AEP Ohio’s Grid Modernization Efforts to Satisfy and Attract Customers

Scott Osterholt
Director, Grid Modernization
UEDA Summer Forum
Tuesday July 24, 2017
AEP Ohio’s Grid Modernization Plan

gridSMART Phase 1

Smart Grid Phase 2

Smart City

AEP Ohio Grid Modernization Efforts
gridSMART Phase 1 Technologies

- **AMI Meters** – 132k Deployed
- **Voltage Variance Optimization** – 17 circuits
- **Distribution Automation Circuit Reconfiguration (DACR)** – 70 circuits
- **Plug In Electric Vehicle** – 10 unit demo with Level 2 Charging Stations
- **Cyber Security Operations Center** – 20 participants
- **Customer Education and Outreach**
- **Smart Appliances** – 20 participants
- **Community Energy Storage** – 80 CES units servicing appx 350 participants (reduced to lab testing of 4 units)
- **Consumer Programs** – 10k participants
Northeast Central Ohio Area
AEP Ohio’s Smart Grid Phase 2 Program

Distribution Automation Circuit Reconfiguration
250 Circuits

Volt Var Optimization
160 Circuits

AMI Meters
894,000 Additional Meters
Significant Benefits

- AMI Meter-related labor reductions: $6 - 7M annually
- AMI Credit / Collections / Revenue Enhancements: $8 - 10M annually
- AMI Enables enhanced DR or time-differentiated pricing customer programs by CRES/DR providers
- DACR Targeted to reduce “Customer Minutes of Interruption” (CMI) by up to 30% (over 3-year average)
  - Estimated improvement of approximately 21 Million CMI per year* yielding customer savings of approximately $71M
- VVO Enables reduction of the average voltage that each customer on the circuit receives, thereby reducing the annual energy consumed by the customers on the feeder while maintaining and improving the quality of service to the end-use customer.
  - Reduction in energy consumption where deployed of appx 3%
  - Reduction in peak demand on circuits where VVO is deployed of approximately 2-3%

* For circuits serving approximately 330k customers in the project area. Results depend on weather.
# Benefit / Cost Analysis

<table>
<thead>
<tr>
<th>CASH VIEW</th>
<th>NET PRESENT VALUE VIEW**</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>15 Year Benefits</strong></td>
<td></td>
</tr>
<tr>
<td>O&amp;M:</td>
<td></td>
</tr>
<tr>
<td>Capital:</td>
<td></td>
</tr>
<tr>
<td>Energy / Capacity:</td>
<td></td>
</tr>
<tr>
<td>Reliability:*</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td></td>
</tr>
<tr>
<td>$199 million</td>
<td>$103 million</td>
</tr>
<tr>
<td>$1 million</td>
<td>$1 million</td>
</tr>
<tr>
<td>$210 million</td>
<td>$102 million</td>
</tr>
<tr>
<td>$1.016 billion</td>
<td>$519 million</td>
</tr>
<tr>
<td>$1.426 billion</td>
<td>$725 million</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>15 Year Costs</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>O&amp;M:</td>
<td></td>
</tr>
<tr>
<td>Capital:</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL:</strong></td>
<td></td>
</tr>
<tr>
<td>$148 million</td>
<td>$83 million</td>
</tr>
<tr>
<td>$368 million</td>
<td>$282 million</td>
</tr>
<tr>
<td>$516 million</td>
<td>$365 million</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>15 Year Customer Impact</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Net Cash Flows:</td>
<td></td>
</tr>
<tr>
<td>Benefit / Cost Ratio:</td>
<td></td>
</tr>
<tr>
<td>$909 million</td>
<td>$361 million</td>
</tr>
<tr>
<td>2.8</td>
<td>2.0</td>
</tr>
</tbody>
</table>

* Based on the “Cost of Power Interruptions to Electricity Consumers in the United States, Ernest Orlando Lawrence Berkeley National Laboratory” (2006)

** The Cash View reflects the nominal estimated expenditures and benefits related to the Phase II implementation. The Net Present Value (NPV) is calculated using an After Tax Weighted Average Cost of Capital (WACC) of 7.69%.

