Virtual Power Plant Evaluation

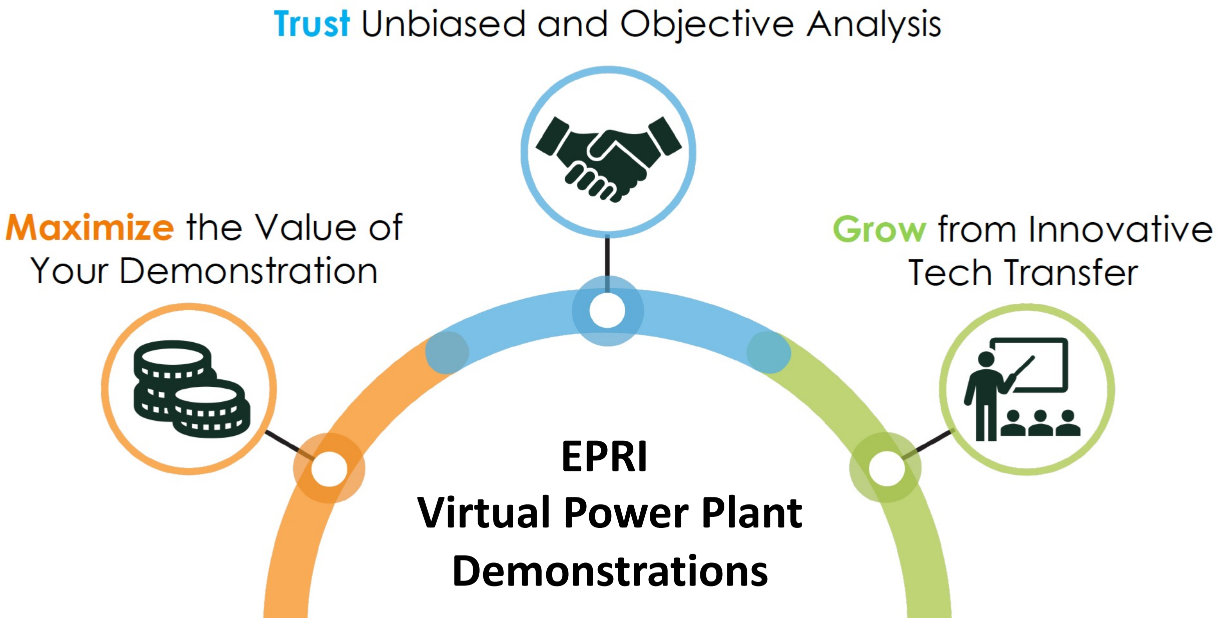
SMUD Board Committee of Energy & Customer Services

Ajit Renjit, Integration of DER
Nick Tumilowicz, Energy Storage & Customer Solutions

