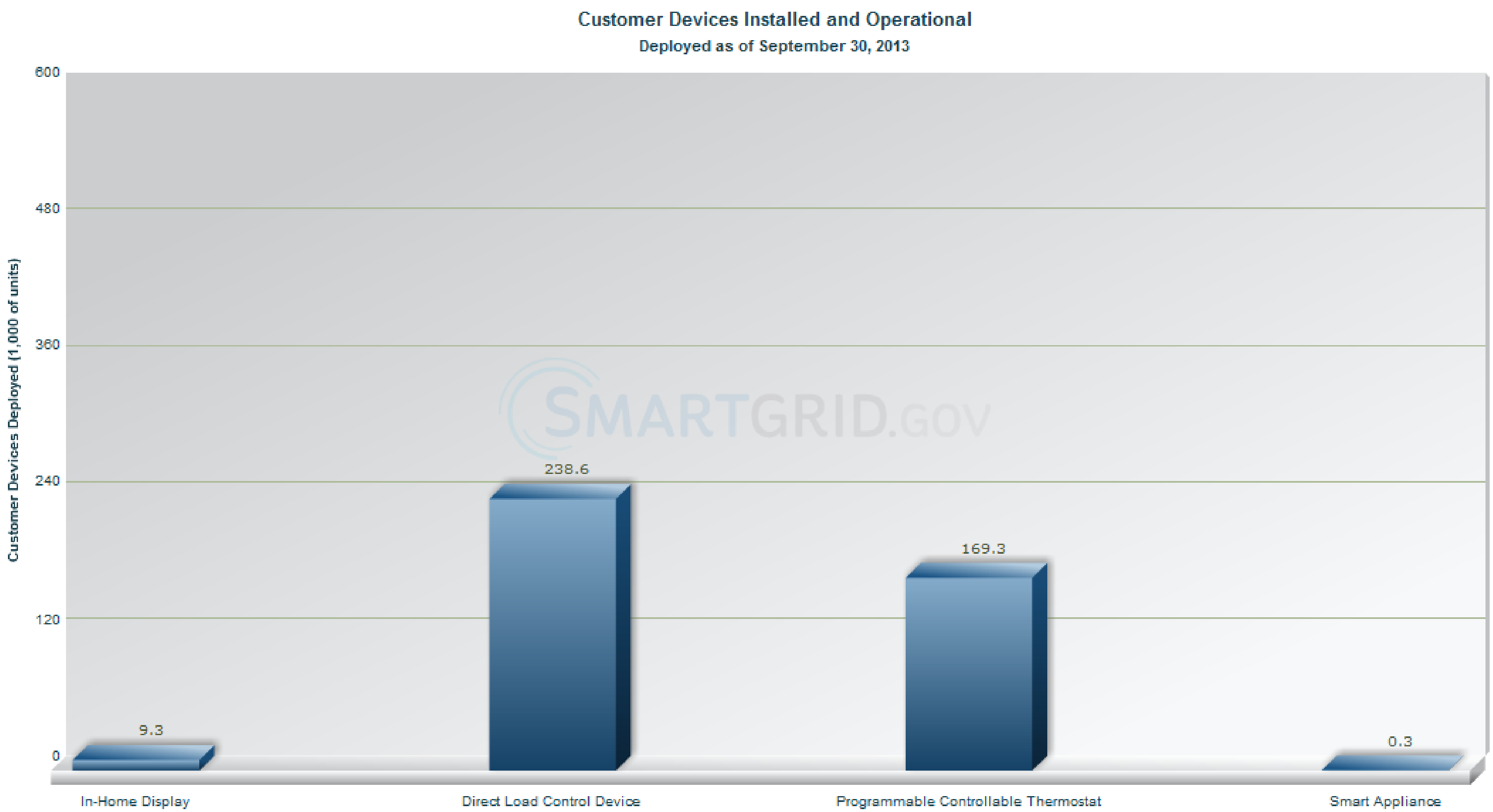
SGIG/SGDP Areas of Smart Grid Technology Deployment				
Customer Systems	**Advance Metering Infrastructure**	**Electric Distribution Systems**	**Electric Transmission Systems**	**Equipment Manufacturing**
				
• Displays • Internet portals • Direct load controls • Programmable thermostats • EV Chargers	• Smart meters • Data management • Back office integration	• Auto switches • Automated capacitors • Auto voltage regulators • Equipment monitoring • Energy Storage	• Wide area monitoring • Synchrophasor Technology • Phasor data concentrators • Dynamic line rating • Energy Storage	• Energy devices • Software • Appliances