Note on Reliability: Customer Minutes Interrupted (CMI) and SAIDI are subject to impacts of weather.
## gridSMART Phase 2 Environmental Benefit Expectations

<table>
<thead>
<tr>
<th>Program</th>
<th>Phase 1 Quantity</th>
<th>Phase 1 Annual CO\text{\textsuperscript{2}} Avoided</th>
<th>Phase 2 Quantity</th>
<th>Phase 2 Annual CO\text{\textsuperscript{2}} Avoided Estimate</th>
<th>Phase 2 Annual CO\text{\textsuperscript{2}} Avoided – car equivalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>DACR Avoided truck rolls</td>
<td>70 DACR Circuits</td>
<td>11.24 metric tons</td>
<td>250 DACR Circuits</td>
<td>40.16 metric tons</td>
<td>9.13 cars</td>
</tr>
<tr>
<td>Consumer Programs Energy Reduction</td>
<td>Appx 10% of 110,000 customers with AMI</td>
<td>69.12 metric tons</td>
<td>Appx 10% of 894,000 customers with AMI</td>
<td>562.22 metric tons</td>
<td>127.78 cars</td>
</tr>
<tr>
<td>AMI Avoided truck rolls</td>
<td>From 110,000 AMI meters</td>
<td>202.92 metric tons</td>
<td>From 894,000 AMI meters</td>
<td>1,649.19 metric tons</td>
<td>374.82 cars</td>
</tr>
<tr>
<td>VVO Energy Reduction</td>
<td>17 VVO Circuits</td>
<td>12,536 metric tons</td>
<td>160 VVO Circuits</td>
<td>117,985.9 metric tons</td>
<td>26,814.98 cars</td>
</tr>
</tbody>
</table>
Advanced Metering Infrastructure (AMI)

894,000 AMI Meters to be installed
- Aclara Meters (formerly GE)
- Silver Spring Networks Communication System

Features/Benefits:
- Employee safety benefits
- Reduces estimated reads
- Enables new customer programs
- Automated alarms/alert tool
- Outage Ticket Creation
- Outage Verification (Ping)
- Faster meter connects for new service
- Automated reconnects 24/7
- Reduce unbilled revenues and KWH lost
AMI Deployment Locations

<table>
<thead>
<tr>
<th>City</th>
<th>Estimated AMI Qty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Columbus</td>
<td>479,296</td>
</tr>
<tr>
<td>Canton</td>
<td>96,189</td>
</tr>
<tr>
<td>Lima</td>
<td>32,279</td>
</tr>
<tr>
<td>Newark</td>
<td>31,846</td>
</tr>
<tr>
<td>Zanesville</td>
<td>22,460</td>
</tr>
<tr>
<td>Findlay</td>
<td>22,363</td>
</tr>
<tr>
<td>Portsmouth</td>
<td>19,058</td>
</tr>
<tr>
<td>Lancaster</td>
<td>18,188</td>
</tr>
<tr>
<td>Steubenville</td>
<td>16,972</td>
</tr>
<tr>
<td>Chillicothe</td>
<td>15,241</td>
</tr>
<tr>
<td>Wooster</td>
<td>14,181</td>
</tr>
<tr>
<td>Fremont</td>
<td>11,171</td>
</tr>
<tr>
<td>Athens</td>
<td>10,347</td>
</tr>
<tr>
<td>New Philadelphia</td>
<td>10,017</td>
</tr>
<tr>
<td>Tiffin</td>
<td>9,918</td>
</tr>
<tr>
<td>East Liverpool</td>
<td>8,209</td>
</tr>
<tr>
<td>Fostoria</td>
<td>7,669</td>
</tr>
<tr>
<td>Cambridge</td>
<td>7,391</td>
</tr>
<tr>
<td>Coshocton</td>
<td>7,292</td>
</tr>
<tr>
<td>Marietta</td>
<td>7,235</td>
</tr>
<tr>
<td>Circleville</td>
<td>7,107</td>
</tr>
<tr>
<td>Ironton</td>
<td>6,671</td>
</tr>
<tr>
<td>Bucyrus</td>
<td>6,629</td>
</tr>
<tr>
<td>Van Wert</td>
<td>5,973</td>
</tr>
<tr>
<td>Kenton</td>
<td>4,282</td>
</tr>
<tr>
<td>Hillsboro</td>
<td>4,277</td>
</tr>
<tr>
<td>Upper Sandusky</td>
<td>3,539</td>
</tr>
<tr>
<td>Southpoint/Chesapeake</td>
<td>2,902</td>
</tr>
<tr>
<td>Gallipolis</td>
<td>2,750</td>
</tr>
<tr>
<td>Waverly</td>
<td>2,574</td>
</tr>
<tr>
<td>Nelsonville</td>
<td>2,505</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>894,000</strong></td>
</tr>
</tbody>
</table>
Customers are the Focus
AEP Ohio Customer Communications

Plan for customer communications includes

- Pre-deployment mixed media customer outreach
- Pre-install postcards sent to all residential premises
- Pre-install automated phone calls to all residential premises
- Door hanger when meter installed describing benefits to customer
- Post-install mailer on AEP-Ohio customer web portal
- Post-install mailer on AEP-Ohio smart phone app

New Customer Timeline of Touchpoints
Customer Web Portal

- Similar Home Comparison
- Rating
- Links to Tips

- Monthly Usage Comparison
- Green Button Download Link
- Links to Tips
AMI Customers can login and view their interval usage (15 minutes)

Drive usage behaviors
Bill forecast uses a time-series based predictive algorithm that takes into account both current and historical data to project energy use for the remainder of the billing period.

