The State of the Art in Virtual Power Plants (VPP)

Charging Ahead Webinar

July 22, 2025

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Agenda and Housekeeping

Agenda

- Drivers of Distributed Energy Resources (DER)
- DER Services, Economics, Sources and Business Models
- Benchmarks and Case Studies
- Takeaways and Recommendations
- Next Charging Ahead

Housekeeping

This webinar is being recorded and distributed to all registrants along with this presentation

Add your questions in the chat. My colleague, Sara, is monitoring the queue of questions for the Q&A session

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Drivers of Decentralized Energy Resources

Decarbonization

Growth in Electrification and Renewable Energy

Growth in Data Centers

Market and Grid Impacts

Costs

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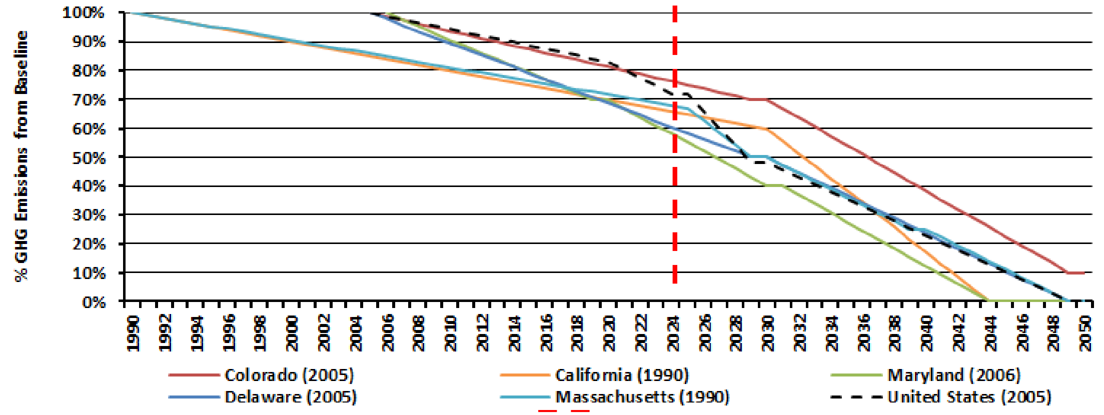
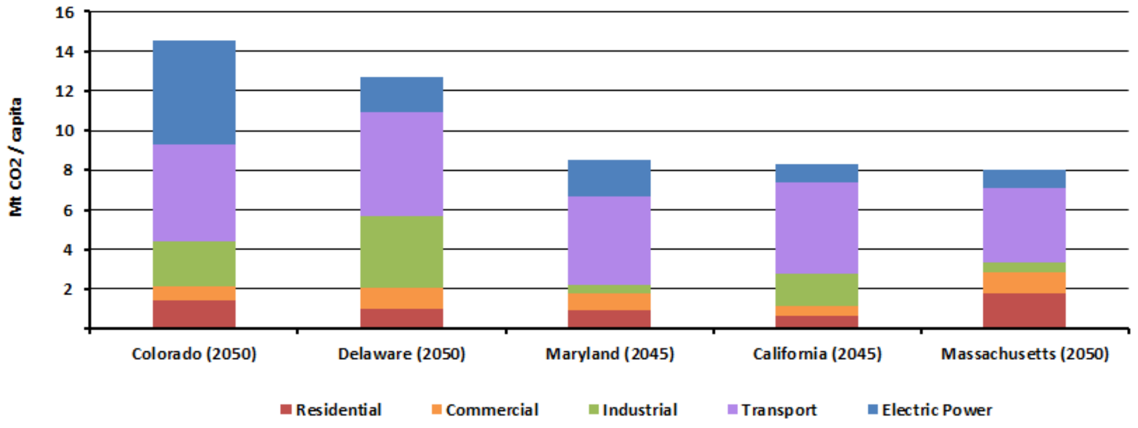
United States CO2 Targets by Key State

Leading State and Federal CO2 Targets



Note: legend includes "State" ("Baseline Year") = Current Year
Source: Energeia Research, US EIA (2022)

Leading States Emissions per Capita by Sector

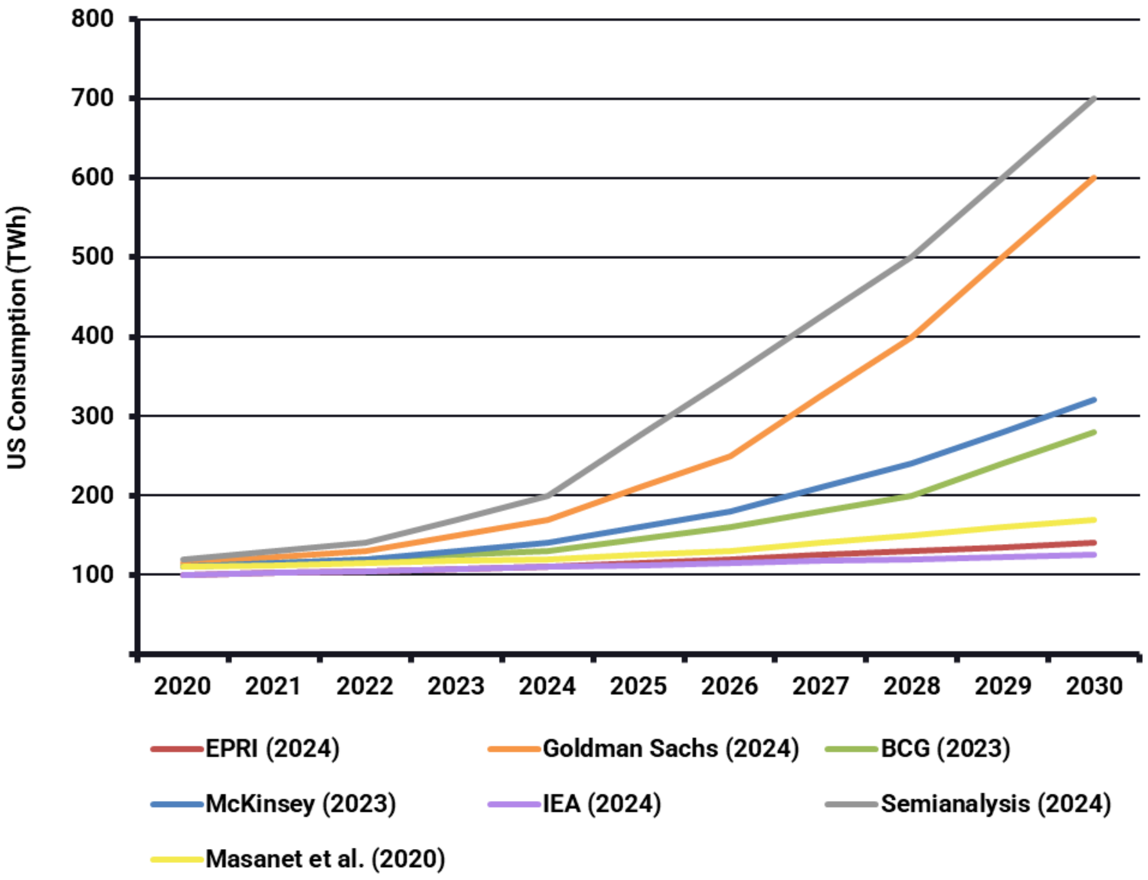


Note: labeling includes "State" ("Target Year")
Source: Energeia Research, US EIA (2022)

- The United States had adopted a trajectory to reduce emissions by 50-52% of 2005 baseline levels by 2030 under its NDC to the Paris Agreement, but is expected to alter or scrap the targets per the withdrawal from the Paris Agreement
- State CO2 targets vary substantially in terms of baseline year, target sectors, and trajectory, with California, Colorado, Massachusetts, and Maryland undertaking some of the most comprehensive climate action plans, driven by state policy
  - States with most comprehensive CO2 roadmaps have been included, but may not represent the states with the most stringent targets
- Achievement of CO2 targets requires significant investment in direct and indirect electrification:
  - **Residential** – This is largely natural gas, and likely to be electrified via heat pumps
  - **Commercial** – This is also largely natural gas, and likely to be electrified via heat pumps
  - **Industrial** – This is a mix of natural gas and petroleum products, and likely decarbonized via direct and indirect (e.g. H^2) electrification
  - **Transport** – This is mostly petroleum products, and likely decarbonized via electrification with niche H^2
  - **Electric Power** – This requires transition to renewable and/or nuclear and/or niche H^2 generation, and batteries

Data Center Consumption Outlooks

US Data Center Consumption Forecast Comparison



Source: IEA (2024), Energeia Research

- Key industry authorities have forecasted data center growth in the US and international contexts, with no consensus on what the future holds
- Estimates for 2030 US data center energy consumption range from 120 TWh to more than 600 TWh
  - Current and historical consumption is not exact as some large-scale enterprise data centers not required to release consumption metrics
- Combined with the potential development of more manufacturing facilities in the US, regional planners are increasingly seeing 100% peak demand growth in next 10 years
- Data center loads, like other industrial loads, often obtain very low prices due to their high volumes, they are likely to share resource and transmission costs with lower voltage consumers
- Reductions in lower voltage load could free up capacity at sub-transmission and transmission networks to connect additional industrial and data center load growth

