Virtual Power Plant Evaluation

SMUD Board Committee of Energy & Customer Services

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Nick Tumilowicz, Energy Storage & Customer Solutions

June 16, 2021
VPP Webcast Agenda

1. Technology, Architecture, Risks
2. Case Studies & Applications
3. Programs and Business Models
4. Vendor Landscape
5. Demonstration/Pilot Development
EPRI VPP Demonstration Framework

- Project Design
  - System Architecture
- Laboratory Evaluation
  - Modeling & Simulation
- Monitoring & Data Collection
  - Field Demonstration
- Analytics
  - Cost-Benefit Assessment
- Reporting and Outreach

Diagram showing the stages of EPRI VPP Demonstration Framework:
Locational Value Drives Effective VPP Demonstrations

<table>
<thead>
<tr>
<th>Utility Value Streams</th>
<th>Transmission and Generation</th>
<th>Distribution and Substation</th>
<th>Community</th>
<th>Customer</th>
</tr>
</thead>
</table>
| • Renewable Integration
• Energy Arbitrage
• Frequency Regulation
• Transmission Deferral
• Black Start
• Voltage Support | • Renewable Integration
• Demand Reduction
• Energy Arbitrage
• Frequency Regulation
• Voltage Support
• Distribution Deferral
• Transmission Deferral
• PV Hosting Capacity | • Renewable Integration
• Demand Reduction
• Energy Arbitrage
• Frequency Regulation
• Voltage Support
• Distribution Deferral
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• Volt Var Optimization
• Distribution Deferral
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• Demand Reduction
• Energy Arbitrage
• Frequency Regulation
• Voltage Support
• Volt Var Optimization
• Distribution Deferral
• Transmission Deferral
• PV Hosting Capacity |

Values Streams Increase Closer to Customer

- Self consumption
- Backup Power
- Time-of-use bill management
- Demand Charge Reduction
- Backup Power
VPP Demonstration with Multiple DERs

Five Different DER Technologies

Three Different Aggregators

Open Standard Communication Protocols
Example Demand Response Event

- Sum of Controllable Devices
- Event Window
- HVAC
- Heat-Pump Water Heater
- Battery Energy Storage System
### Arizona Public Service – VPP Design

<table>
<thead>
<tr>
<th>DER Type</th>
<th>Quantity</th>
<th>Vendor</th>
<th>Ownership</th>
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</thead>
<tbody>
<tr>
<td>Smart Thermostats</td>
<td>6000 units (residential)</td>
<td>Multiple</td>
<td>Customer-Owned</td>
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<tr>
<td>Heat Pump Water Heater</td>
<td>200 units (residential)</td>
<td>Rheem</td>
<td>Customer-Owned</td>
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<td>Battery Energy Storage</td>
<td>40 units (residential)</td>
<td>Sunverge</td>
<td>Utility-Owned</td>
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<tr>
<td>Solar PV</td>
<td>25 units (commercial, multi-family)</td>
<td>SMA</td>
<td>Utility-Owned</td>
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</tbody>
</table>

![Diagram showing VPP design with DER types and their configurations]
Arizona Public Service – VPP Use Cases

- System Peak Reduction – Advanced controllable load dispatch technology to maximize load shed while working within the utility’s time of use (TOU) pricing structure. Pre-cooling strategies optimized for APS’s TOU pricing structure in order to keep customers’ homes cool throughout the day and effectively reduce load during afternoon peak hours.

- Load Shifting & Duck Curve Management - Charging during peak PV production periods and thereby decreasing the impact of PV ramping in the afternoon and decreasing evening load peaks. Limiting peak demand by load shifting using thermal and battery energy storage.

- Backup Power – Provide backup power for customers with battery energy storage installations during grid outage conditions.
Austin SHINES – VPP Design

### DER Type

<table>
<thead>
<tr>
<th>DER Type</th>
<th>Quantity</th>
<th>Aggregator/System Integrator/Vendor</th>
<th>Ownership</th>
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<tr>
<td>Residential Solar PV</td>
<td>18</td>
<td>Fronius Primo Smart Inverters</td>
<td>Utility-Owned*</td>
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<tr>
<td>Residential Energy Storage</td>
<td>7 stationary ESS and 1 EV</td>
<td>Pecan Street</td>
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<td>Commercial Energy Storage</td>
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<td>Stem</td>
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<td>Utility Energy Storage</td>
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<td>Doosan</td>
<td>Utility-Owned</td>
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</table>

[Diagram showing DERMS and various DER components connected to ISO/RTO (ERCOT) via SCADA/Field Communication Networks.]

- **DERMS**
- **PV Forecasts**
- **DMS**
- **ISO/RTO (ERCOT)**
- **Utility-Scale Energy Storage**
- **Utility-Scale PV**
- **SCADA/Field Communication Networks**

[Image of DER connectivity flowchart showing DER Aggregator connections to DER Gateways and Energy Storage systems.]