ARRA Smart Grid Progress

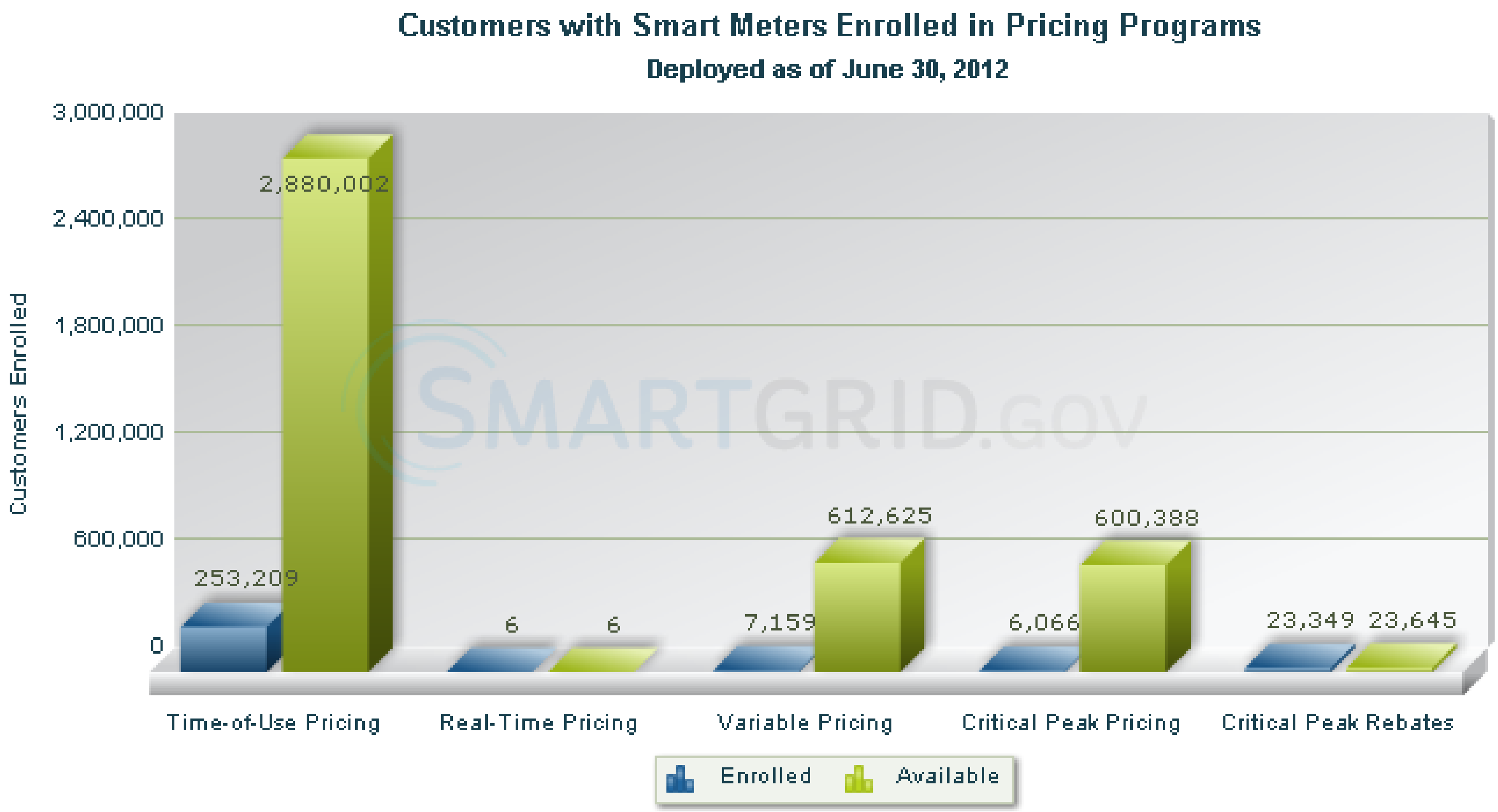
SGIG Deployment Status



Customer Devices in SGIG Projects



Customers with Smart Meters Enrolled in Pricing Programs in SGIG



Case Studies/Success Stories

Peak Demand Reduction from AMI, Pricing, and Customer Systems

Selected examples from SGIG projects reporting initial results

Project Elements	OG&E 770,000 customers	MMLD 11,000 customers	SVE 18,000 customers
Customers Tested	6,000 residential	500 residential	600 mostly residential
Time-Based Rate(s)	TOU and VPP, w/CPP	CPP	CPP
Customer Systems	IHDs, PCTs, and Web Portals	Web Portals	Web Portals
Peak Demand Reduction	Up to 30% 1.3 kW/customer (1.8 kW/customer w/CPP)	37% 0.74 kW/customer	Up to 25% 0.85 kW/customer
Outcome	Deferral of 210 MW of peak demand by 2014 with 20% participation	Lowers total purchase of peak electricity	Lowers total purchase of peak electricity
Customer Acceptance	Positive experience, many reduced electricity bills	Positive experience, but did not use the web portals often	Interested in continued participation, many reduced electricity bills

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

Reliability Improvements from Automated Feeder Switching

Selected examples from SGIG projects reporting initial results

4 Projects involving 1,250 feeders

April 1, 2011 through March 31, 2012

Index	Description	Weighted Average (Range)
SAIFI	**System Average Interruption Frequency Index (outages)**	**-22 %** (-11% to -49%)
MAIFI	**Momentary Average Interruption Frequency Index (interruptions)**	**-22 %** (-13% to -35%)
SAIDI	**System Average Interruption Duration Index (minutes)**	**-18 %** (+4% to -56%)
CAIDI	**Customer Average Interruption Duration Index (minutes)**	**+8 %** (+29% to -15%)