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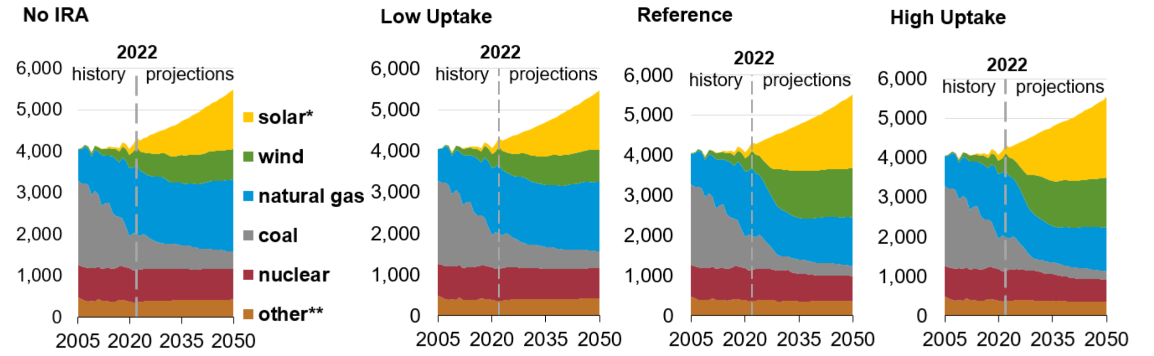
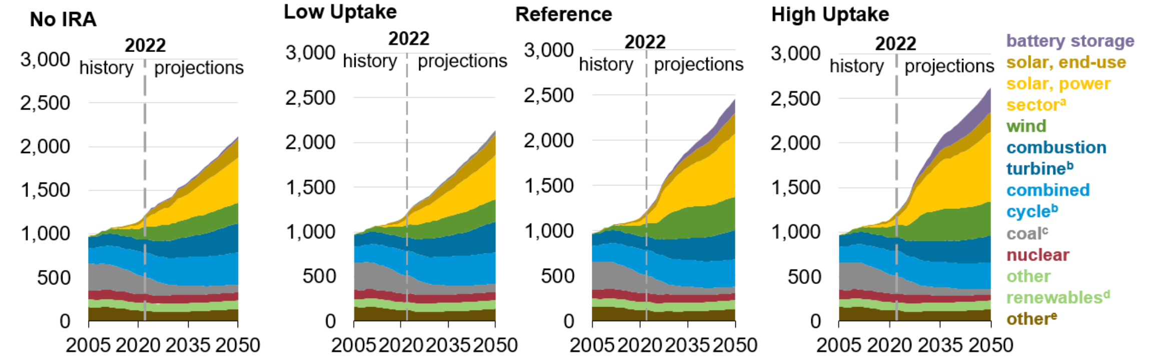
US Utility Scale Generation Investment Outlook

US Generation Outlook by Scenario (GWhs)



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note:
IRA=Inflation Reduction Act
*Includes utility-scale and end-use photovoltaic generation and excludes off-grid photovoltaics.
**Includes petroleum, conventional hydroelectric power, geothermal, wood and other biomass, pumped storage, non-biogenic municipal waste in the electric power sector, refinery gas, still gas, batteries, chemicals, hydrogen, pitch, purchased steam, sulfur, and miscellaneous technologies.

US Generating Capacity Outlook by Scenario (GWs)



Data source: U.S. Energy Information Administration, *Annual Energy Outlook 2023* (AEO2023)
Note: CC=combined cycle; IRA=Inflation Reduction Act
[a] Excludes off-grid photovoltaics
[b] Power sector only
[d] Includes coal plants that co-fire biomass
[d] Includes conventional hydroelectric, geothermal, biomass, and municipal solid waste from all sectors
[e] Includes oil/gas steam turbine, fuel cells, and pumped storage hydro from the power sector and petroleum, natural gas, other gases, and miscellaneous technologies from the end-use sector

- The US outlook for renewable energy capacity expansion is substantial under a range of electrification scenarios
  - 100%-250% increase in nameplate MWs to 2050
- Decarbonization is thus rebuilding the bulk supply system in a different place, using different technology, while doubling in size
- This all costs money

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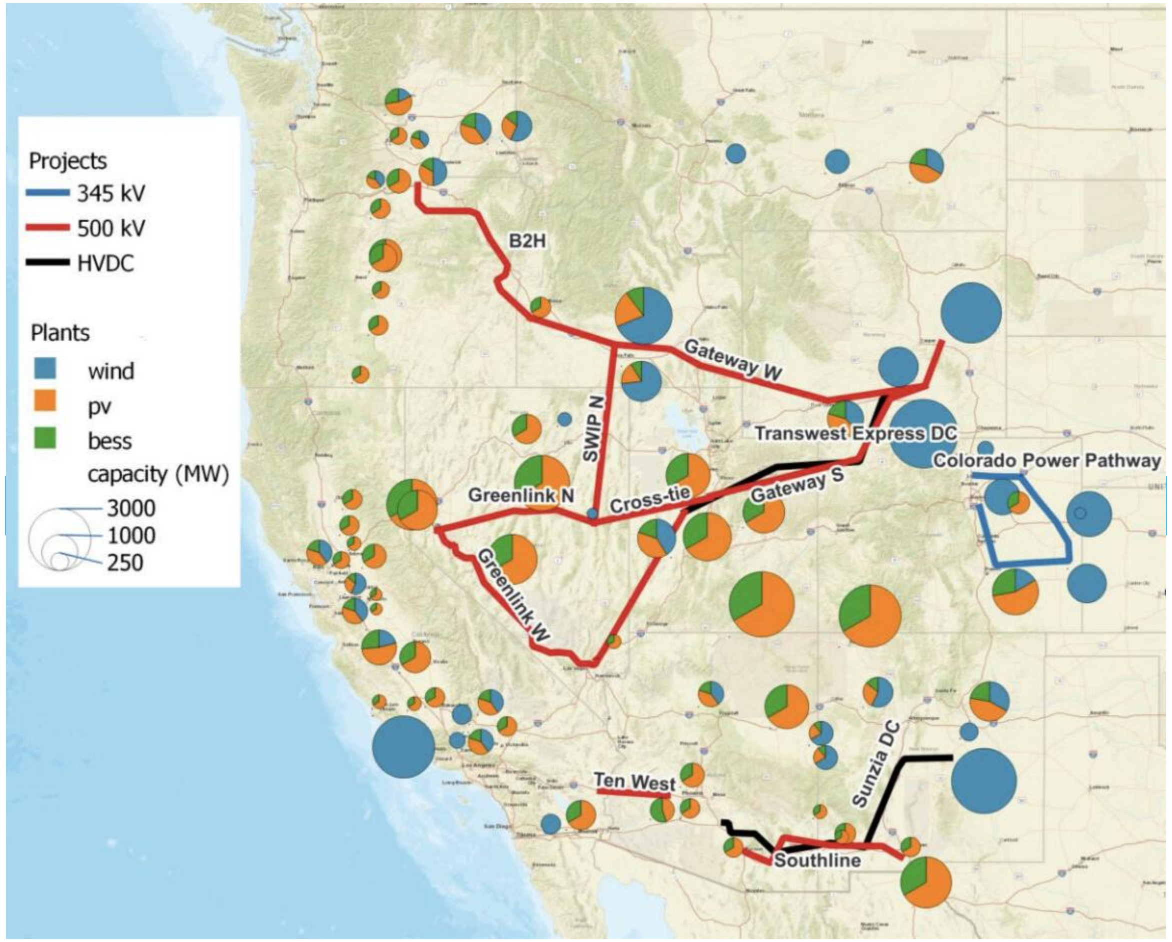
US Utility Scale Transmission Investment Outlook

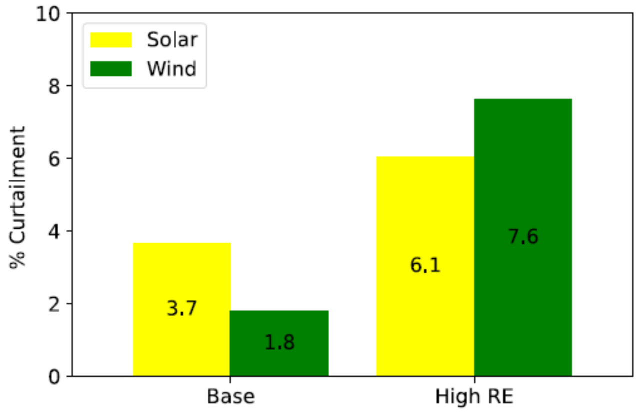
Selected Transmission Projects



Western Interconnection Baseline Study, September 2024

- Investment in new resource frontiers requires major new transmission lines to be built
  - Community resistance and transmission bottlenecks are delaying planned transmission projects
  - Transmission costs are increasing due to inflation and global pressure on the supply chain
- Renewable generation also prone to curtailment, which is expected to rise significantly
- Again, this all costs money

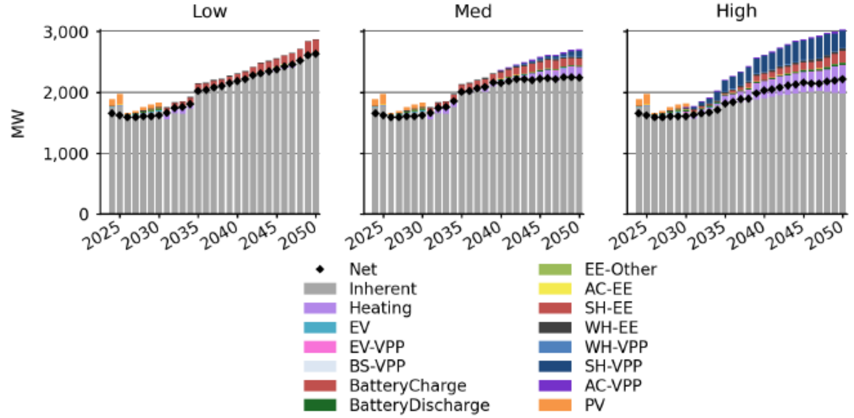
Forecast Curtailment in the Western Interconnect (2030)