*Utility-Owned* indicates that the DER type is owned by the utility.
Austin SHINES – VPP Use Cases

- Utility Peak Load Reduction – To Lower transmission cost obligation
- Day-Ahead Energy Arbitrage - To realize economic value through price differential (Charge when prices are low, discharge when prices are high)
- Real-Time Price Dispatch – To realize economic value from real-time price spikes
- Voltage Support – To reduce losses and increase solar generation
- Distribution Congestion Management – To increase local grid reliability
- Demand Charge Reduction – To lower customer bills and realize system benefit
# VPP Case Studies

<table>
<thead>
<tr>
<th>Use Case / Application</th>
<th>APS</th>
<th>Avangrid</th>
<th>ConEd</th>
<th>Eneris / EDF</th>
<th>Eversource</th>
<th>PG&amp;E</th>
<th>PGE</th>
<th>SDG&amp;E</th>
<th>SCE</th>
<th>Tesla/CSE/Oliver Energy</th>
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Note: List of use cases for each utility may not be comprehensive

*Utility is designing and deploying DERMS but did not yet have detailed use case(s) to discuss.
Key Lessons Learned from Utility Pilots

- Investments in foundational technologies are needed to fully enable the potential of VPPs
- There is a lack of standard communication protocols between utilities and DER aggregators
- Cost of DER management through aggregators challenges project economics for utilities
- Growing interest from DER developers on utility managed operation
- Need for standard solutions (gateways/site controllers) to integrate diverse DER types with VPP operations
- Methods for verification, settlement, and penalties for services provided by DER aggregations are yet to be defined
Utility VPP Programs
Energy Resource VPP Business Models

Utility Ownership & Aggregation

Pros
- Maintains Customer Relationship
- Full Control of Distributed Energy Storage Asset
- Outside Utility Comfort Zone
- Potential to Rate Base Distributed BESS Asset

Cons
- Must Reserve Customer Backup Capacity
- Regulatory Challenges
- Customer Pays for a Portion of the Asset

Utility Manages Customer Programs & Leverages 3rd Party Aggregation

Pros
- Customer Pays for a Portion of the Asset
- Some Control of Distributed Energy Storage Asset
- Customer Relationship Retention

Cons
- Less Potential to Rate Base
- Less Control of Energy Storage Asset
- Less Customer Relationship Retention

Utility Purchases Services from 3rd Party

Pros
- No Customer Relationship
- Risk: 3rd party goes out of business
- No Aggregation Costs for Various Proprietary Protocols
- Outsourcing of aggregation responsibilities

Cons
- Less Control of Energy Storage Asset
- No Rate Base Potential
- No Customer Relationship
- Some Indirect Control of Distributed Energy Storage Asset

Utility Owns Asset and Customer Relationship

Utility Retains Customer Relationship

No Customer Relationship or direct control of assets
Customer Energy Resource Aggregation Programs

VPPs Demonstrations Evolving to Scaled Customer Solutions

Oregon: PGE 525-unit Resi BESS Pilot
Washington: PSE BESS Pilots: • Resi • Community • Distribution
Vermont: Green Mountain Power Lease & BYOD programs: 2,800-units operating enabling backup and NEISO transmission peak reduction
New Hampshire: • Liberty Utilities Lease @ $50/mth or $4860 to reduce system peak
Massachusetts, Connecticut National Grid and Eversource ConnectedSolutions Program: $225 per kW • Sunrun/Sunpower to provide 31MW of Capacity to ISO-NE
California: • PG&E: 60% attach rate • SCE: 5MW Sunrun pilot • SMUD: StorageShares • CCA’s: 20MW Sunrun Pilot
Wisconsin: MG&E Resi BESS Pilot
Colorado: Xcel Energy 500 residential BESS proposal being investigated
New York: • O&R: 300-unit Sunrun pilot • PSEG-Long Island peak demand proposal via BYOD program
Massachusetts, Connecticut
Florida: Jacksonville Electric Authority providing up to $4k per residential BESS system
Hawaii: HECO Purchasing Grid Services via 3rd party aggregators
Arizona: • APS: 900-units operating; $500/kW storage installed (up to $2,500) • SRP: 1000-units reserved via $3600/unit incentive
Alabama & Georgia: Southern Company subsidiaries Alabama Power and Georgia Power create Smart Neighborhood pilot
Nevada: NV Energy creates $5M incentive program for residential customers installing storage with PV
Washington: MG&E Resi BESS Pilot
Wisconsin: MG&E Resi BESS Pilot
Oregon: PGE 525-unit Resi BESS Pilot

VPPs Demonstrations Evolving to Scaled Customer Solutions
# Xcel Energy | Residential Battery Pilot

## Program Overview
Up to 500 customers will receive a $1,250-$1,500 upfront rebate for Xcel Energy’s use of 80% of system.

## Program Goals
- Test DR capabilities of customer & third party owned systems
- Learn about customer interests & preferences
- Evaluate cost effectiveness

## Utility Use Case
- Summer/winter Capacity
- Shoulder Season Solar Time-Shift
- Controlled Charging
- Distribution deferral

## Customer Drivers
- Up-Front Incentive
- Resiliency

## Additional Program Details
- TBD whether incentive is attractive enough to incentivize purchase of BES systems
- 60% response rate to survey, with offer for $1250 upfront incentive
**Program Overview:** Massachusetts & Rhode Island residential customers receive $225/kW performed during the summer and $50/kW in winter.