Weighted average based on numbers of feeders

Value of Service from Improvements in Reliability

Selected example from an SGIG project reporting initial results
1 project involving 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 to 54.6 minutes

Estimated Average Customer Interruption Costs US 2008$ by Customer Type and Duration

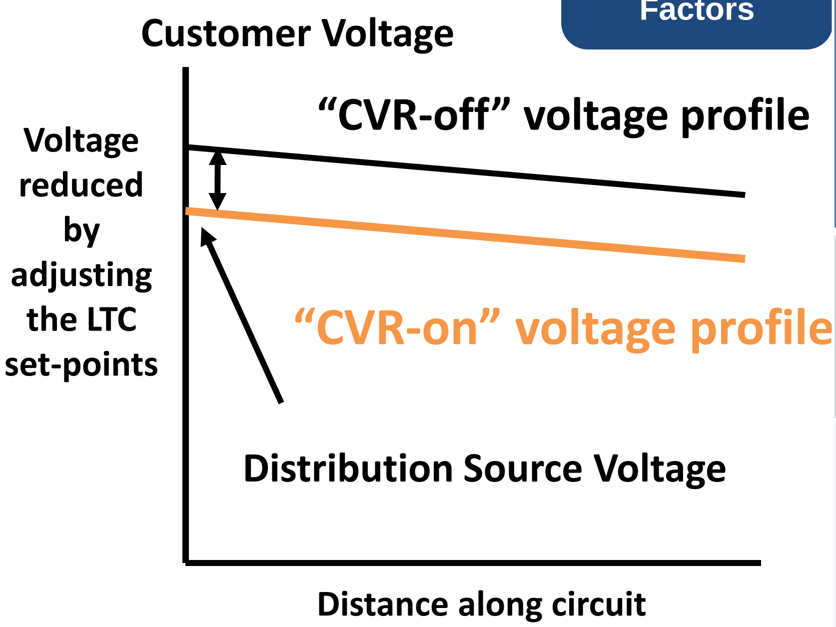
Customer Type	Interruption Cost Summer Weekday	Interruption Duration				
		Momentary	30 mins	1 hr	4 hr	8 hr
Large C&I	Cost Per Average kWh	$173	$38	$25	$18	$14
Small C&I	Cost Per Average kWh	$2,401	$556	$373	$307	$272
Residential	Cost Per Average kWh	$21.6	$4.4	$2.6	$1.3	$0.9

Estimated monetary value of this improvement in reliability based on value-of-service data is $21 million

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

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



Energy and Capacity CVR Factors

Example Using SGIG Project Data

Results averaged across 11 circuits	% Reductions	Potential savings for a 7 MW peak circuit with 53% load factor	
Customer Energy Reduction	2.9%	943 MWh/year	$75,440 (at $.08/kWh)
Peak Demand Reduction	3%	210 kW	Defer construction of peaking plants

Case Study

Investor-Owned Utility

Florida Power and Light (FPL)

Smart Grid Solutions Strengthen Electric Reliability and Customer Services in Florida

Key Activities

- 3 million smart meters being installed with pilot programs testing customer systems and time-based rate programs.
- Thousands of substation devices for automating switches, capacitors, transformers, and regulators and equipment health monitors at substations.
- 45 phasor measurement units and supporting transmission line monitors.