June 16, 2021

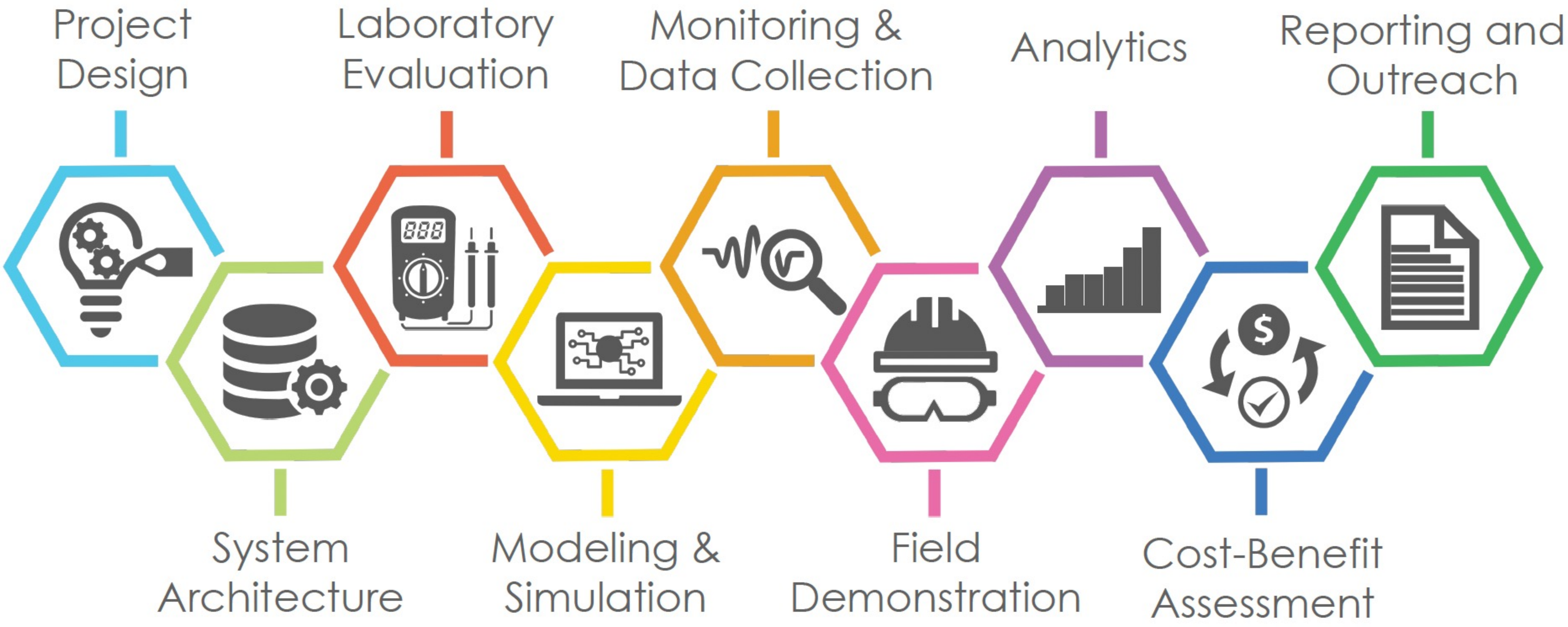
VPP Webcast Agenda

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



 www.epri.com

EPRI VPP Demonstration Framework



Locational Value Drives Effective VPP Demonstrations

Utility Value Streams

Transmission and Generation

- Renewable Integration
- Energy Arbitrage
- Frequency Regulation
- Transmission Deferral
- Black Start
- Voltage Support

Distribution and Substation

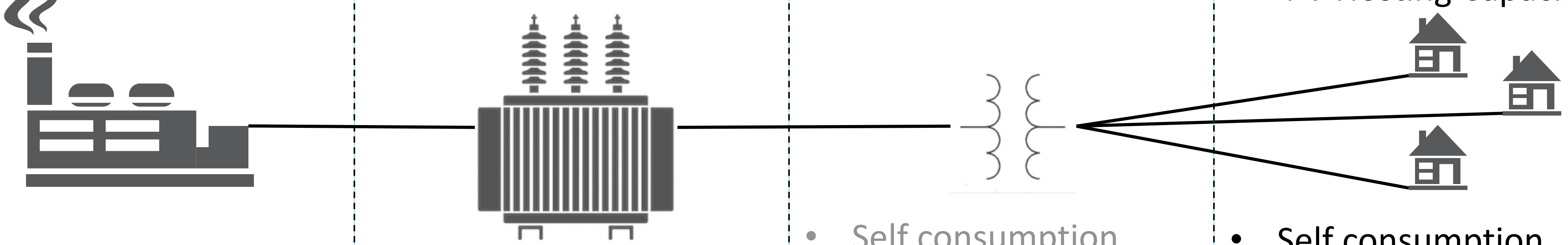
- Renewable Integration
- Demand Reduction
- Energy Arbitrage
- Frequency Regulation
- Voltage Support
- Distribution Deferral
- Transmission Deferral
- PV Hosting Capacity

Community

- Renewable Integration
- Demand Reduction
- Energy Arbitrage
- Frequency Regulation
- Voltage Support
- Distribution Deferral
- Transmission Deferral
- PV Hosting Capacity

Customer

- Renewable Integration
- Demand Reduction
- Energy Arbitrage
- Frequency Regulation
- Voltage Support
- Volt Var Optimization
- Distribution Deferral
- Transmission Deferral
- PV Hosting Capacity



Customer Value Streams

Community:

- Self consumption
- Backup Power

Customer:

- Self consumption
- Time-of-use bill management
- Demand Charge Reduction
- Backup Power

