Cost and Value Analysis of Distribution System Modernization

35th PLMA Conference  Nashville TN

Michael Brown – NV Energy
Wayne Callender – CPS Energy
Allison Hamilton - NRECA
Heather Manypenny – NHEC

Joseph E. Childs – Eaton (Moderator)
Future Uncertainty Principal
(With apologies to Werner Heisenberg)

What & When are mathematical complementary values.

The future is uncertain, knowledge & experience enhance prediction, but don’t guarantee adoption. The more detailed a vision, the fuzzier the adoption timeline.

Joseph E. Childs – April 2017
DER Value Chains

External Value
- ISO/ RTO Markets
  - Capacity
  - Energy
  - Reserves
  - Regulation
  - Frequency
- Non-Market Participants
  - Capacity
  - Energy

Internal Value
- Infrastructure Upgrade Deferral
  - Dist. Transformer
  - Cable Upgrade
- Operations
  - Voltage Management
  - Reverse Power Flow
  - Local Situations
  - Power Quality
- Energy Efficiency

Customer Value
- Utility Bill
  - Incentives
  - Energy
  - Demand
  - TOU/CPP
- Power Quality
  - Voltage/ Frequency
  - Reliability
  - Quality of Service
- Other
  - Special Requirements
  - Independence

Value State:
- Known & Quantified
- R&D
- Largely TBD or Local
Panelists

Wayne Callender
CPS Energy San Antonio
Zero Emissions Resource Manager

Heather Mannypenny
New Hampshire Electric Cooperative
Power Resources Executive

Allison Hamilton
NRECA
Senior Principal, Markets & Rates

Michael Brown
NV Energy
Manager, Demand Response & Distributed Energy Resources

• Utility View Points
  • Investor Owned
  • Municipal Utility
  • Cooperative

• ISO/RTO
  • NE-ISO
  • WECC / CA-ISO Imbalance
  • Balancing Authority
  • ERCOT

• Perspective
  • Rates
  • Market
  • Distribution System

• Background
  • NY-REV
  • Distribution Deferral
DERs at CPS Energy and ERCOT

PRESENTED BY: Wayne Callender
PLMA April 4, 2017
Vision 2020 transitions CPS Energy from a company that is highly dependent on power from traditional generation sources to a company that provides competitively priced power based on a diverse generation portfolio.
Definition

For CPS Energy we define a Distributed Energy Resource as the following:

Power generation, load reduction configuration, and/or storage technologies situated behind a customer's retail meter for the purpose of supplying all or part of that customer's electric load, selling energy, ancillary services, and/or load response.
CPS Energy’s Initial Goals

• Save for Tomorrow Energy Plan (STEP)
  • Save for Tomorrow Energy Plan (STEP)
  • Reduce energy demand growth by 771 megawatts by 2020.

• Demand Response (DR)
  • 180 MW for 2016

• Solar Distributed Energy Resources (DERs) (67 MWs)

• SimplySolar
  • SolarHostSA
  • Roofless Solar
Solar is growing

# of Solar Rebate Customers added per year

9,000 customers and 67 MWs by the end of the rebate program
## Programs

<table>
<thead>
<tr>
<th>Program</th>
<th>Net-to-Gross Ratio</th>
<th>Net Energy Savings (kWh)</th>
<th>Net Coincident Peak Demand Savings (kW)</th>
<th>Net Non-Coincident Demand Savings (kW)</th>
<th>Net ERCOT 4CP Demand Savings (kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial Demand Response</td>
<td>100%</td>
<td>2,168,927</td>
<td>105,550</td>
<td>106,639</td>
<td>67,089</td>
</tr>
<tr>
<td>Auto Demand Response</td>
<td>100%</td>
<td>81,251</td>
<td>4,576</td>
<td>5,172</td>
<td>3,540</td>
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<tr>
<td>Emergency Demand Response</td>
<td>100%</td>
<td>19,833</td>
<td>19,833</td>
<td>19,833</td>
<td>4,958</td>
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<tr>
<td>Smart Thermostat</td>
<td>100%</td>
<td>1,002,740</td>
<td>43,103</td>
<td>47,266</td>
<td>37,512</td>
</tr>
<tr>
<td>Home Manager</td>
<td>100%</td>
<td>728,387</td>
<td>45,593</td>
<td>49,158</td>
<td>41,689</td>
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<tr>
<td>Bring Your Own Thermostat</td>
<td>100%</td>
<td>28,187</td>
<td>3,268</td>
<td>3,845</td>
<td>2,566</td>
</tr>
<tr>
<td>ThinkEco Air Conditioner</td>
<td>100%</td>
<td>1,152</td>
<td>204</td>
<td>256</td>
<td>188</td>
</tr>
<tr>
<td><strong>Demand Response Subtotal</strong></td>
<td></td>
<td><strong>4,030,475</strong></td>
<td><strong>222,127</strong></td>
<td><strong>232,169</strong></td>
<td><strong>157,543</strong></td>
</tr>
</tbody>
</table>
Meanwhile in ERCOT