Aims and Strategies

- Improve reliability by monitoring key transmission and distribution equipment for preventative maintenance and avoidance of outages.
- Make operational efficiency improvements by reducing truck rolls for service calls by automating meter functions.
- Engaging customers through information exchange via web portals and pilot programs with customer systems and time-based rates

Results and Benefits

- In January, 2012, monitor detected an out-of-tolerance high voltage bushing and customers served by this transformer temporarily switched to another one. Meanwhile, the faulty bushing replaced, preventing an outage that would have affected several thousand customers.
- In September, 2011, an alarm signaled a potential problem with a degraded phase on a capacitance voltage transformer. Field engineers located the damaged transformer, removed the affected transmission line section from service, and replaced the defective device thus preventing an extended outage and that could have affected several thousand customers.

One of SGIG's largest and most comprehensive projects

Smart transformers report on health and status to FPL control centers

Facts & Figures

Total Project Budget:
$578,000,000

Federal Share:
$ 200,000,000

FPL Facts:
4.5 million customers
70,000 miles of power lines
16 power plants

Case Study

Electric Cooperative

eEnergy Vermont

A State-Wide Strategy for Smart Grid Development

Key Activities

- Smart metering roll-out for outage management and time-based rates for demand response.
- Distribution system automation including switches, reclosers, SCADA, and communications backbone systems.
- Consumer behavior studies by Vermont Electric Cooperative (VEC)and Central Vermont Public Service to assess customer acceptance, response, and retention.

Aims and Strategies

- A collaborative effort involving all of the state's electric distribution companies to modernize Vermont's electric grid and foster economic growth as part of the state's "eState Initiative" with telecommunications and health care.

Results and Benefits

- VEC's outage management system has improved SAIFI by 50% and CAIDI by 40% since installed in 2008.
- VEC's smart metering roll-out and outage management system has a 5 year payback period from operational saving alone.
- VEC received POWER Magazine's first "Smart Grid Award" in August 2011 for its pioneering efforts in outage management.
- Restoration of the grid from Tropical storm Irene occurred quicker and with greater customer awareness of repair schedules due to smart meters, web portals, and more effective outage management.

Utilities working together to modernize the grid.

Vermont Electric Cooperative's Smart Grid Operations Center

Facts & Figures

Total Project Budget:
$137,857,302

Federal Share:
$69,928,650

Distribution Automation:
47 circuits and substations

Smart meters:
311,380

Time-Based Rates:
1,500 customers targeted

Case Study

Municipal Power

Electric Power Board of Chattanooga

Improved System Restoration

Key Activities

- EPB's Smart Grid Project covers 600 miles throughout 9 counties of Georgia and Tennessee affecting 170,000 customers.
- Installing automated feeder switches, automated circuits, advanced SCADA, AMI, in-home displays, and communications infrastructure.

Aims and Strategies

- Electric Distribution System Automation – installing automated feeder switches and sensor equipment for distribution circuits that can be used to detect faults and automatically switch to reroute power and restore all other customers.
- Communications Infrastructure – includes fiber optic systems that enable two-way communication between the meters, substations, and control office which provides EPB with expanded capabilities and functionality to optimize energy delivery, system reliability, and customer service options.

Results and Benefits

- During the April 2011 storms, three fourths of EPB customers – 129,000 residences and businesses – lost power.
  - Smart switches avoided thousands of hours of outage time due to the devices and automation already installed
  - EPB was able to avoid sending repair crews out 250 times

Integrating Smart Grid Applications

Smart switches help ensure grid reliability and power quality

Facts & Figures

Total Project Budget:
$226,707,562

Federal Share:
$111,567,606

Equipment Deployed:
Smart Switches: 1,500
AMI:170,000
Direct LC Devices: 5,000
HEMS: 5,000
Thermostats: 5,000
Automated Circuits:164

DRAFT

Life After ARRA Smart Grid Program

Life After ARRA Smart Grid Program

Build and maintain momentum

- Make business case
- Identify, allocate, and quantify benefits
- Identify and quantify costs
- Address technical issues
- Address regulatory issues
- Address customers concerns

Contact Information

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Federal Smart Grid Website
www.smartgrid.gov

Smart Grid Clearinghouse
www.sgiclearinghouse.org/

Smart Grid Implementation Strategy
www.netl.doe.gov/smartgrid/index.html

Questions ?