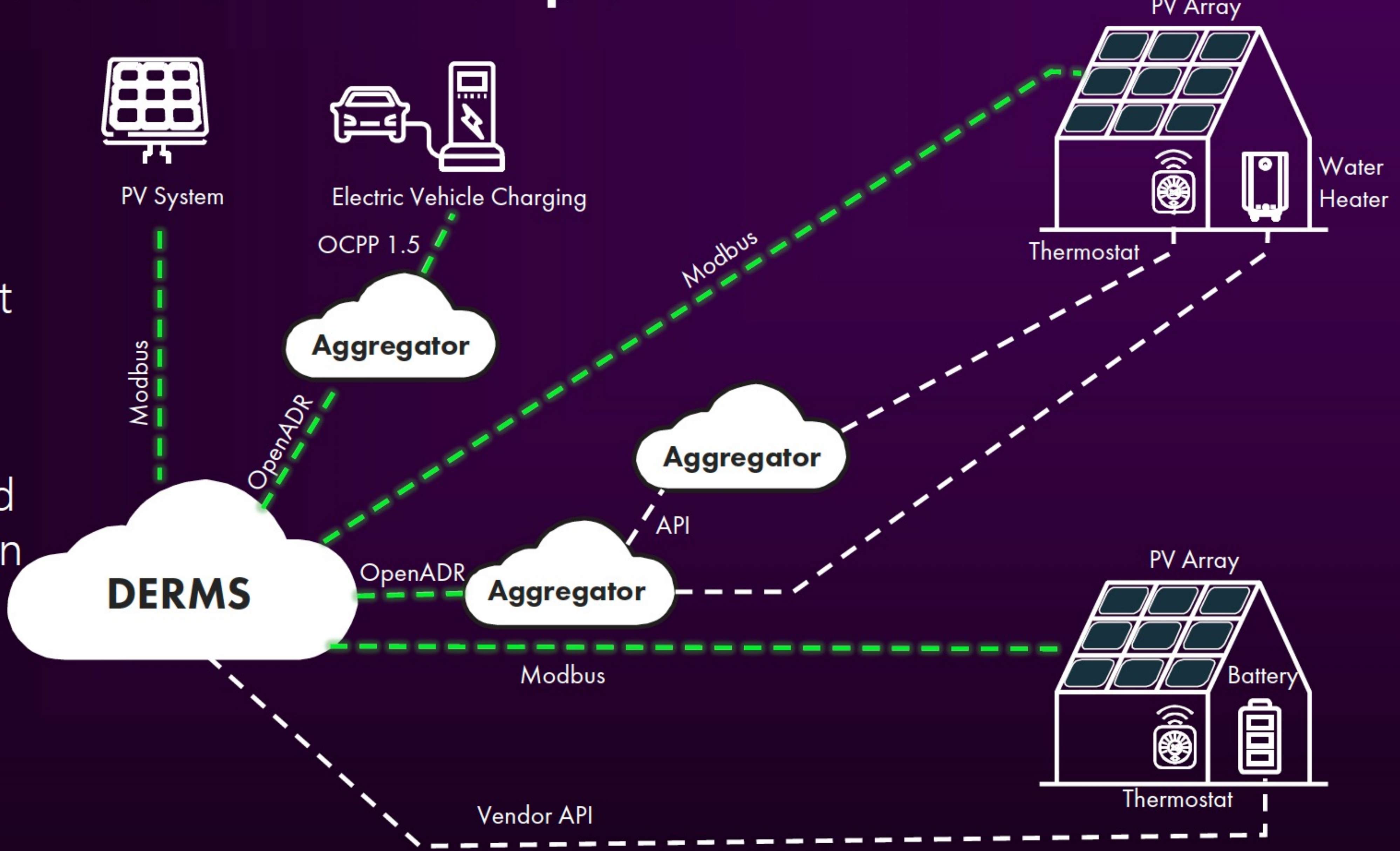
Values Streams Increase Closer to Customer