• DR growing in response to 4CP transmission pricing
• Texas PUC gives customers the right to have DERs
• ERCOT DER Participation in Wholesale Markets
  • implemented a task force
  • developed white papers
• Objective: get ahead of the curve related to high DER penetration.
ERCOT/CPS load shapes (summer non-DR day)
ERCOT/CPS load shapes (coincident peak day)

Key Takeaways:
- Market-wide DR has significant impact on peak load shape (flatter peak, longer duration)
- CPS Energy goal for 4CP -> match largest load reduction from DR deployment to the highest 15-minute interval for ERCOT load
Path forward

- CPS Energy expanding DR portfolio
  - More BYOT
  - Behavioral DR
  - Conservation Voltage Reduction
- Behind the meter generation
  - Several pilots
  - Solar/Storage RFP
  - Continued solar rebates
  - Comprehensive review of rates and regulations
- Aggregation system
  - Adding more DR programs to DRMS
  - Adding smart inverters to the system
The Value of Data
Cost and Value Analysis of Distribution System Modernization
PLMA Spring Conference 2017

Allison Hamilton
Senior Principal, Markets and Rates
Business and Technology Strategies
National Rural Electric Cooperative Association

• Not-for-profit, national service organization representing over 900 not-for-profit, member-owned, rural electric cooperative systems.

• Serve 42 million customers in 47 states. NRECA estimates that cooperatives own and maintain 2.5 million miles or 42 percent of the nation’s electric distribution lines covering three-quarters of the nation’s landmass.

• Cooperatives serve approximately 18 million businesses, homes, farms, schools and other establishments in 2,500 of the nation’s 3,141 counties.
Cooperative Service Territory
Business and Technology Strategies

Inputs

Member Resolutions
- Member Advisory Groups
- Industry Bodies
- Labs & Universities
- Feedback
- Partnerships and more …

How We Are Different….

Outputs

BTS Resources
- Cooperative Research Network
- Energy & Power
- Strategic & Economic Analysis

Engineering | Research
Economic Analysis | Policy & Standards Development | Tech Trends | Tools | Business Models
Emerging Landscape

Power System that is Highly **Flexible**, **Resilient**, **Comms Connected** and Optimizes Energy Resources

Source: EPRI
Value of Data

• Connected networks provide better, more timely data, so we can make more accurate decisions

• Better understand our system and our customers to enable future business models

• Incentivize behaviors that benefit the customer and optimizes the system
Value of Data Feedback Loop
System Optimization

- Data aggregation for better planning
- Accuracy and immediacy
- Locational and temporal
- Power quality
- Electricity withdrawals and injections
- Visualization and forecasting
- Identify and project impacts
New Business Models

- Regressive net pricing models
- Innovative rate design
- Service level oriented pricing
- Innovative product offerings
- Distributed System Operator (DSO)
Customer Engagement

- Customer choice
- Demand response
- Smart appliances
- EV Charging
- Behind the meter
- Energy Storage Arbitrage
- Microgrids
Utility of the Future

“The ‘smart’ grid uses computers to alleviate the abiding problem of peak load. It also has the benefit of producing new things that customers might find appealing to buy: autonomous vacuum cleaners, programmable clothes driers, and learning thermostats. Following the model of the telecommunications industry the utilities would like to remake themselves into providers of services and gadgets. If they can manage this double task they will likely stay alive.” Gretchen Bakke, The Grid
NRECA Resources to Help

- Solar Utility Network Deployment Acceleration (SUNDA) Project
- Distributed Generation (DG) Toolkit
- Open Modeling Framework - provides a framework to evaluate DG options on the distribution system
Other BTS Projects

- Advanced control architecture (on own and with DOE)
- GridBallast (with Eaton and Sparkmeter)
- DOE Communications planning model (based on OMF)
- ABC4PV (with Carnegie Mellon)
- DSOSS (with Georgia Tech)
- Microgrid Integration Tool
- Engagement with DERMS vendors
New Hampshire Electric Cooperative
Distribution Generation Costs & Value: Myth or Reality?