Western Interconnection Baseline Study, September 2024

Residential and Commercial Electrification Impacts

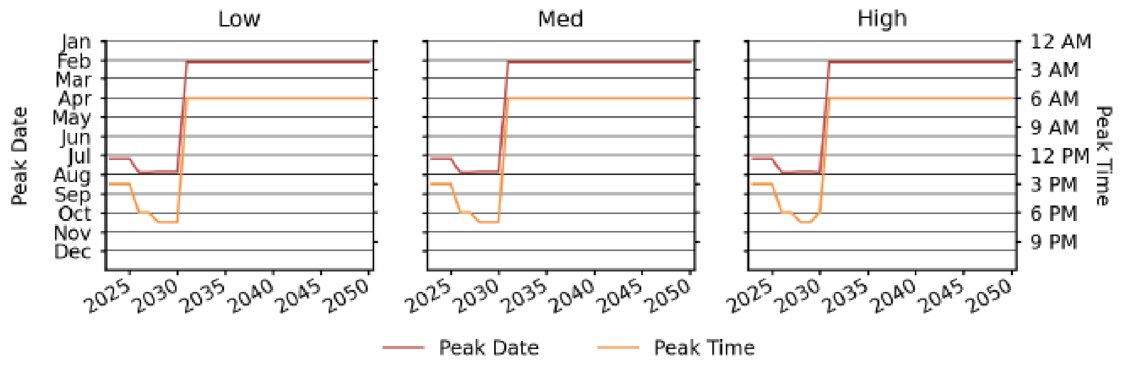
Peak Demand by Scenario



Source: Energeia uSim simulation of NE Utility

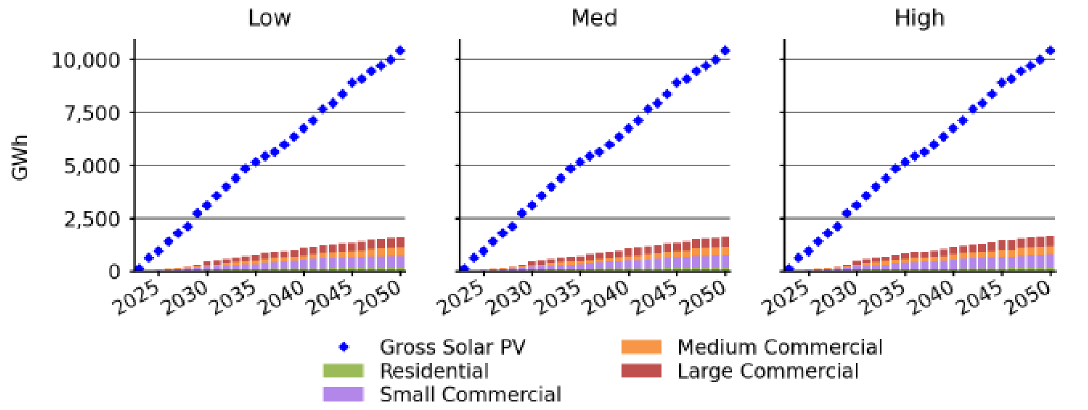
- Electrification of residential and commercial buildings and transport expected to drive peak demand increases
- It will also impact on the timing of peak, potentially moving from evenings in summer to mornings in winter
- This will in turn impact on bulk system resource needs, availability and cost
- Rooftop solar PV policies also expected to drive significant adoption and eventually, curtailment
- Note the impact of VPP resources in the Med and High scenarios

Peak Demand Timing



Source: Energeia uSim simulation of NE Utility

Solar PV Curtailment by Class and Scenario



Source: Energeia uSim simulation of NE Utility

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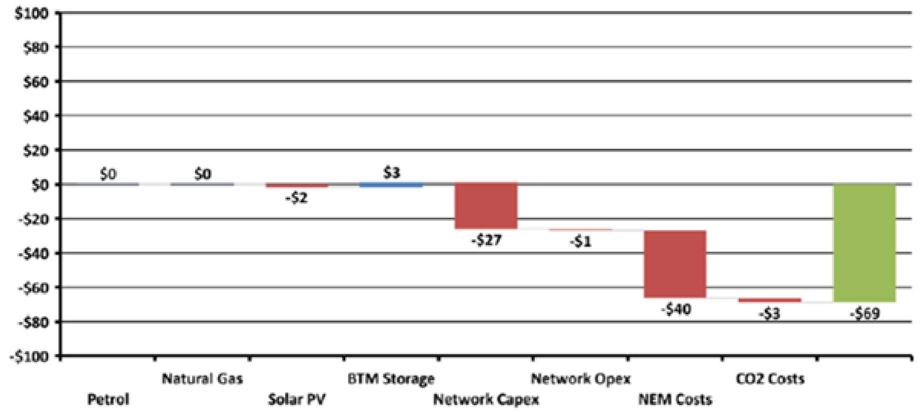
Community Benefits from Effectively Integrating DER (AU)

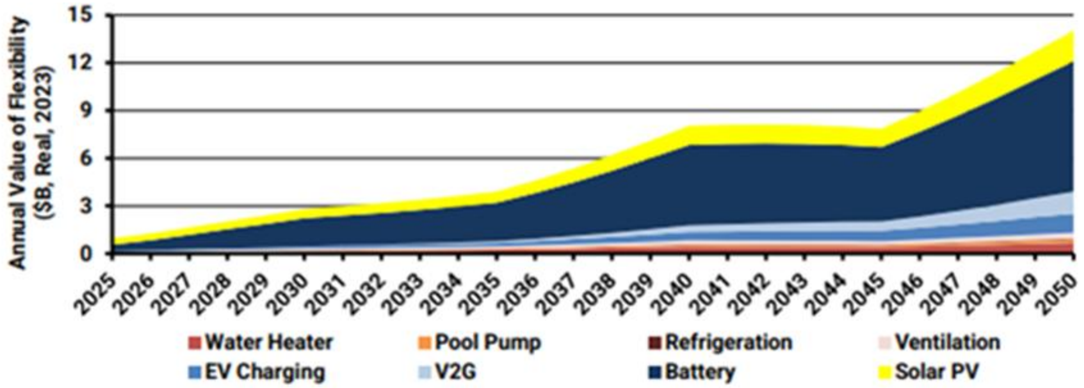
$69b in Benefits Across Bulk and Distribution System (2050)



Source: Energeia

- Whole-of-system modeling for Energy Consumers Australia (peak consumer advocate) and Renew (consumer advocate) found almost $70b in savings to 2050
- Australia's National Electricity Market (NEM) saw a 33,716 MW peak demand in 2024, about the size of California (48,353 MWs)

Up to $40b in Bulk System Benefits + Distribution (2050)



Source: Energeia

- Whole-of-system modeling for the Australian Energy Market Commission (equivalent of the FERC) found $40b in benefits from wholesale benefits alone for the NEM

Decentralized Energy Resources

Services

Economics

Definitions

Models

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VPP System and Grid Services

VPP Service Definitions, Metrics and Beneficiaries

Service	Definition	Performance Metric	ISO	T&D	LSE
Frequency Response	Maintaining stable grid frequency through fast response services	Up/down (MW) available to respond to frequency excursions	✓	×	×
Contingency Response	Ensures system security by providing contingency resources	Up/down (MW) available to respond to contingency events	✓	×	×
Balancing Services	Ensures system remains in balance despite random, non-correlated random variations	Up/down (MW) available to respond to random demand/supply variations	✓	×	×
Ramping Services	Ensures system remains in balance despite major RE supply ramps	Up/down (MW) available to respond to major changes in RE capacity	✓	×	×
Thermal Constraint Relief	Avoiding thermal overloads by reducing load during the peak	MW load reduction during peak	×	✓	×
Operational Flexibility	Provides additional asset headroom to support switching	Reduction in SAIDI	×	✓	×
Voltage Regulation	Stabilizing voltage levels for grid reliability	Ability to respond to over/under voltage conditions	×	✓	×
Resource Adequacy	Ensuring sufficient capacity to meet peak system demand	Capacity (MW) available at system peak	×	×	✓
Local Resource Adequacy	Ensuring sufficient local capacity to peak local peak demand	Capacity (MW) available at local peak	×	×	✓
Wholesale Cost Minimization	Minimizes wholesale settlement costs or maximizes wholesale trading benefits	Change in wholesale settlement costs	×	×	✓
Transmission Cost Minimization	Minimizes transmission charges	Change in OATT costs	×	×	✓
CO_2 Emissions Minimization	Minimizes CO_2 emissions costs or maximizes CO_2 trading benefits	Change in CO_2 certificate costs	×	×	✓

Note: T&D = Transmission and Distribution, ISO = Independent System Operator, LSE = Load Serving Entity
Source: Energeia Research

- Energeia identified key VPP services and use cases, and mapped them to key beneficiary categories, shown at left
  - Not all services are currently active, e.g,. operational flexibility
  - Voltage compensation
  - Local RA included, though not applied in California
  - Ramping is another ancillary service that has not yet been applied
- The associated benefits for these vary from utility to utility
  - This project will develop estimates for services Roseville agrees to
- Benefits such as enhanced resiliency or renewables integration are provided by existing utility services such as contingency, load reduction, and/or voltage compensation
- VPP control systems can be used to minimize customer bills, but that does not involve 'virtualization' and is therefore not counted here

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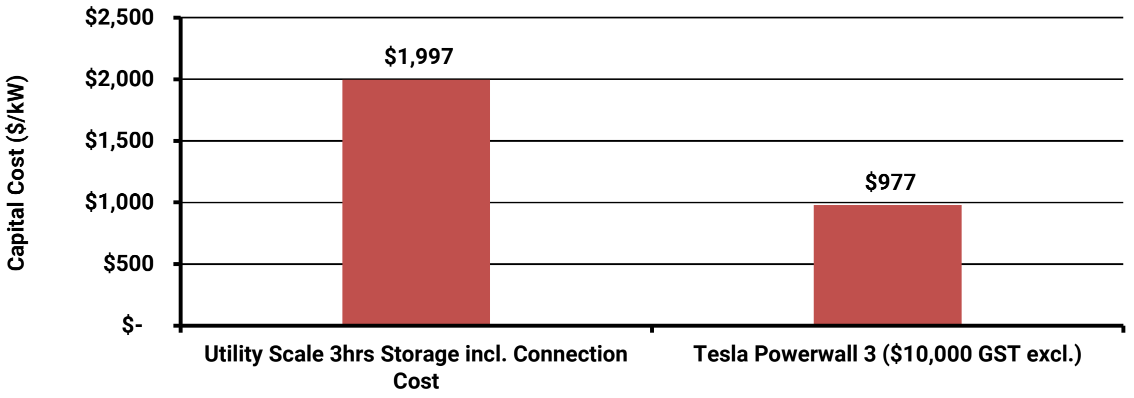
Decentralised Residential vs. Centralised Utility Scale Storage