This algorithm has been optimized using the largest set of AMI, rate, and weather data in the world.

Analytics to display what time of the day each customer used the most energy

Call to action pushes customers to self-service channels where they can learn progressively more about their energy use

Messaging is consistent and synchronized across channels for a seamless customer experience
Weekly AMI Insights (Opt In)

Support customer satisfaction to let customers know when they are trending towards a high bill and how they can adjust their energy use before the end of the billing period, reducing bill shock and associated calls into the call center.

Provide enhanced customer care functionality to all active AEPO AMI customers.
Smart Grid Programs & Tariffs

**Tariffs**
- SMART Shift<sup>SM</sup> – 2-tier TOD
- SMART Shift Plus<sup>SM</sup> – CPP
- SMART Choice<sup>SM</sup> RTP-da

**Programs**
- SMART Cooling<sup>SM</sup> – Programmable Communication Thermostat
- SMART Cooling Plus<sup>SM</sup> – Load Control Switches (LCSs)
- eVIEW<sup>SM</sup> – in Home Displays (IHDs)
It’s Your Power App

Get Your Free Tools Now—And Save For Years To Come

The free IT’S YOUR POWER™ app and AEP Ohio Energy Bridge can help lower your electric bills.

Thousands of your neighbors are saving on their electric bills with this powerful combination of free tools that lets you see your electrical usage almost instantly.

Download the free IT’S YOUR POWER app to your smart phone to take advantage of the FREE Energy Bridge (a $100 value) offer available for a limited time. Together, you’ll have the information you need to make money-saving choices about your electricity usage.

CLICK HERE for download and other information.

IT’S YOUR POWER app features
• Easy-to-use, smart phone navigation
• Energy Clock allows you to pinpoint when you’re using electricity throughout the day and what influences your usage. When paired with the free Energy Bridge, you can see your usage in near real-time.
• Budget targets (kWh or $) to help manage your electricity usage
• Notifications and alerts about energy usage
• Tips on how to optimize your energy usage
• Remote control of your heating and cooling with the IT’S YOUR POWER communicating thermostat
• Convenient control of other smart devices
Smart Grid Mobile
Smart Grid Phase 2 Customer Engagement

QUICK TURN DISPLAY
20’x10’ Tented Display – Mid-July Launch
Distribution Automation Circuit Reconfiguration (DACR)

- Deployment: 250 circuits across Ohio, consisting of 13 kV and 34.5 kV distribution
- All circuits completed within 6 years
- Vendors: SEL and G&W Reclosers
- Telecommunications Network: TBD
- Targeted Deployment area: Ohio service territory with max benefit
- SAIFI Improvement target of >15.8%
- Phase 1 System has saved 11,456,905 customer minutes of interruption time for more than 135,000 customers *

* Based on data through 3/8/17
Permanent Fault
With DA = 300 Customers Outaged
Volt VAR Optimization (VVO)

- 160 circuits across Ohio, consisting of 13 kV and 34.5 kV distribution
- All circuits completed within 6 years
- Vendors: Utilidata
- Telecommunications Network: TBD
- Targeted Deployment area: Ohio service territory with max benefit
- Target benefit EE >3%
Volt VAR Optimization

Distance from Substation

Voltage

114
120
126
What is the Smart City Challenge?

The USDOT has pledged up to $40M to help Columbus define what it means to be a “Smart City.”

Vulcan has pledged $10M to Columbus to help it increase use of electric and other alternative vehicles with low- or zero emissions.
Dot smart city challenge
We won the job to become a smart city

1,400 local officials, companies, academics and nonprofits joined our webinars
800 people participated in our Smart City Forum
300 companies have expressed interest in partnering
78 applications received for the Smart City Challenge
7 Smart City Challenge Finalists announced in March at SXSW
1 Smart City Challenge Winner announced in June

#DOTSmartCity
www.transportation.gov/smartcity
Picked to lead

Beating out 77 other cities, Columbus won the U.S. Department of Transportation’s Smart City Challenge, earning us a coveted global platform to demonstrate for the world what the future can look like.