Heather Manypenny
April 4, 2017
Background on NHEC

- Service territory: approximately 1/3 of New Hampshire (shown in yellow on map to the right)
- Second largest electric utility in New Hampshire
- Member accounts: 80,000+
  - 86% residential (61% of total energy usage)
  - 14% commercial and industrial (39% of total energy usage)
- “Self-regulated” by member-elected board of directors
  - Except:
    - Service territory open to Retail Competition for energy supply
    - Qualifying Facilities including net metering up to a “cap”
    - “Systems benefits” including energy efficiency and low income programs
Background Information

• “NHEC values and supports the development of renewable generation by and to serve its members.”

• NHEC’s share of NH state law “net metering cap” = 3.16MW
  • Full retail net metering
  • Reached that cap in early 2015 (due in part to incentives)

• Self-regulation = flexibility
  • Other NH utilities approaching or surpassing caps
  • PUC docket DE 16-576 – about 200 documents filed
“Above the Cap” Rate Development

• 4 Options Considered:
  X Feed-in Tariff
    • Long-term set prices require long-term cost estimates creating risk for NHEC’s other members
    • Potentially duplicates RPS compensation
  X TOU rate
    • Not able to implement a Critical Peak element
    • Without CP, the math didn’t work
  X Fixed monthly net metering charge per kW generation
    • Not transparent relationship between costs (avoided or otherwise)
  ✓ Modified Net Metering
    • Full retail for energy delivered from the utility
    • Less than full retail for energy exported to the utility
    • Full retail for any energy consumed instantaneous with generation
“Above the Cap” Rate Development

- No quantifiable distribution system costs which NHEC actually avoids due to member-sited generation
  - Continuing incentive for the value NHEC has long placed on member-sited renewables.
  - Exported rate includes distribution-related under-recovery
- Exported rate includes NHEC’s avoided costs of power supply capacity and transmission

<table>
<thead>
<tr>
<th></th>
<th>Monthly</th>
<th>Per kWh</th>
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</thead>
<tbody>
<tr>
<td>Standard Residential Rate</td>
<td>$28.93</td>
<td>$0.14761</td>
</tr>
<tr>
<td>Net metered &lt;=20kW Generator</td>
<td>$28.93</td>
<td>$0.14761</td>
</tr>
<tr>
<td>Delivered to Residence</td>
<td>$28.93</td>
<td>$0.14761</td>
</tr>
<tr>
<td>Exported to Distribution System</td>
<td>($0.10960)</td>
<td></td>
</tr>
</tbody>
</table>
Hypothesis #1: “PV Generates at Peak Times”

- Well, sometimes…. Not all the peaks…. Not full capacity
- Analysis of more than 250 PV systems
- Coincidence with ISO-NE Forward Capacity Market peak
  - 19% July 28, 2015 hour-ending 6:00 pm
  - 51% August 12, 2016 hour-ending 3:00 pm
- Coincidence with monthly regional network transmission peaks
  - 7 months per year --- after dark --- 0%
  - 21% to 48% the other 5 months
Hypothesis #2:
BTM Generation = Lost Revenues

• Well, maybe not as much as you think
• An interesting and unexpected discovery:
  • NHEC members who install net metered systems increase their total home
electric usage by an average of 50%
  • Replace fossil fuel heating systems with mini-split heat pumps
• Rate development recognized this as well as a continued
distribution-related incentive
NV Energy DER Initiatives

Cost and Value of Distribution System Modernization
Company Overview

- Vertically Integrated (for now) Electric and Gas Utility
- State Commission Regulated
- 1.2 M Electric Customers
- 156 k Gas Customers
- 93% of Nevadans Served
- 7,961 MW Peak (July 28, 2016 @ 5pm)
- 230 MW statewide of Demand Response