Comparable Storage Costs ($/kW)



Note: Tesla Powerall 3 assumed ~$3,500 lower from avoided cost of 12 kW solar PV inverter
Source: Energeia Modelling, AEMO IASR (2023)

- Energeia's research found that residential VPPs can:
  - deliver over 15% more value than utility scale storage assets to electricity retailers, e.g.
    - Minimization of network charges
    - Distribution grid services revenues
  - be 50% cheaper on an installed basis in specific circumstances, e.g. collocated with PV, and
  - have shorter lead times
- Retailers that harness VPPs will therefore achieve a competitive advantage over those overweighted to utility scale resources

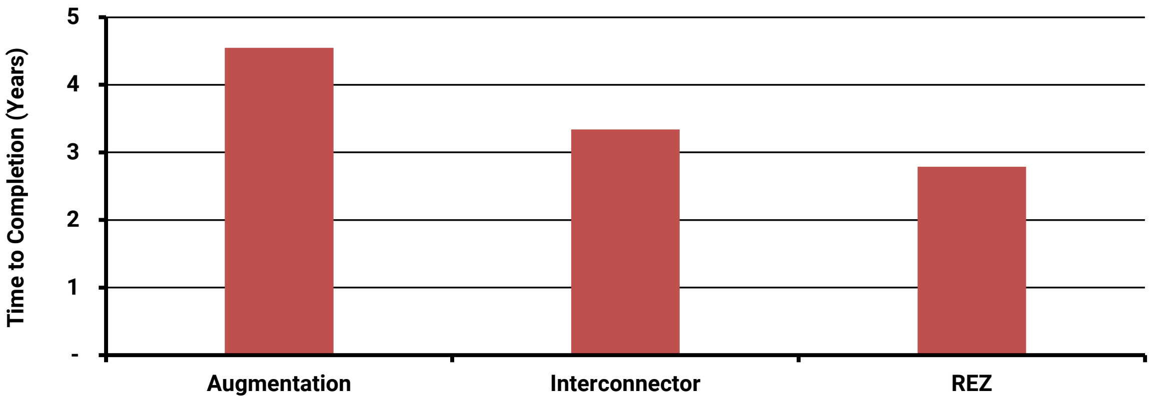
Storage Benefit Stream Comparison ($/kW/Year)

Storage Applications	Utility Scale Storage	VPP Storage
Market Services		
NEM FCAS Markets*	$2,000	$2,000
Energy Markets**	$80	
Transmission Services		
Peak Demand Management	$75	$75
Voltage Management	$5	
Distribution Services		
Peak Demand Management		$250
Voltage Management		$10
Retailer Services		
Network Charge Minimization***		$20
NEM Settlement Cost Minimization**		$80
Customer Services		
Customer / Host Backup		$50
Total ($/kW/Year)	**$2,160**	**$2,485**

Notes:
* = VPP expected to be able to participate in regulation market, but not yet
** = Energy market dispatch equivalent to retailer NEM settlement cost reductions
*** = Network charge minimization will ultimately be the same as peak and voltage service benefits
Source: Energeia Modelling

Source: Energeia Modelling, AEMO IASR (2023)

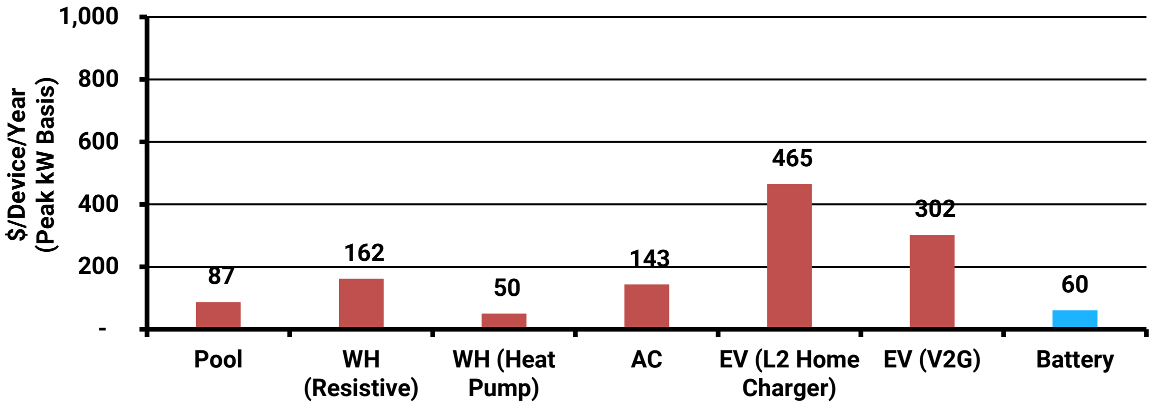
Transmission Project Speed to Market



Source: AEMO IASR (2023),Note: REZ + Renewable Energy Zones

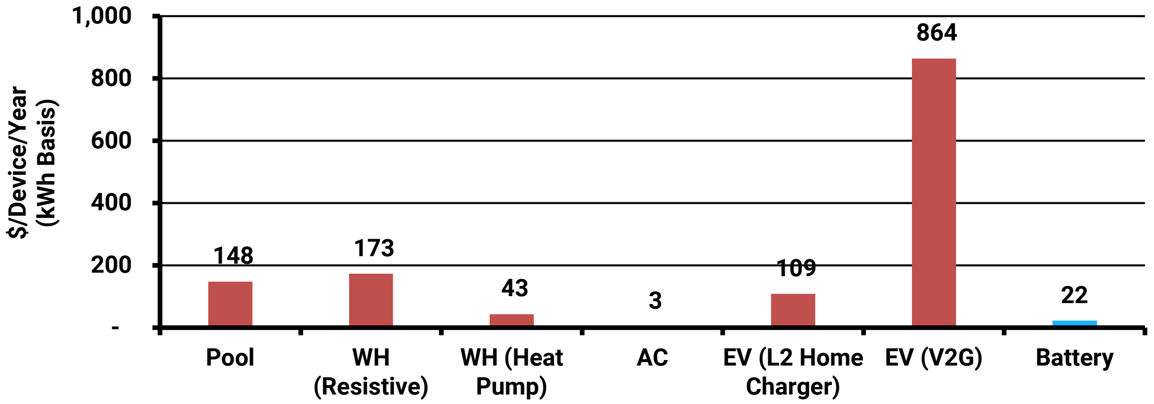
Estimated Value by Type of DER (Residential)

Estimated DER Value by Type – Peak kW Basis



Source: Energeia modeling

Estimated DER Value by Type – kWh Basis



Source: Energeia modeling

- Energeia developed a volume-weighted average (VWA) $/kW-4hr storage incentive as a market average for a battery VPP
- We then divided it by the battery's power (5 kW) and energy (14 kWh), and scaled it based on each DER's 3-hour peak power or energy, respectively, to identify the relative value of other DER
  - AC peak kWs were reduced by 50% for cycling
  - EV Level 2 and V2G kWs and kWhs were reduced by 20% for opt-outs
- The results show that other CER, with the exception of AC energy shifting, are potentially more valuable than batteries
  - More analysis needed to confirm load reduction kWs available when likely to be needed, e.g. during price spikes and network peaks

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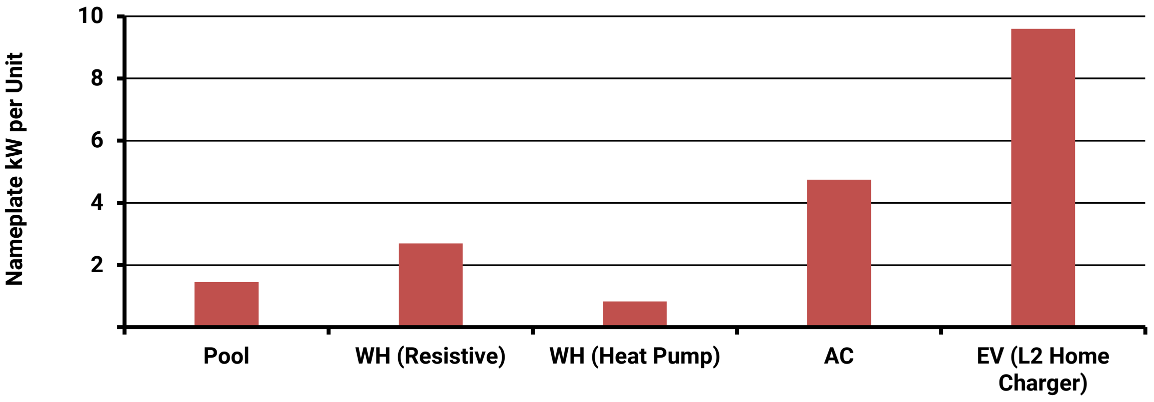
Estimated DER Size by Type and Illustrative Impact

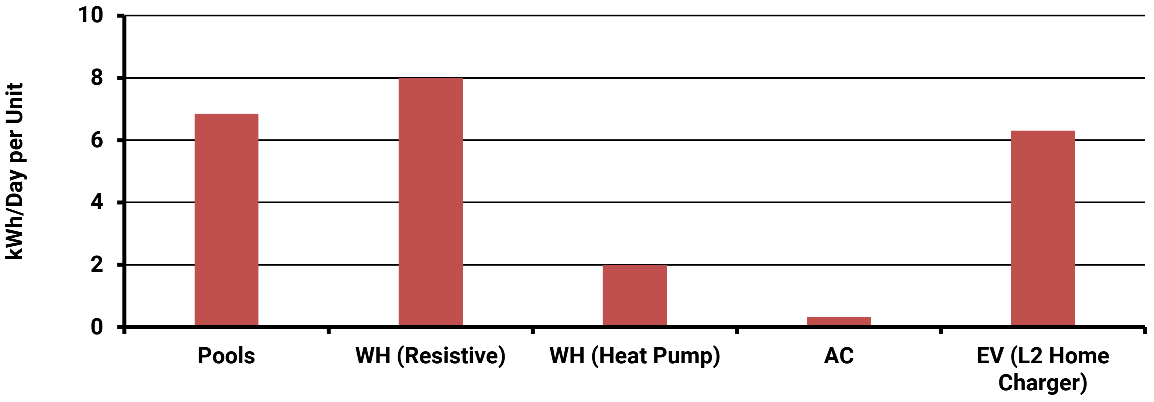
Load Demand Flexibility (kW)