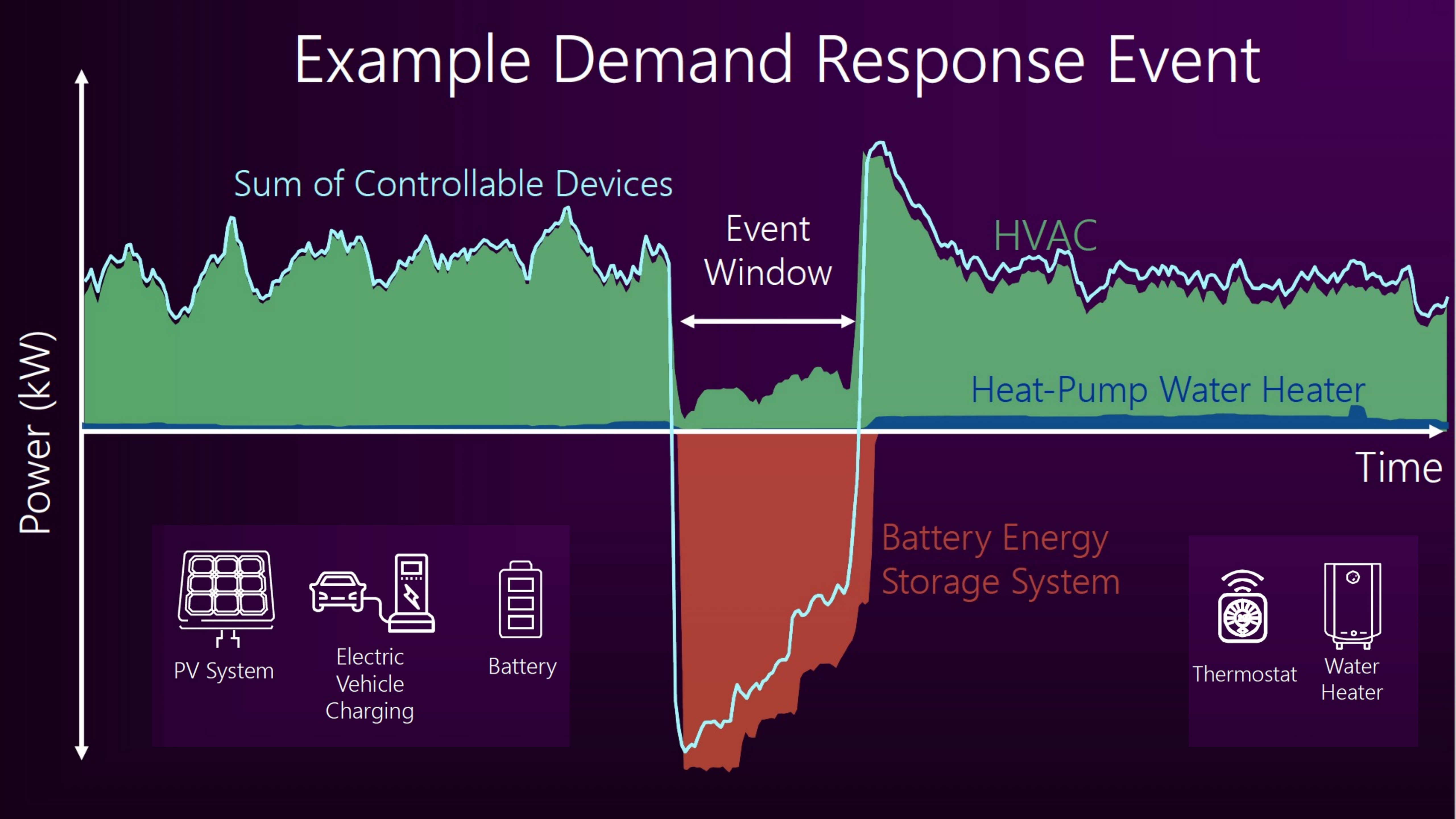
VPP Demonstration with Multiple DERs

Five Different DER Technologies

Three Different Aggregators

Open Standard Communication Protocols



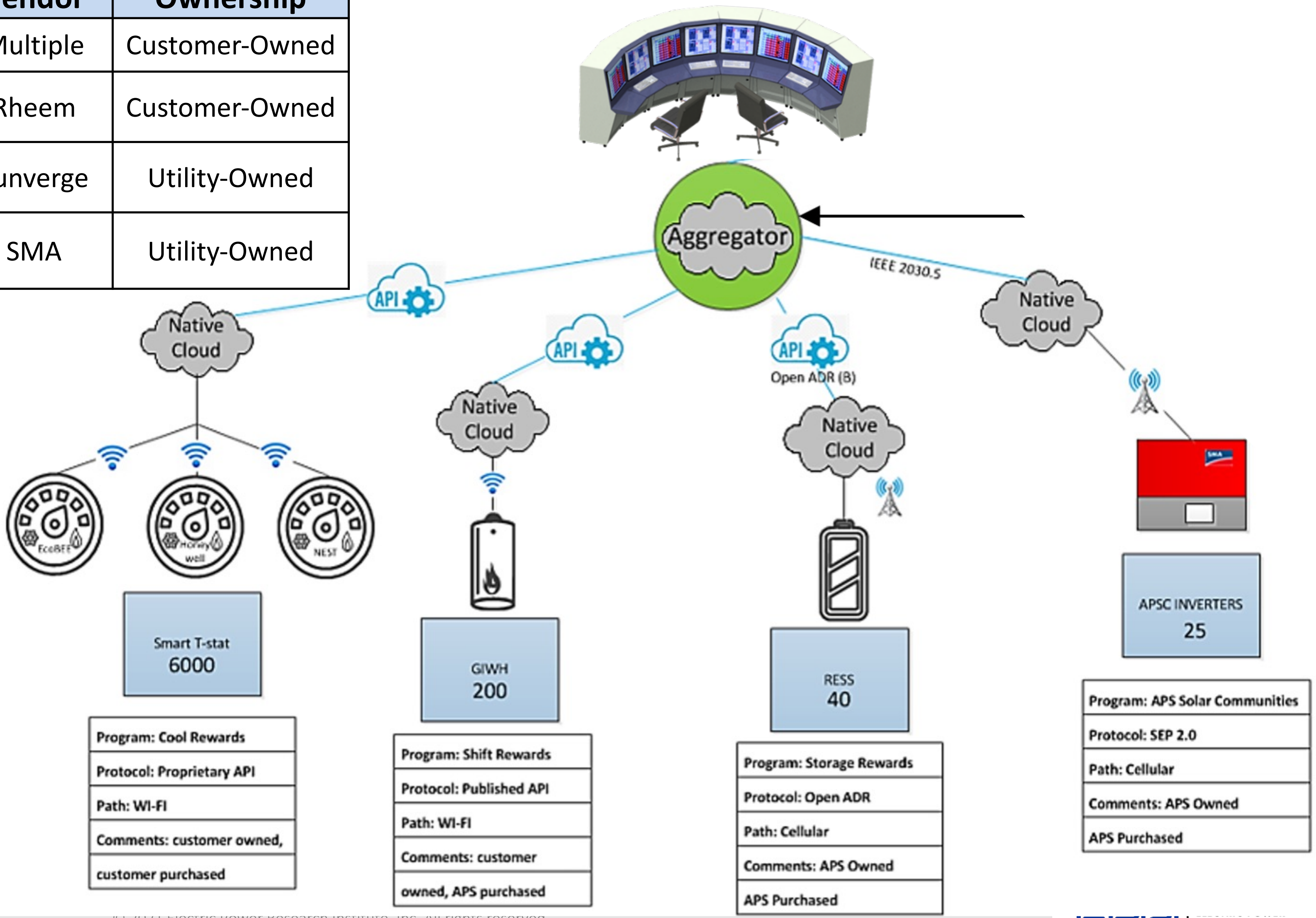


Example Demand Response Event
Power (kW)
Time
Sum of Controllable Devices
Event Window
HVAC
Heat-Pump Water Heater
Battery Energy Storage System
PV System
Electric Vehicle Charging
Battery
Thermostat
Water Heater

VPP Case Studies

Arizona Public Service – VPP Design

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



Arizona Public Service – VPP Use Cases

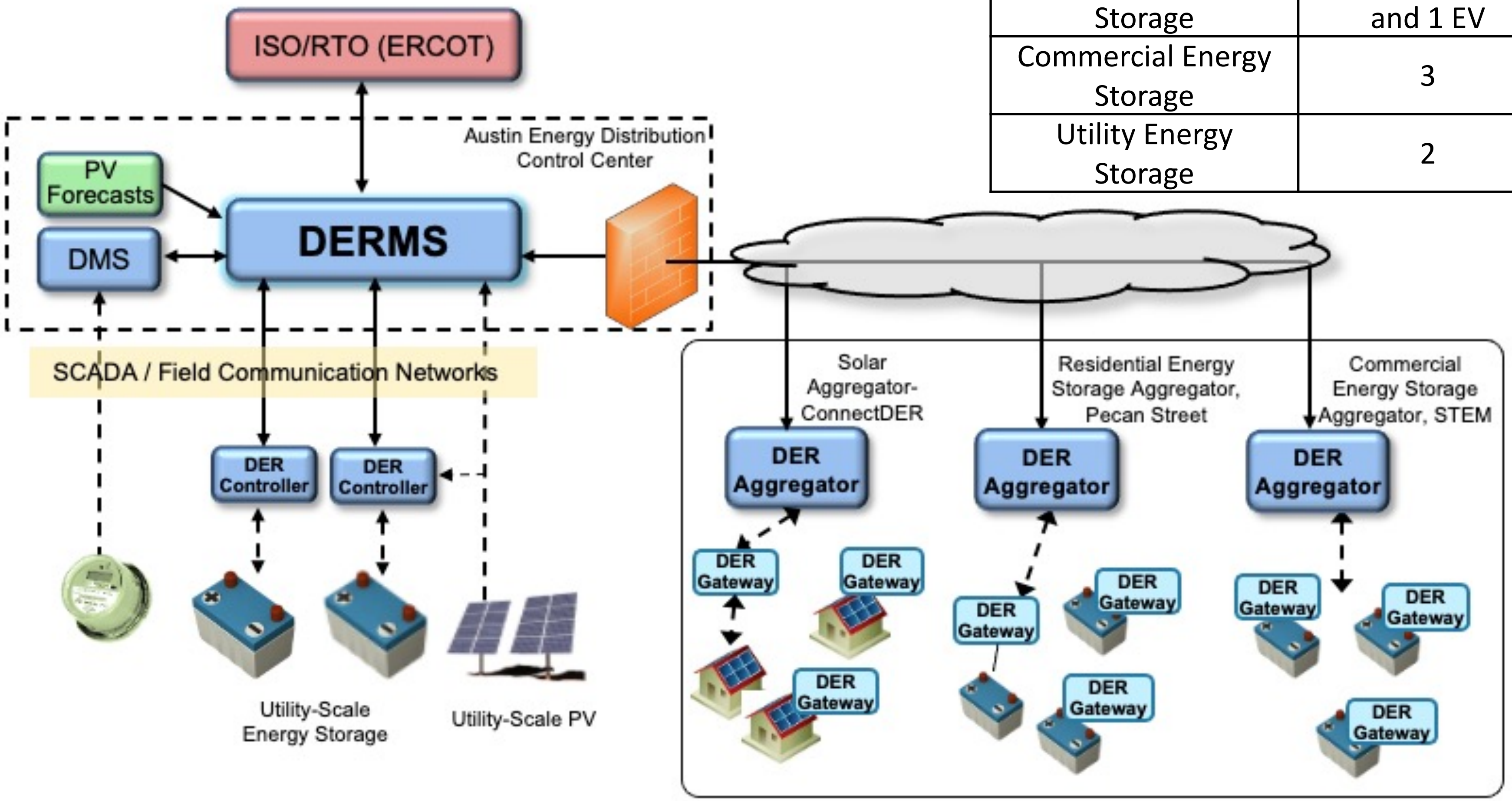
- ✓ System Peak Reduction – Advanced controllable load dispatch technology to maximize load shed while working within the utility's time of use (TOU) pricing structure. Pre-cooling strategies optimized for APS's TOU pricing structure in order to keep customers' homes cool throughout the day and effectively 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	Quantity	Aggregator/System Integrator/Vendor	Ownership
Residential Solar PV	18	Fronius Primo Smart Inverters	Utility-Owned*
Residential Energy Storage	7 stationary ESS and 1 EV	Pecan Street	Utility-Owned*
Commercial Energy Storage	3	Stem	Utility-Owned*
Utility Energy Storage	2	Doosan	Utility-Owned