Foundational Infrastructure

<table>
<thead>
<tr>
<th>Statewide AMI</th>
<th>aDMS</th>
<th>EMS</th>
<th>DRMS</th>
<th>SOA</th>
<th>BDP</th>
</tr>
</thead>
</table>

Drivers of Change

- 3rd Party Solar
- Energy Prices
- Economic Development
- Storage & EV
- Regulatory
- Energy Choice
Summary of Initiatives (DER & Modernization)

• Organizational Changes
  • New business unit “Renewable Energy & Smart Infrastructure”

• DER Testing & Deployment
  • Behind the Meter – testing smart inverters and PV plus battery storage systems
  • Distribution System/Substation – piloting Conservation Voltage Reduction (“CVR”) and searching for non-wires solutions
  • Capital Projects Review – all T&D infrastructure projects already in the ten-year plan are under re-evaluation for DER alternatives

• Technology Review – new process to assist in evaluating investments and the capability of technologies to satisfy business case requirements

• DER Valuation & Planning
  • Valuation – working to determine the value of grid services
  • Planning Procedures – working to incorporate hosting capacity studies and more robust distribution system forecasting models
  • Infrastructure Gap Analyses - identifying gaps in existing systems that would be needed to realize non-wires solutions
Valuation of Grid Service Benefits

- Black Start
- Voltage Support
- Frequency Regulation
- Spin/Non-Spin Reserve
- Energy Arbitrage
- Resource Adequacy
- Transmission Deferral
- T&D Congestion Relief
- Distribution Deferral
- Back-up Power
- Increased PV Self-Consumption
- Demand Charge Reduction
- TOU Bill Management
### Mapping & Harmonization of Methods

<table>
<thead>
<tr>
<th>Known: Traditional Demand Response (DR)</th>
<th>Benefits</th>
<th>Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Shaving / Shaping (avoided capacity &amp; energy)</td>
<td>Resource Adequacy</td>
<td>Customer Systems</td>
</tr>
<tr>
<td>Operating Reserve (10-min spinning reserve)</td>
<td>Energy Arbitrage</td>
<td>Communications</td>
</tr>
<tr>
<td>Avoided T&amp;D</td>
<td>Spin/Non-Spin Reserve</td>
<td>Engineering</td>
</tr>
<tr>
<td><strong>Unknown: “Fast DR”, PV + Battery Storage, Grid-Interactive Loads</strong></td>
<td><strong>T&amp;D Deferral</strong></td>
<td>Field Services</td>
</tr>
<tr>
<td>Area and Distribution Operations:</td>
<td><strong>Voltage Support</strong></td>
<td>Customer Engagement</td>
</tr>
<tr>
<td>Renewables Integration</td>
<td><strong>Frequency Regulation</strong></td>
<td>Back office/IT</td>
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<tr>
<td></td>
<td><strong>T&amp;D Congestion Relief</strong></td>
<td><strong>Battery Systems</strong></td>
</tr>
<tr>
<td></td>
<td>Renewable Energy Time Shift Firming intermittent generation</td>
<td>Analytics / M&amp;V</td>
</tr>
<tr>
<td>Customer Benefits</td>
<td><strong>Back-up Power</strong></td>
<td><strong>DRMS &gt; DERMS</strong></td>
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<tr>
<td></td>
<td><strong>Increased PV Self-Consumption</strong></td>
<td></td>
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<tr>
<td></td>
<td><strong>Demand Charge Reduction</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>TOU Bill Management</strong></td>
<td></td>
</tr>
</tbody>
</table>
Valuation of Grid Service Costs

Key Gap Areas
- DERMS
- Co-Optimization
- IT Architecture
- Telemetry
- Standards

SEP 2.0 Control Requests
DNP 3 Control Requests

End of Line Volt/VAR information

DERMs
- DRMS
- DMS
- EMS

RNI

Behind the meter Storage
Sub-station Storage

Smart Metering
- Event Management
- Outage Notification
- Demand Response
- Distribution Automation
- Voltage Regulation
Panelists