Source: UTS (2023), Energeia Modelling

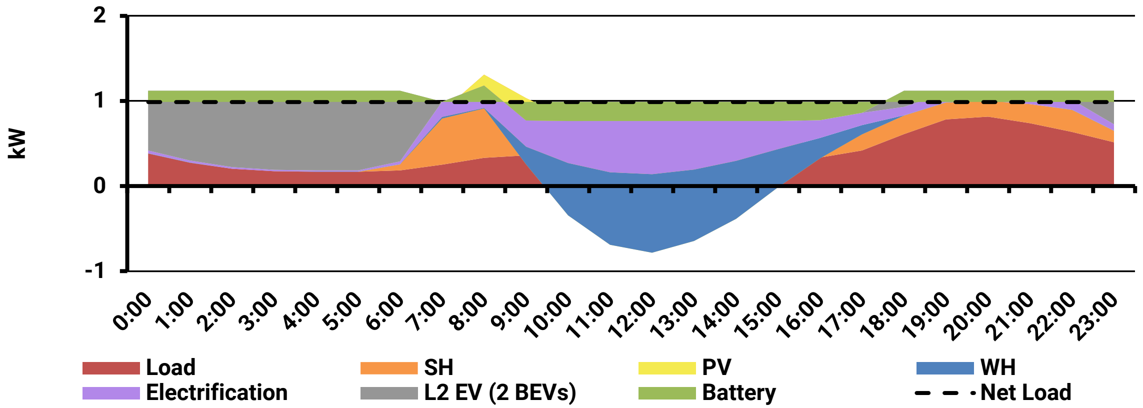
- Customer decisions regarding the devices and/or services they choose can radically alter their needs
- Adoption of DER results in more opportunities for management and related services
- Battery storage places a special role by adding an additional level of optimisation per below right

Load Energy Flexibility (kWh/Day)



Source: UTS (2023), Energeia Modelling

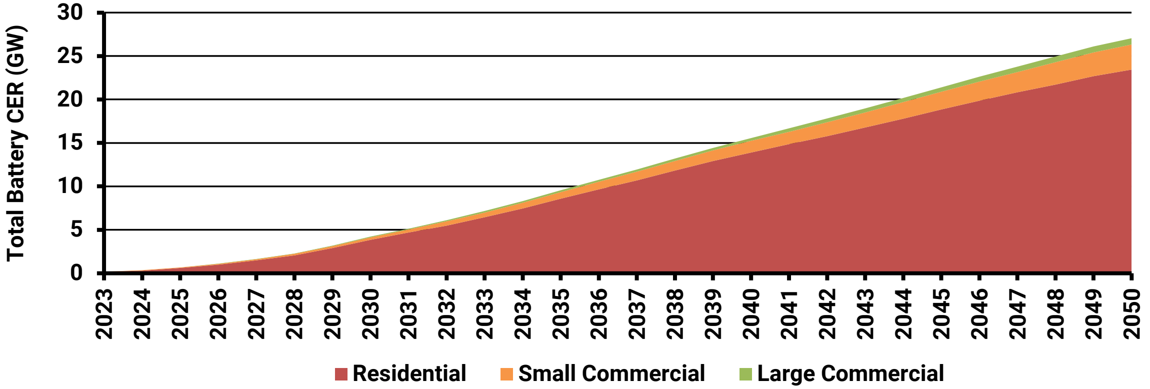
Illustrative Residential Load Profile Post Optimisation



Source: Energeia Modelling. Note: WH = Water Heating, SH = Space Heating

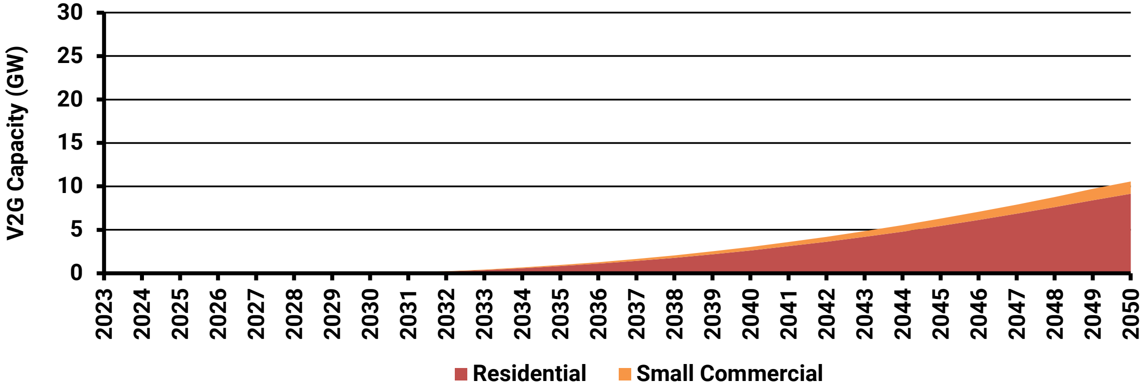
Outlook for Batteries and V2G VPP Feedstocks

Flexible Battery Capacity (GW) by Customer Class



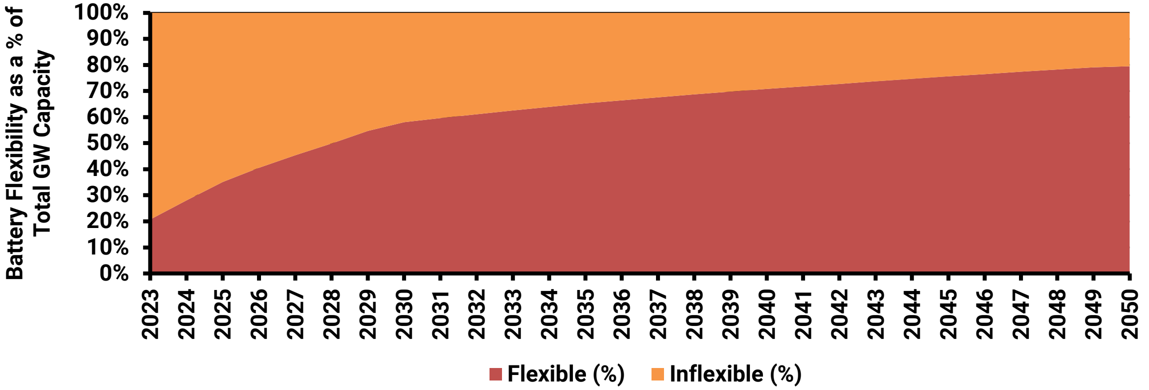
Source: Energeia Modelling, AEMO IASR (2023)

Flexible V2G Capacity (GW) by Customer Class



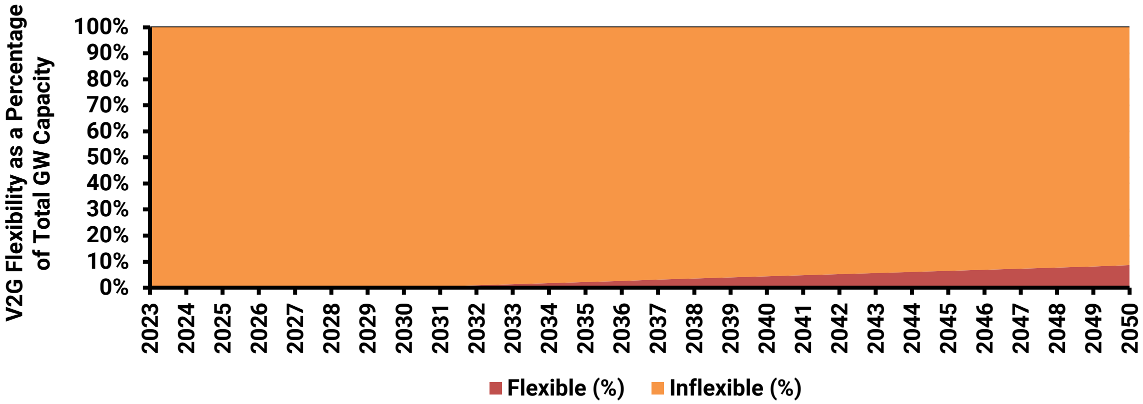
Source: Energeia Modelling, AEMO IASR (2023)
Note: Assumes 5 kW export limit per EV

Flexibility as a Percentage of Total



Source: Energeia Modelling, AEMO IASR (2023)

Flexibility as a Percentage of Total



Source: Energeia Modelling, AEMO IASR (2023), Note: Assumed total GWh capacity of V2G to be 50kWh per vehicle

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Two Business Models are Emerging: VPPs and HEMS

Virtual Power Plants (VPPs)

- Guaranteed Payments to Participants
- Managed by VPP Operators
- Delivers a Service, e.g. FCAS or T&D Peak Reduction
- VPP Operator Exposed to Risk/Reward
- Requires Service Definitions, Market Place, DSO, Prices
- Main Gap is Service Definitions, Market Plan, DSO, Prices
- Examples incl. FCAS, Retailer VPPs, etc.