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

Use Case / Application	APS	Avangrid	ConEd	Enedis / EDF	Eversource	PG&E	PGE	SDG&E	SCE	Tesla/CSE/Olivine	Tesla/Energy Locals	UKPN	WPD
Backup Power	X										X		
Constraint of DERs Participating in Wholesale Markets						X			X				
Contingency Frequency Response							X				X		
Contingency Voltage Response							X						
DER Flexible Interconnection		X										X	
Distribution Grid Upgrade Deferral						X		X					
Distribution Grid Voltage Support				X		X		X					
Economic Optimization						X							
Fault Restoration Support												X	X
ISO Market Products (Day Ahead/RTE)								X		X			
Load reduction to extend maintenance window													X
Load Shifting & Duck Curve Management	X												
Microgrid Control								X					
Peak Load Reduction	X				X	X		X					X
Regulation Reserve										X			
Scheduled Dispatch							X	X					
Self-Consumption of Solar PV											X		
Spinning Contingency Reserve										X		X	
Transmission System Voltage Support												X	
Wholesale Energy Price Response											X		
General VPP Rollout*			X										

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	Cons
Potential to Rate Base Distributed BESS Assets	Outside Utility Comfort Zone
Customer Pays for a Portion of the Asset	Regulatory Challenges
Full Control of Distributed Energy Storage Asset	Must Reserve Customer Backup Capacity
Maintains Customer Relationship	

Utility Owns Asset and Customer Relationship

Utility Manages Customer Programs & Leverages 3rd Party Aggregation

Pros	Cons
Customer Pays for a Portion of the Asset	Less Potential to Rate Base
Some Control of Distributed Energy Storage Asset	Less Control of Energy Storage Asset
Customer Relationship Retention	Less Customer Relationship Retention

