September 24, 2014

Progress and Results from ARRA Smart Grid Programs

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Office of Electricity Delivery and Energy Reliability
Presented to the Electricity Advisory Committee
1. **Rapidly deploy smart grid technologies and systems** as prescribed under EISA and ARRA.

2. **Communicate the results and costs/benefits** to support decisions for continued investment. (advance cost/benefit methodology)

3. **Actively engage key stakeholders** to better understand and address issues affecting investment decisions. (including States/local govts examining grid futures)

4. **Advance the state-of-the-art in cybersecurity** to ensure smart grid systems are properly protected.

5. **Advance smart grid interoperability and standards** to improve efficiency and enable greater adoption. (including grid architecture, information management and control systems for advanced grid)

6. **Evaluate progress of grid modernization across the United States.** (Smart Grid Systems Report)
SGIG Deployment Status

SGIG Project Expenditures ($MM)

15.3 of 15.5 million residential and commercial smart meters

$4,120

$4,520

AMI

8,659 which exceeds 7,500 expected at completion automated switches and 12,599 of about 18,500 automated capacitors

$1,915

$2,010

EDS

1,075 which exceeds 800 expected at completion networked phasor measurement units

$470

$560

ETS

684,000 direct load control devices, programmable communicating thermostats, and in-home displays

$635

$850

CS

Reported as of March 2014

Estimated at Completion

99 Projects; 228 Utilities

Office of Electricity Delivery and Energy Reliability
Demonstrates how a suite of existing and emerging smart grid concepts can be innovatively applied and integrated to prove technical, operational, and business-model feasibility.
<table>
<thead>
<tr>
<th>Benefits</th>
<th>Consumer-Based Demand Management Programs (AMI-Enabled)</th>
<th>Advanced Metering Infrastructure (AMI) Applied to Operations</th>
<th>Fault Location, Isolation and Service Restoration</th>
<th>Equipment Health Monitoring</th>
<th>Improved Volt/VAR Management</th>
<th>Synchrophasor Technology Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital expenditure reduction – enhanced utilization of G,T &amp; D assets</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Energy use reduction</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Reliability improvements</td>
<td></td>
<td>✔</td>
<td>✔</td>
<td>❌</td>
<td>✔</td>
<td>❌</td>
</tr>
<tr>
<td>O&amp;M cost savings</td>
<td></td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>❌</td>
</tr>
<tr>
<td>Reduced electricity costs to consumers</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
<td>✔</td>
<td>❌</td>
</tr>
<tr>
<td>Lower pollutant emissions</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>❌</td>
</tr>
<tr>
<td>Enhanced system flexibility – to meet resiliency needs and accommodate all generation and demand resources</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
<td>❌</td>
</tr>
</tbody>
</table>
SMUD deployed opt-in and opt-out Flat w/ CPP, TOU and TOU w/CPP in Summers 2012-2013

- Opt-out customers produced lower average peak period load impacts in response to TOU than Opt-in customers but…
- Acceptance rates were much higher for Opt-out (>93%) than Opt-in (16-18%); drop-out rates were low in ALL cases (5-9% for Opt-In and 4-8% for Opt-Out)
- Survey results indicate 59% of customers preferred some type of time-based pricing design (TOU or CPP) over the existing tiered rate structure and preferred TOU over CPP pricing by roughly 2 to 1
- Due to the study’s results, SMUD has decided to alter the standard residential rate design from a tiered rate to a TOU in 2018

### TOU Pricing Plans

<table>
<thead>
<tr>
<th>Rate Period</th>
<th>Flat w/CPP</th>
<th>TOU</th>
<th>TOU w/CPP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base/Off-Peak &lt;700 kWh</td>
<td>8.5</td>
<td>8.5</td>
<td>7.2</td>
</tr>
<tr>
<td>Base/Off-Peak &gt;700 kWh</td>
<td>16.7</td>
<td>16.6</td>
<td>14.1</td>
</tr>
<tr>
<td>Peak</td>
<td>n/a</td>
<td>27.0</td>
<td>27.0</td>
</tr>
<tr>
<td>Critical Event</td>
<td>75.0</td>
<td>n/a</td>
<td>75.0</td>
</tr>
</tbody>
</table>

### Average kW Reduction Between 4 and 7 PM

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2012 All</th>
<th>2012 With Movers Removed</th>
<th>2013 With Movers Removed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opt-in TOU, No IHD Offer</td>
<td>0.17</td>
<td>0.19</td>
<td>0.15</td>
</tr>
<tr>
<td>Opt-in TOU, IHD Offer</td>
<td>0.24</td>
<td>0.26</td>
<td>0.2</td>
</tr>
<tr>
<td>Default TOU, IHD Offer</td>
<td>0.12</td>
<td>0.13</td>
<td>0.1</td>
</tr>
<tr>
<td>Default TOU-CPP, IHD Offer</td>
<td>0.16</td>
<td>0.17</td>
<td>0.18</td>
</tr>
</tbody>
</table>

### Scenario Benefit/Cost Ratio

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Benefit/Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default TOU, no IHD</td>
<td>4.48</td>
</tr>
</tbody>
</table>

### 10 Year NPV ($ millions)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Benefits</th>
<th>Costs</th>
<th>Net Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Default TOU, no IHD</td>
<td>$66.9</td>
<td>$15.0</td>
<td>$52.0</td>
</tr>
</tbody>
</table>

*Difference is statistically significant at 95% confidence level*
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>

**Talquin Electric Cooperative** - In 2011 and 2012, smart meters avoided 6,000 truck rolls for service connections and disconnections and 9,000 for non-payments saving more than $640,000.

<table>
<thead>
<tr>
<th>Additional 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>
Smart Grid 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

Application of value-of-service estimates to calculate avoided societal costs (ICE Calculator)
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 can provide a 3.0% reduction in annual energy consumption for the electricity sector. 80% of this benefit can be achieved from 40% of feeders.

CVR Study (due October 2014):
Report on technology applications, impacts and institutional hurdles. Seeing energy reductions ranging from 0.75 – 3.0% and peak reductions from 0.84 – 7.0%.
Improved reliability, capacity and operational efficiency – Energy flows on the California-Oregon Intertie can be increased by 100 MW or more reducing energy costs by an estimated $35 - $75 million over 40 years without new capital investments

April 2007

Networked Phasor Measurement Units in North American Power Grid

November 2012

Phasor Measurement Units in North American Power Grid

Legend
- Existing PMU locations
- PMU installations in progress
*Does not include stand-alone units
## Communication Strategy

**Maintain and develop key stakeholder relationships for sharing information and addressing issues:**
- EEI, EPRI, APPA, NRECA, NARUC, NASPI
- IEEE smart grid community

**Continue to use smartgrid.gov as the library for ARRA materials**
- Improve search capability (matrix)
- Create portal to other sites
- Mailing list

**Share results at conferences, e.g.**:
- IEEE (ISGT), Distributech, Town Hall Meetings, EPRI, NARUC

**Organize webinars and focus groups**

**Address key audiences (e.g., States)**

### SGIG/SGDP Information

(DOE and Awardee Generated)

- SGIG Progress Reports
- Metrics and Benefits Reports
- Case Studies
- Presentations/Briefings & Articles
- Best Practices/Lessons-Learned
- Consumer Behavior Reports
- Technology Performance Reports

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Office of Electricity Delivery and Energy Reliability
Long-Term Investment Strategy

Objectives:
- Reliability
- Resiliency
- Efficiency
- Sustainability
- Affordability

Customers
Owners
Operators
Regulators

Technology

Decision-Making Framework

Markets
Questions/Comments

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