Wayne Callender
CPS Energy San Antonio
Zero Emissions Resource Manager

Heather Mannypenny
New Hampshire Electric Cooperative
Power Resources Executive

Allison Hamilton
NRECA
Senior Principal, Markets & Rates

Michael Brown
NV Energy
Manager, Demand Response & Distributed Energy Resources
Wayne Callender  
CPS Energy  
Zero Emissions Resource Manager

Wayne is currently the Zero Emissions Resource Manager for CPS Energy. He works in the Energy Market and Operations area and has operational responsibility for the utility’s wind, solar and demand response assets. He has been at CPS for 23 years, and worked on a variety of projects, including: wholesale deregulation; retail market design; automated meter reading deployment; advanced meter infrastructure (AMI) and meter data management (MDM) procurement and deployment; home area network (HAN) pilots; load research and analysis; and demand response. His most recent project is the implementation of a Demand Response Manage System (DRMS) for CPS Energy.
Heather Manypenny  
New Hampshire Electric Cooperative  
Power Resources Executive

Heather has been employed by New Hampshire Electric Cooperative for 26 years. She is currently the Power Resources Executive, involved in all aspects of power procurement. In this role she is part of a team that is responsible for contracting for power and renewable attributes, interaction and compliance with the Independent System Operator of New England (ISO-NE), load management / demand response, rate/revenue requirements for power supply and “Regional Access” (transmission). Ms. Manypenny leads an interdepartmental team responsible for the development, design and implementation of Demand Response programs. Prior to her role as Power Resources Executive, she held a variety of positions within NHEC including Controller, Rates and Financial Analysis Manager and Accountant. Ms. Manypenny holds a bachelor’s degree from Franklin Pierce College. Heather Manypenny is a member of PLMA’s Executive Committee.
Allison Hamilton
NRECA
Senior Principal, Markets and Rates
Allison.Hamilton@nreca.coop
www.nreca.coop

Allison Hamilton is the Senior Principal, Markets and Rates for Business and Technology Strategies at the National Rural Electric Cooperative Association (NRECA). She provides technical expertise for NRECA staff and membership with respect to issues affecting price formation in centralized/organized markets, wholesale rate making issues in decentralized/bilateral markets and the integration of rates across wholesale and retail markets and business structures. Prior to NRECA, Ms. Hamilton worked for Pepco Holdings in various roles in business and finance. She has almost 15 years’ experience in the regulated and deregulated energy industry. She holds an B.A. in Psychology from Valparaiso University and an M.B.A. from Johns Hopkins University.
Michael Brown
NV Energy
Manager, Demand Response & Distributed Energy Resources

Michael has over eighteen years of experience in the energy sector focused on demand response, energy efficiency, and renewable energy in both deregulated and regulated electricity markets. He has held a variety of positions at consulting and energy service firms, including: energy systems analysis; energy efficiency project development and project management; key account management for energy and commodity (gas and electricity) services; product development; and strategy development. Since 2005, Michael has worked at NV Energy. He currently manages a business unit focused on smart grid enabled customer solutions for energy and peak demand management. Michael’s efforts have included the design and implementation of: one of the largest two-way communicating programmable thermostat program in the country; a large scale Home Area Network program that integrates energy efficiency and demand response; a commercial building demand response program that utilizes automated communications and optimization software technology to obtain significant energy and peak demand savings; and, an advanced Demand Response Management System that allows demand side resources to actively participate in utility energy resource portfolio optimization and risk management processes. He is currently focused on improving utility energy resource options and customer offerings via business process and technical integration of demand response, energy efficiency, advanced consumer gateways, advanced building control techniques, distributed energy resources, and smart grid technologies. Michael has a Bachelor of Science in Chemistry and International Relations from The College of William and Mary, and a Master of Business Administration from The Cranfield School of Management.
Joseph E. Childs  
Eaton  
Senior Program Manager, Smart Grid Network Solutions  
josephechilds@eaton.com

Joe’s primary responsibility at Eaton is to work with customers on value assessment and data analysis. Joe has worked in and with utilities for the last 30 years on utility control systems as a supplier and user including SCADA/EMS, Power System Restoration, Operator Training Simulators, and Demand Response. Joe holds a B.S. in Computer Science and an M.S. in Bioclimatology from Colorado State University. He currently holds the officer position of Secretary for the PLMA. Mr. Childs has been awarded two US patents for DR/EE solutions.