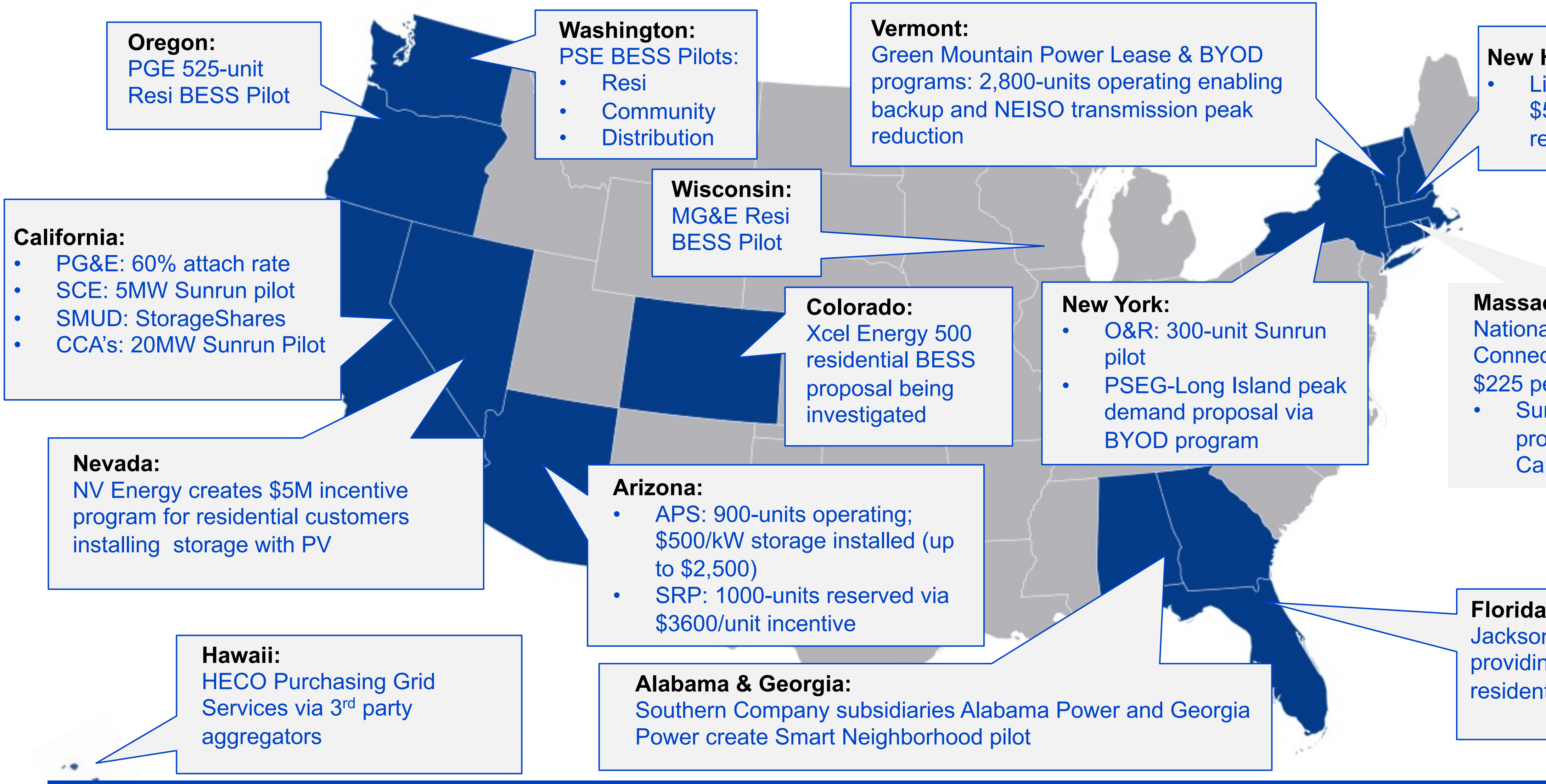
Utility Retains Customer Relationship

Utility Purchases Services from 3rd Party

Pros	Cons
Some Indirect Control of Distributed Energy Storage Asset	Less Control of Energy Storage Asset
No Aggregation Costs for Various Proprietary Protocols	No Rate Base Potential
Outsourcing of aggregation responsibilities	Risk: 3rd party goes out of business
	No Customer Relationship

No Customer Relationship or direct control of assets

Customer Energy Resource Aggregation Programs



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

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
National Grid and Eversource ConnectedSolutions Program: $225 per kW
- Sunrun/Sunpower to provide 31MW of Capacity to ISO-NE

Nevada:
NV Energy creates $5M incentive program for residential customers installing storage with PV

Arizona:
- APS: 900-units operating; $500/kW storage installed (up to $2,500)
- SRP: 1000-units reserved via $3600/unit incentive

Florida:
Jacksonville Electric Authority providing up to $4k per residential BESS system

Hawaii:
HECO Purchasing Grid Services via 3rd party aggregators

Alabama & Georgia:
Southern Company subsidiaries Alabama Power and Georgia Power create Smart Neighborhood 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

Customer Owned

Utility Dispatch / Control

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

National Grid/Eversource | **Connected**Solutions BYOD program

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 to15 times during December-March, from 2pm-7pm.

Customer Owned

3rd Party Dispatch / Control

Example of an event day performance:

Time Interval	Customer's Baseline	Event Day Load	Baseline Adjustment	Event Day Performance
Noon – 1pm	500kW	600kW	100kW	Performance = Baseline + Adjustment – Event Day
2pm – 5pm	500kW	400kW		500kW + 100kW – 400kW = 200kW

Utility Use Case

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

Customer Drivers

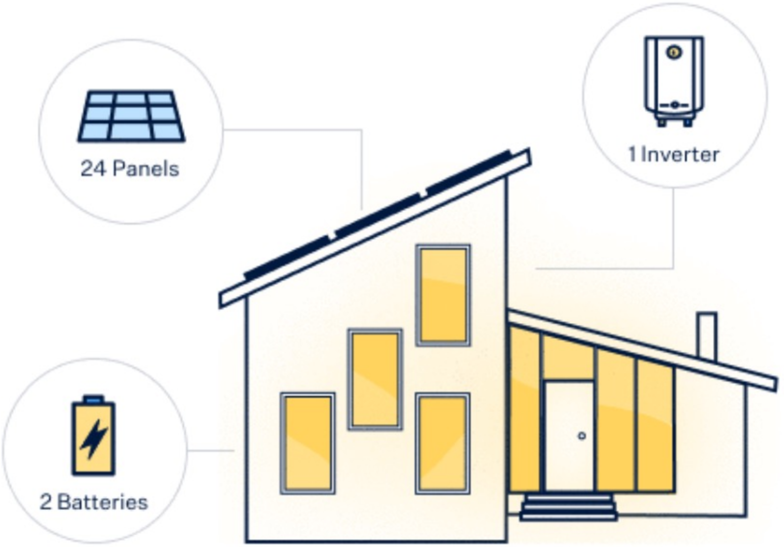
- Ongoing financial incentives
- Resiliency

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 **Connected**Solutions & ISO-NE programs at same time.
- A similar program is being discussed for Connecticut