Home Energy Management Systems (HEMS)

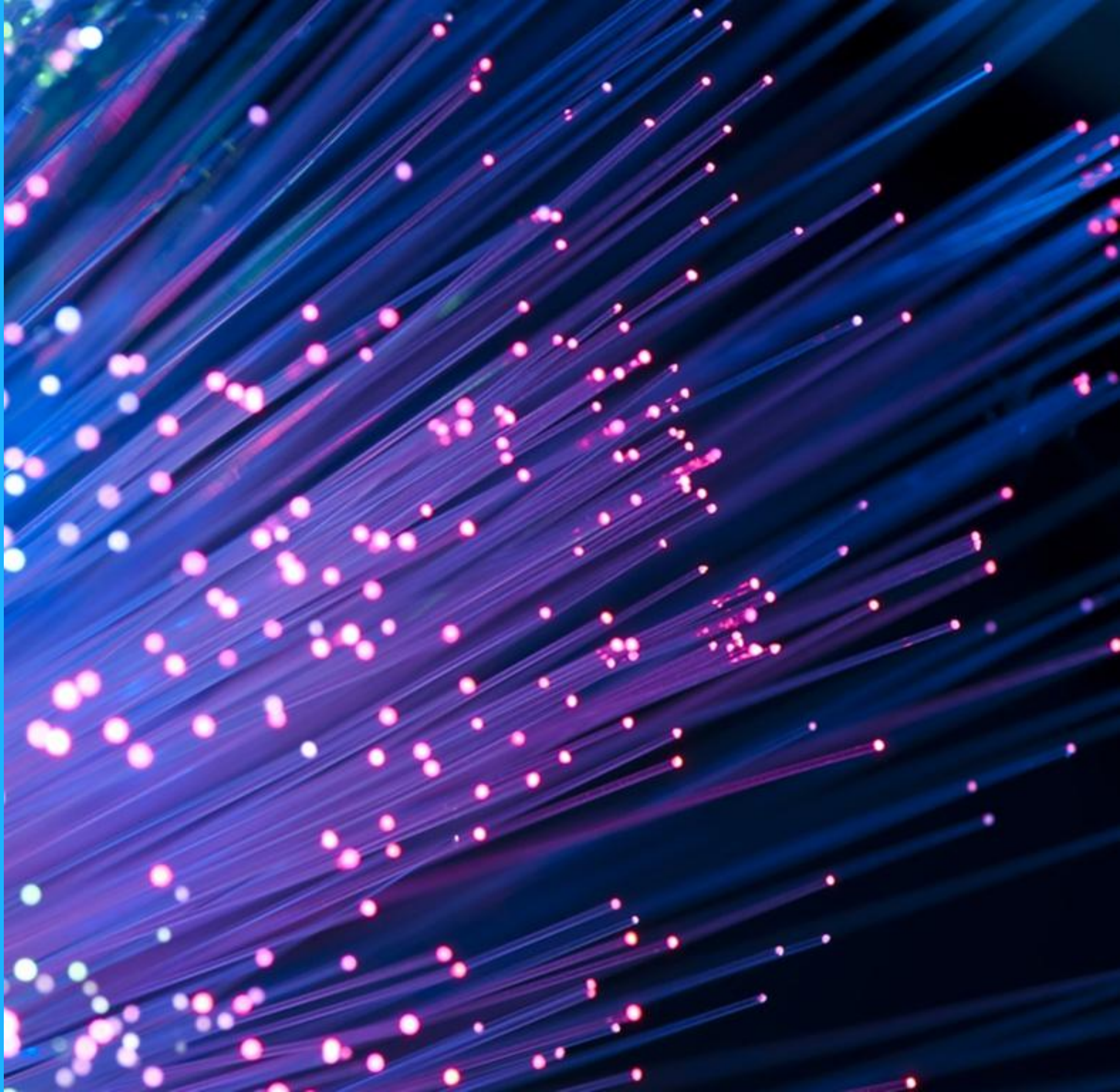
- Market based payments to participants
- Managed by HEMS Operators
- Delivers an Optimisation Service to Consumers
- Consumer Exposed to Risk/Reward
- Requires Cost Reflective Pricing (like NEM market participants)
- Main Gap is Cost Reflective Network Pricing
- Examples incl. Energy Master, Edith, Amber, Local Volts, etc.

Virtual Power Plant Case Study – Australia

Program Benchmarks

Key Positioning

Economics



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Summary of Australia's Main Battery VPPs

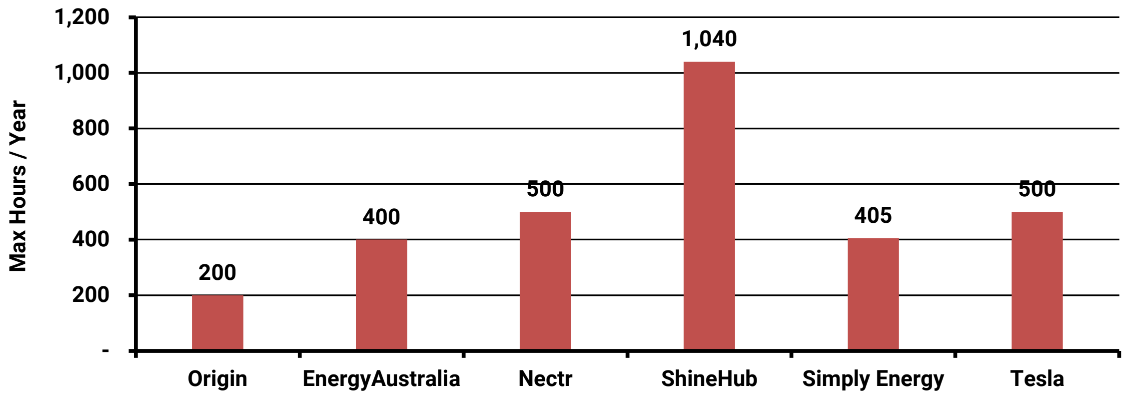
VPP Feature		AGL "Bring Your Own Battery"	Amber for Batteries	Discover Energy VPP	EnergyAustralia "Solar Optimiser"	Nectr VPP	Origin 'Loop' VPP	Powershop VPP	Arcstream by Qcells	Reposit "No Bill"	ShineHub VPP	Simply Energy VPP	SolarHub / AGL VPP	SonnenConnect	Tesla Energy Plan
Provider	Company	agl	amber	Discover Energy	EnergyAustralia	nectr	origin	POWERSHOP	arcstream by qcells	reposit	ShineHub	simply energy	solarhub	sonnen	TESLA ENERGY PLAN
	Primary Function	Energy Retailer	Energy Retailer	Energy Retailer	Energy Retailer	Energy Retailer	Energy Retailer	Energy Retailer	Battery Retailer	VPP Operator	VPP Operator	Energy Retailer	VPP Operator	Battery Retailer	Battery Retailer
	Registered FCAS Load	✓	×	✓	×	×	×	×	×	×	✓	✓	×	✓	✓
Offer Regions	NSW	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	QLD	✓	✓	✓	×	✓	✓	✓	✓	×	✓	✓	×	✓	✓
	SA	✓	✓	✓	×	✓	✓	✓	×	×	✓	✓	×	✓	✓
	VIC	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	×	✓	✓
Sign-up Restrictions	Retail Customer of Provider	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	×	✓
	Battery Customer of Provider	×	×	×	×	×	×	×	✓	✓	×	×	×	✓	✓
	BYOB	Optional	✓	✓	✓	Optional	Optional	✓	Optional	×	✓	Optional	Optional	Optional	Optional
	Solar Min Capacity Limits	×	×	×	×	>2MWh Annual Export	>5kW	×	>5kW	×	×	>3kW	×	×	<15kW
	Battery Min Capacity Limits	×	×	×	×	>2MWh Annual Export	×	×	×	×	×	×	×	>4kWh	×
Min Contract Length	Years	5 (Rebate) or 1 (BYOB)	None	None	3	5	None	None	1	7	None	None	None	1	1
Subscription Fees	Annual	×	$228	×	×	×	×	×	$708-$948	×	×	×	×	×	×
Tariffs	Feed-in Structure	-	ToU	ToU	ToU	-	-	-	×	×	Flat	-	Block	-	-
	Feed-in Rate	Standard	Wholesale Prices	ToU	ToU	Standard	Standard	Standard	×	×	Standard	Standard	Declining Block	Standard	Standard
	Usage Structure	-	ToU	-	Flat	-	-	-	Flat	×	-	-	-	-	-
	Usage Rate	Standard	Wholesale Prices + Network Charge	Standard	Standard	Standard	Standard	Standard	Standard	×	Standard	Standard	Standard	Standard	Standard

Source: Energeia Research, Note: Standard tariff means the customer is not moved onto a specific tariff structure

- Companies are setting up Virtual Power Plants to offer a **better than retail bill savings** outcome for consumers
  - Retailer VPPs require being the retailer, but a few, like Sonnen, Reposit, ShineHub do not (SolarHub is partnered with AGL)
  - Battery manufacturers and Reposit require buying their battery, e.g. Qcells, Reposit, Sonnen, and Tesla, with some limits on sizing
  - Terms range from month to month (M2M) to 7 years, with M2M or 1 year being the most common