**Program Goals**

- Reduction of long-term capacity requirements in ISO-NE
- Summer program calls upon batteries 30 to 60 times during June-September, from 2pm-7pm. Maximum event duration is 3 hours.
- Winter program calls upon batteries 5 to 15 times during December-March, from 2pm-7pm.

**Utility Use Case**

- Reduction of long-term capacity requirements in ISO-NE
- Demand Management

**Customer Drivers**

- Ongoing financial incentives
- Resiliency

**Additional Program Details**

- Partners include Sunrun, Tesla, Generac and Sonnen
- Battery integrators are responsible for DR event communications
- National Grid cancels events that may occur before large storms
- Customers may not participate in ConnectedSolutions & ISO-NE programs at same time
- A similar program is being discussed for Connecticut

**Example of an event day performance:**

<table>
<thead>
<tr>
<th>Time Interval</th>
<th>Customer's Baseline</th>
<th>Event Day Load</th>
<th>Baseline Adjustment</th>
<th>Event Day Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noon - 1pm</td>
<td>500kW</td>
<td>600kW</td>
<td>100kW</td>
<td>Performance = Baseline + Adjustment - Event Day</td>
</tr>
<tr>
<td>2pm - 5pm</td>
<td>500kW</td>
<td>400kW</td>
<td>200kW</td>
<td>500kW + 100kW - 400kW = 200kW</td>
</tr>
</tbody>
</table>
3rd Party Programs
Energy Independence & Aggregation Advancements

Sunrun: 80 MW Brightbox deployed US
• Whole home = 2 Powerwalls
• Essential only = LG Chem

Tesla: >500 MW PW’s deployed Global
• All new solar paired with 2 BESS

Swell: 100 MW aggregation contracted
• 8,000 customers SCE VPP GridRevenue
• 6,000 customers Hawaiian Electric
• 100 customers Brooklyn/Queens, NY
VPP Vendor Landscape
Focused on aggregation over many DER that may or may not be location dependent (geographically or based on grid topology).

Often reside purely on the cloud (internet).

Over time, aggregators have evolved their platforms to provide a wider range of services such as wholesale energy market participation or distribution grid services.
Aggregator Landscape – Observations
Aggregator DERMS – Vendor Landscape

- Corrective controls are common among most technologies. This involves taking corrective actions in real time based on changes in the system state, such as a power system event, a grid service request from the grid operator, etc.

- Preventive or look-ahead controls are being actively developed or are on the roadmap of most vendors. This involves using a day-ahead, or hour-ahead, forecast of power system states to identify grid constraints or market events, and optimizing the dispatch of DER accordingly.

- Most vendor offerings support a mix of standard and proprietary protocols for communication with DER.

- Few of the technology offerings support DER group management protocols between Utility DERMS-to-Aggregator DERMS.

- Most vendor offerings have demonstrated integration with different types of DER, including controllable loads and EV charging stations.

- Supported cyber security standards and methods differ widely across different vendor offerings, which is indicative of its nascency to the DER integration and management domain.

- Certain vendor offerings support locally autonomous fail-safe methods for DER management, using local control systems with distributed algorithms to monitor DER compliance and communications health.
Barriers to VPP Adoption (Aggregator Perspective)

- Lack of consistency in every other project deployment
  - Market rules, regulations, utility needs and requirements vary by location
  - Data definitions for DER models to be used in VPPs vary from utility to utility
  - Multiple communications standards exist, in addition to legacy protocols and proprietary APIs, and they evolve over time

- VPPs does not fit nicely into traditional utility business processes, yet
  - Utility business process and roles that traditionally were siloed and distributed across multiple utility groups should be more integrated
  - Utilities may have to adapt their approach to operations and/or their organizational structure in order to take full advantage of the services provide by DER and VPP, which will take time
Barriers to VPP Adoption (Aggregator Perspective)

- Economic optimization at the distribution level for VPP requires a cost basis against which to optimize
  - Currently there are no methods in place to establish cost of distribution grid services provided by DER
- Consistent telemetry and access to an up-to-date network model at the right level are not always available
  - Some advanced VPP functions rely on the power flow information from an ADMS. This requires a DER-aware network model, and good field telemetry data which are not in place today at many utilities.
- Batteries are still relatively expensive
  - Energy storage is one of the most capable DER assets due to its dispatchability, but its deployment is limited due to costs
- Cyber security becomes more challenging as the number of bi-directional communicating devices on the grid edge increases
  - Each device represents a potential security threat that must be managed
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EPRI Journal: The Age of Customer Energy Storage is Approaching

[https://eprijournal.com/the-age-of-customer-sited-energy-storage-is-approaching/](https://eprijournal.com/the-age-of-customer-sited-energy-storage-is-approaching/)
Together...Shaping the Future of Electricity