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
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

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Displays</td>
<td>• Smart meters</td>
<td>• Auto switches</td>
<td>• Wide area monitoring</td>
<td>• Energy devices</td>
</tr>
<tr>
<td>• Internet portals</td>
<td>• Data management</td>
<td>• Automated capacitors</td>
<td>• Synchrophasor Technology</td>
<td>• Software</td>
</tr>
<tr>
<td>• Direct load controls</td>
<td>• Back office integration</td>
<td>• Auto voltage regulators</td>
<td>• Phasor data concentrators</td>
<td>• Appliances</td>
</tr>
<tr>
<td>• Programmable thermostats</td>
<td></td>
<td>• Equipment monitoring</td>
<td>• Dynamic line rating</td>
<td></td>
</tr>
<tr>
<td>• EV Chargers</td>
<td></td>
<td>• Energy Storage</td>
<td>• Energy Storage</td>
<td></td>
</tr>
</tbody>
</table>

![Images of various smart grid technologies]
ARRA Smart Grid Progress
SGIG Deployment Status

15.5 million residential and commercial smart meters (11% US coverage)

Distribution automation equipment on about 8,000 circuits (Roughly 5% US coverage)

Nearly 900 networked phasor measurement units (nearly 100% US coverage)
Customer Devices in SGIG Projects

Customer Devices Installed and Operational
Deployed as of September 30, 2013

- In-Home Display: 9.3
- Direct Load Control Devices: 236.6
- Programmable Controllable Thermostat: 169.3
- Smart Appliances: 0.3
Customers with Smart Meters Enrolled in Pricing Programs in SGIG

Customers with Smart Meters Enrolled in Pricing Programs
Deployed as of June 30, 2012

- **Time-of-Use Pricing**: 2,880,002
- **Real-Time Pricing**: 253,209
- **Variable Pricing**: 612,625
- **Critical Peak Pricing**: 600,388
- **Critical Peak Rebates**: 23,349

[Graph showing the number of customers enrolled in different pricing programs]
Case Studies/Success Stories
# Peak Demand Reduction from AMI, Pricing, and Customer Systems

Selected examples from SGIG projects reporting initial results

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

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

<table>
<thead>
<tr>
<th>Smart Meter Capabilities</th>
<th>O&amp;M Savings</th>
<th>% Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Remote meter reading</td>
<td>Meter Operations Cost</td>
<td>13-77</td>
</tr>
<tr>
<td>• Remote service connections/disconnections</td>
<td>Vehicle Miles</td>
<td>12-59</td>
</tr>
</tbody>
</table>

Future SGIG examples to provide information on other benefits

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

<table>
<thead>
<tr>
<th>Index</th>
<th>Description</th>
<th>Weighted Average (Range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAIFI</td>
<td>System Average Interruption Frequency Index (outages)</td>
<td>-22 % (-11% to -49%)</td>
</tr>
<tr>
<td>MAIFI</td>
<td>Momentary Average Interruption Frequency Index (interruptions)</td>
<td>-22 % (-13% to -35%)</td>
</tr>
<tr>
<td>SAIDI</td>
<td>System Average Interruption Duration Index (minutes)</td>
<td>-18 % (+4% to -56%)</td>
</tr>
<tr>
<td>CAIDI</td>
<td>Customer Average Interruption Duration Index (minutes)</td>
<td>+8 % (+29% to -15%)</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Customer Type</th>
<th>Interruption Cost Summer Weekday</th>
<th>Interruption Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Momentary</td>
</tr>
<tr>
<td>Large C&amp;I</td>
<td>Cost Per Average kWh</td>
<td>$173</td>
</tr>
<tr>
<td>Small C&amp;I</td>
<td>Cost Per Average kWh</td>
<td>$2,401</td>
</tr>
<tr>
<td>Residential</td>
<td>Cost Per Average kWh</td>
<td>$21.6</td>
</tr>
</tbody>
</table>

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 Efficiency

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

---

Example Using SGIG Project Data

<table>
<thead>
<tr>
<th>Results averaged across 11 circuits</th>
<th>% Reductions</th>
<th>Potential savings for a 7 MW peak circuit with 53% load factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Customer Energy Reduction</td>
<td>2.9%</td>
<td>943 MWh/year</td>
</tr>
<tr>
<td>Peak Demand Reduction</td>
<td>3%</td>
<td>210 kW</td>
</tr>
</tbody>
</table>
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

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

Smart transformers report on health and status to FPL control centers
Case Study

Electric Cooperative
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
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
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

Steve Bossart
(304) 285-4643
Steven.Bossart@netl.doe.gov

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?