VPP Incentive, Partner and Service Positioning

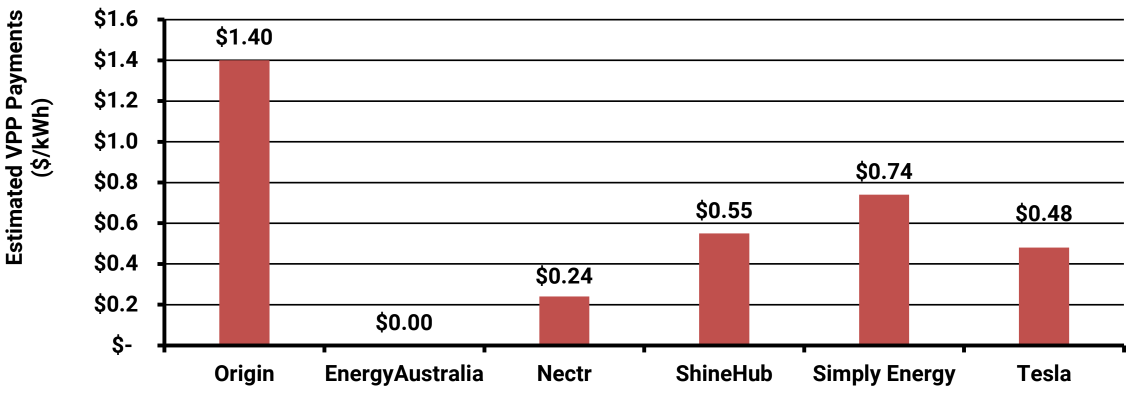
VPP Hours per Year



Source: Energeia Research

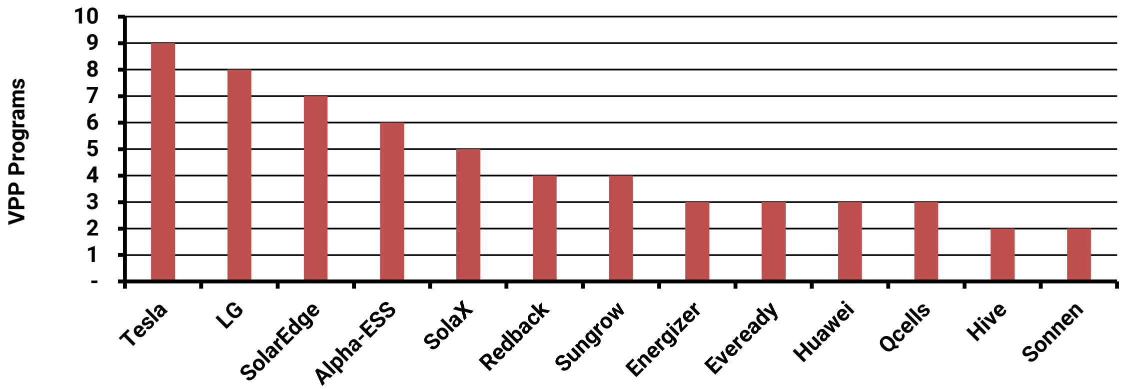
- Australian VPPs taking different positions with respect to hours per year, $/kWh and eligible systems
- Hours per year reflects VPP operator's view of amount of time worth taking control
- Fewer hours will target higher value periods, Origin offers the highest $/kWh for the fewest hours of operation
- No difference in value offered between batteries, generally treated as a commodity

VPP Payments per kWh



Source: Energeia Research

Battery Eligibility



Source: Energeia Research

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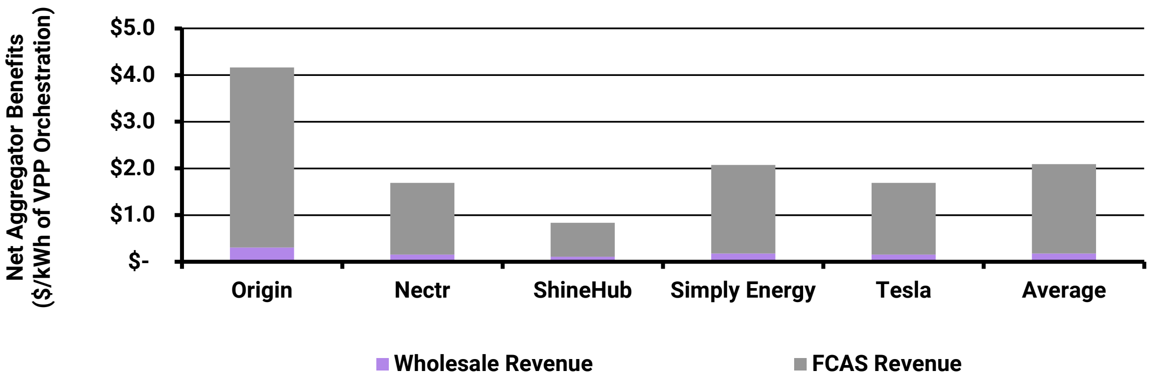
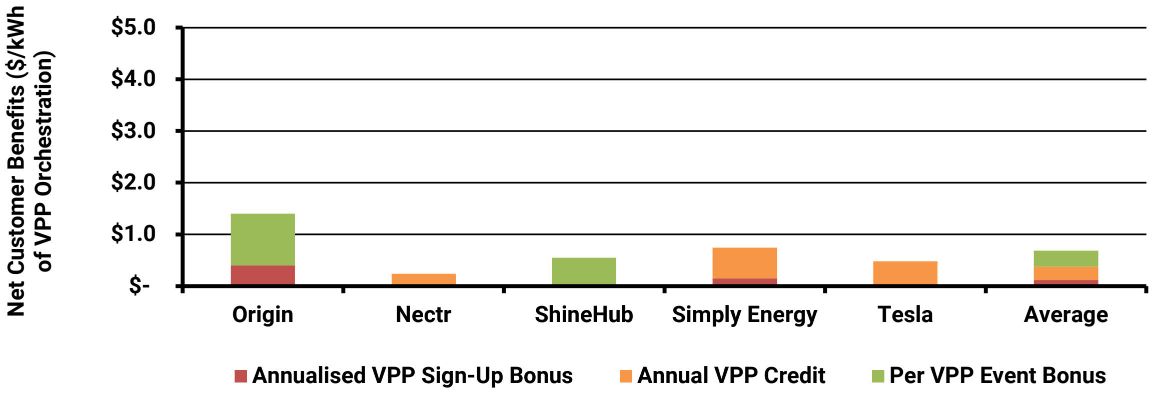
Estimated VPP Economics

Theoretical Maximum Earnings



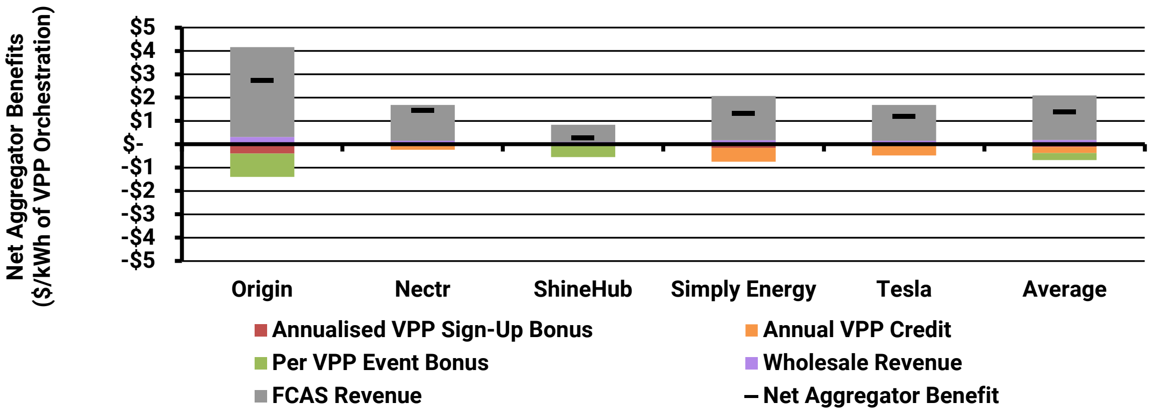
- Analysis assumed perfect information and highest best use strategy implementation
- Note model results are for a residential SA customer, as all selected VPPs are available to this jurisdiction
- Average theoretical max earnings are $2.09/kWh, with $0.68/kWh in estimated costs, producing $1.41/kWh in net aggregator benefits
- Although they offer the best deal to consumers, Origin's VPP terms deliver a higher margin than others

Estimated Costs



Note: Upfront payments based on bring your own battery amounts and contract terms
Source: Energeia Research