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

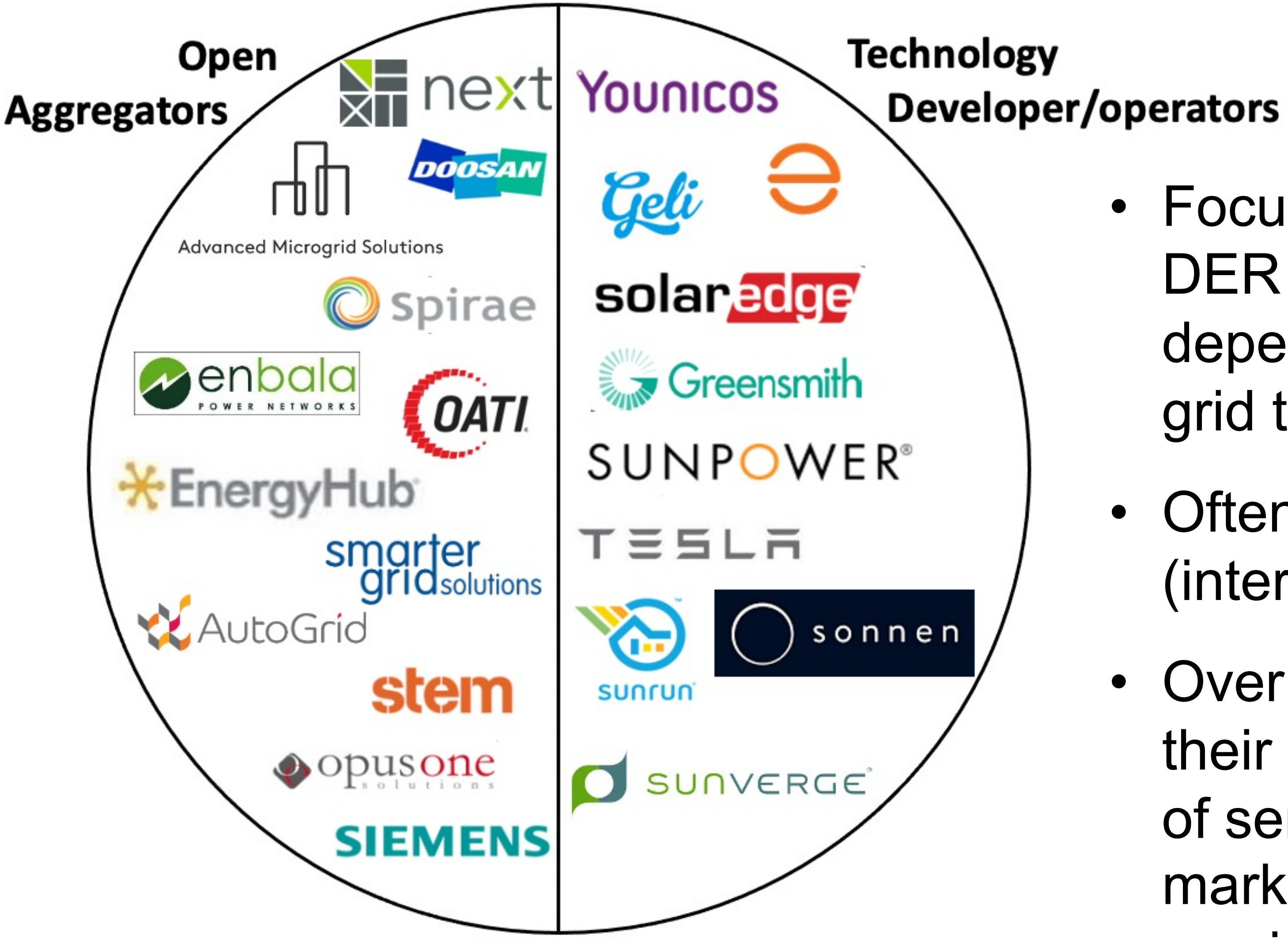
Swell: 100 MW aggregation contracted

- 8,000 customers SCE VPP GridRevenue
- 6,000 customers Hawaiian Electric
- 100 customers Brooklyn/Queens, NY

Customers, Aggregators, and FERC O2222

VPP Vendor Landscape

Aggregator DERMS 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

EPRI | ELECTRIC POWER RESEARCH INSTITUTE

ELECTRIFICATION 2021

VIRTUAL FORUM SERIES

Real Solutions for a Net-Zero World

Mark Your Calendar for These Upcoming Virtual Forums!

June 28 – 30, 2021

A Net-Zero Energy System for All

Scaling the grid for an electrified economy and solving the most difficult decarbonization challenges, with unprecedented resiliency … for all

For more information and to join the mailing list: www.electrification2021.com #ElectricTogether

EPRI Journal: The Age of Customer Energy Storage is Approaching

https://eprijournal.com/the-age-of-customer-sited-energy-storage-is-approaching/

Together…Shaping the Future of Electricity