JUNE 2016 - COLUMBUS WON THE U.S. DEPARTMENT OF TRANSPORTATION’S SMART CITY CHALLENGE

COLUMBUS

$10 M

COLUMBUS

$40 M

TOTAL $140 M

67 FINALISTS

78 APPLICANTS

$90 M

A Paul G. Allen Company
The “Triple helix” knowledge-based economic development
Smarter infrastructure investments modernizing the grid

- 8-10 Micro-grids with Solar and battery storage
- Advance Clean Energy R & D
- Company Fleet Electrification
- Energy Efficiency Programs
- AMI Infrastructure – 528,000 meters

Electric Vehicle Supply Equipment (EVSE) – AEP Workplace plus
- 1000 Residential Chargers
- 250 Level 2 Public Smart Chargers
- 25 DC Fast Chargers

Vehicle to Home Connectivity Research

Solar & Wind Deployment -- 900 MW goal

Smart Lighting - 200k locations
EVSE overview
Electric vehicle supply equipment (EVSE)

- **Home (1,000)**
- **Public Level-2 (250)**
- **DC Fast Charger (25)**
## Supply Equipment Basics

<table>
<thead>
<tr>
<th>Charging Level</th>
<th>Vehicle Range Added per Charging Time and Power</th>
<th>Supply Powers</th>
<th>Applicable Connector(s)</th>
</tr>
</thead>
</table>
| Level 1          | 4 mi/hour @1.4kW  
6 mi/hour @1.9kW | 120VAC/20A (12-16A continuous)                    | J1772 Tesla            |
| Level 2          | 10 mi/hour @ 3.4kW  
20 mi/hour @ 6.6kW  
60 mi/hour @ 19.2 kW | 208/240VAC/20-100A (16-80A continuous)            | J1772 Tesla            |
| DC Fast Charge   | 24mi/20 minutes @ 24kw  
50mi/20 minutes @50kW  
90mi/20 minutes @ 90kW | 208/240VAC 3-phase (input current proportional to output power; ~20-400A AC) | Chademo CCS Combo Tesla Supercharger |
Public infrastructure overview

four primary components

1. Traditional Utility Infrastructure
2. EV Charging Station
3. Networked Management System
4. User Interface

- Control
- Monitoring
- EV Telemetry
- Charging Telemetry

- Load, Demand Response Data
- Grid/Dist. Network
- Transformer
- Meter
- Panel
- Conductor (Boring/Trenching)
- Data Processing Engine
- Control Server
- Realtime Data Storage

Source: Various / Constructed
Market Adoption Assumptions

Forecasted EV Adoption increasing adoption

Existing infrastructure is inadequate to promote greater EV adoption.

Station Location Source: http://www.afdc.energy.gov/locator/stations/
Why Utility Deployment Electric Vehicle Chargers?

- Utilities have a long planning horizon.
- Utilities have the ability to make capital expenditures.
- Utilities have the ability to manage demand.
- Utilities have considerable electric system expertise.
- Utilities are closely regulated.
- Utilities can extend PEV opportunities to disadvantaged segments.
- Utilities can identify best practices for charging station deployment.
- Utilities are uniquely positioned to choose appropriate charging locations.
Microgrid overview
Microgrid Examples

- Match generation to load
- Synch with Utility
- Provide motor starting
- Provide overcurrent protection

Microgrid Examples

Full Substation Microgrid

Full Feeder Microgrid

Partial Feeder Microgrid

Used with permission from EPRI
AEP Ohio Microgrid Benefits

- Improved resiliency and reliability for critical infrastructure and essential services
- Reduced system peak demand during load emergencies
- Integration of intermittent renewable generation facilitating clean energy and reduced emissions
- Ancillary services to the PJM market
- An AEP microgrid can facilitate the dispatch of energy storage system(s) to optimize the value of renewable energy when it is most needed
Powering essential services may require multiple microgrids coordinated by a common control system or new circuitry to connect the critical loads in a common microgrid.
Smart Street Lighting
Smart Street Lighting

Deploy appx. 202,000 Smart Street Lights
Smart Street lighting

Operations

Street Light Monitoring Software

Street Light Control Software

Communication System

Smart City Network

COMMS MODULE

CONTROL NODE

Smart City

INDIVIDUAL CONTROLS

UP TO 100 STREET LIGHTS

CABINET CONTROLS

RTU
Smart Street Lighting

- Deployed in the gridSMART Phase 1 & Phase 2 areas
Smart Street Lighting Benefits

- Improved safety and security through rapid light repair.
- Energy savings through repair of day burners.
- Operational savings and customer satisfaction through reduced call center volume.
- Additional operational savings through streamlined repairs.
- Potential for dimming and other advanced functionality.
- Faster response to lighting restoration requests.
Smart Street Lighting Use Cases

- Public Safety, gun shot detection
- Transportation – Parking spot availability
- Economic Development – Car and Pedestrian Counts
- Environmental - Smog detection
- Nature – Sea Turtles

From designboom.com
Questions?