Gross Margin Estimate

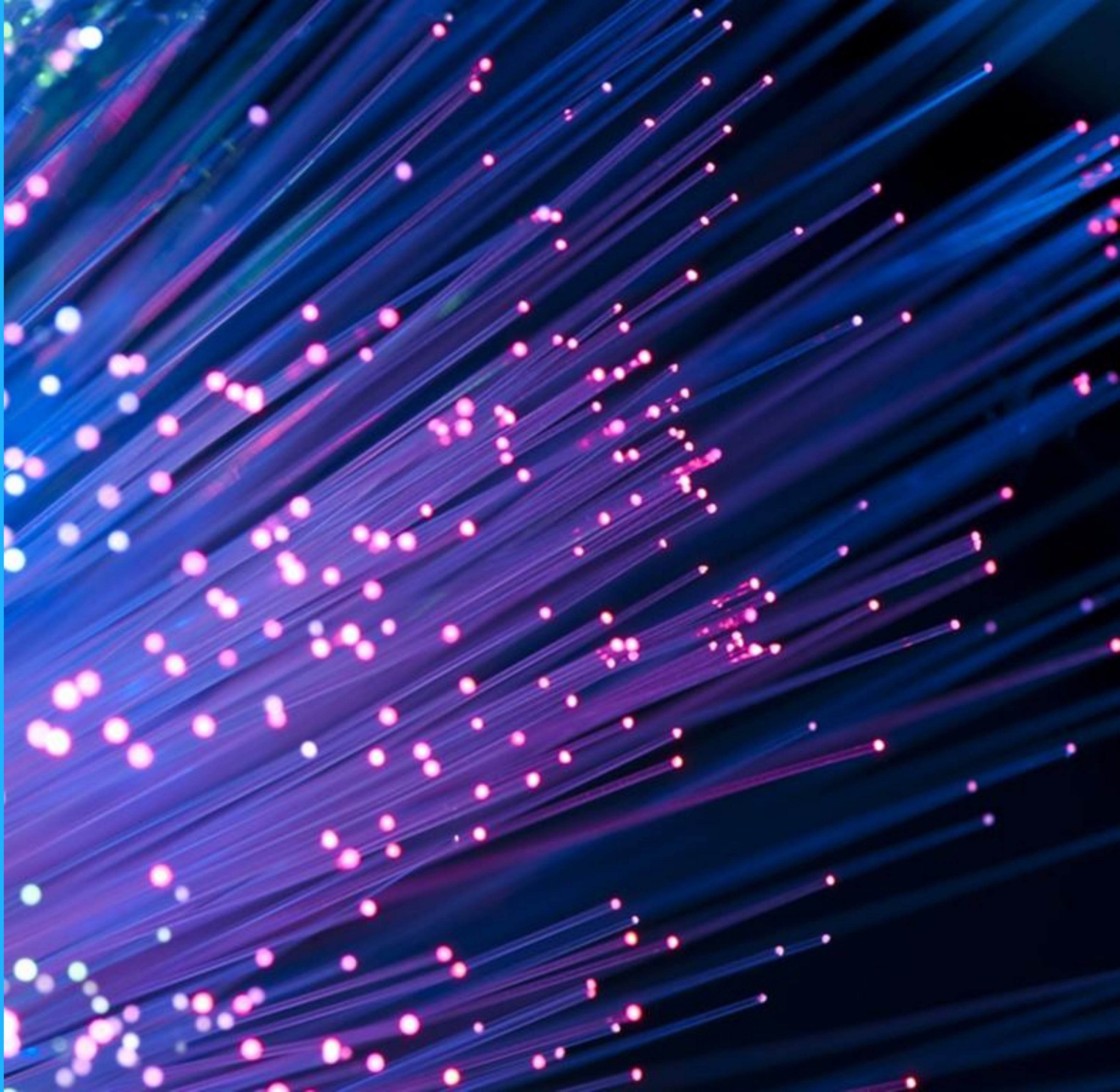


Source: Energeia Research

HEMS
Case Study - Australia

Behind-the-Meter Integration

Managing 5-Min Pricing Signals



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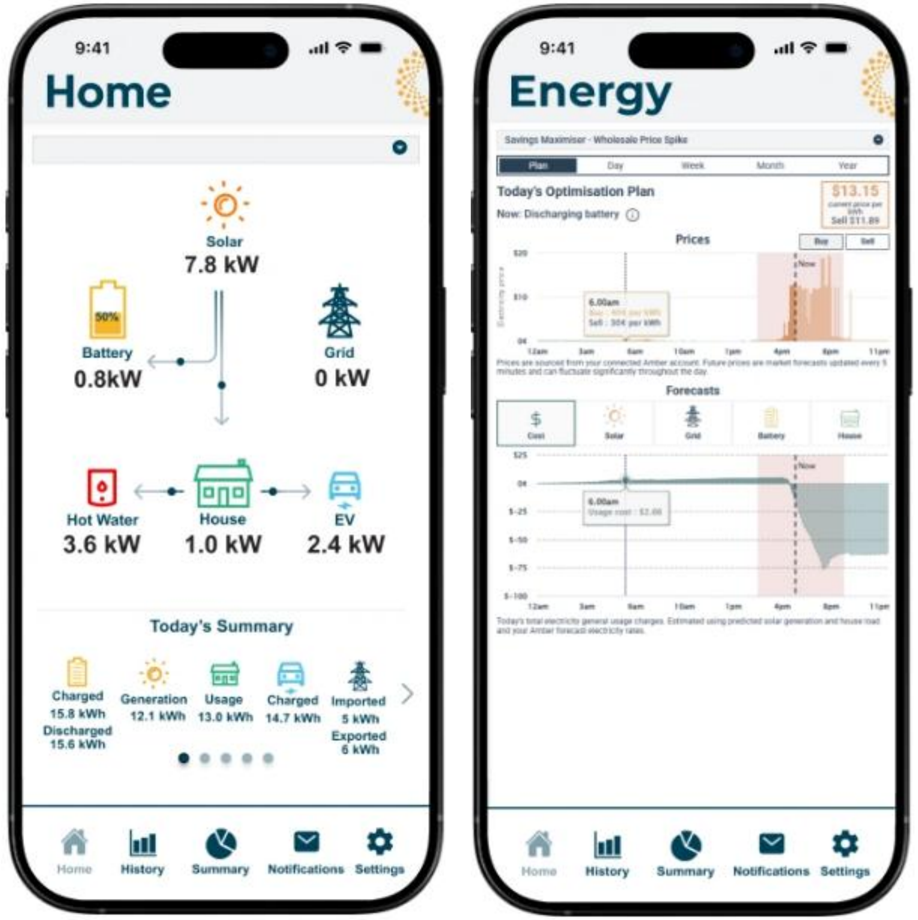
HEMS Case Study

Multiple Devices Optimized w/5-Min Market and T&D Prices



- Emerging retail business model is to charge a subscription to access wholesale market prices, like Costco
- Distribution networks increasingly examining and trialing market aligned (5-min) prices
- HEMS technology able to respond as fast as bulk system resources to market and grid cost drivers:
  - Utility scale renewable energy generator outages
  - Coal generator outages
  - Utility scale battery outages
  - Transmission outages
  - Cloud cover
  - Asset peak demand
  - Ancillary services
  - Voltage excursions (planned)
- Consumers value service as managing their risk, while accessing very low and negative price opportunities

Source: Empower Energy, https://demo.my.elektrobank.au/home

Virtual Power Plant Case Studies

Australia

US

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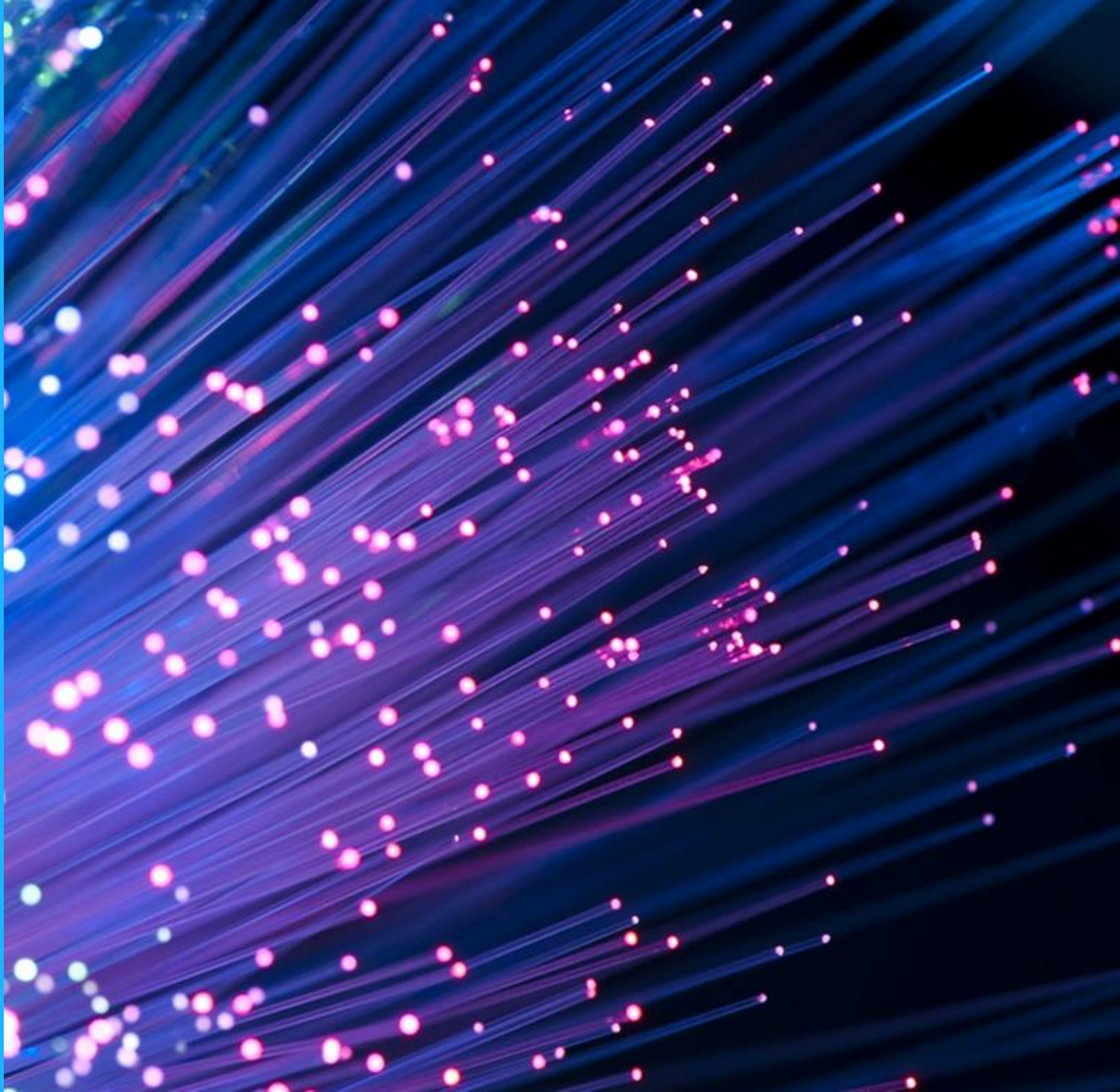

Prog. Benchmarking – Customers, Resources, Services & Size

Program	Smart Charge	EV Home Charging Plan	Peak Power Rewards	Charging Perks Pilot	SMUD Partner +	Bring-Your-Own-Device (BYOD)	Solar Battery Savings Program	Energy Partner on Demand*	Energy Storage Lease	Battery Bonus Program	Connected Solutions Program - Res	Connected Solutions Program - Com Daily	Connected Solutions Program - Com Target	WattSmart Battery
Overview														
Service Buyer	DTE Energy	Duke Energy	Pacific Gas & Electric	Xcel Energy	SMUD	Green Mountain Power	San Diego Community Power	Portland General Electric	Green Mountain Power	Hawaiian Electric	NationalGrid	NationalGrid	NationalGrid	Rocky Mountain Power
Program Developer	DTE Energy	Individual OEMs	Sunrun	Xcel Energy	Swell Energy + SMUD	Virtual Peaker	San Diego Community Power	Portland General Electric	Tesla	Hawaiian Electric	NationalGrid	NationalGrid	NationalGrid	Rocky Mountain Power
Program Start Date	Jul-23	Sep-23	2023	Jun-21	2023	2015	2024	2023	2015	Jul-21	2019	2019	2019	Dec-20
Program End Date	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing
Customer Segment														
Residential	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	×	×	✓
Commercial	×	×	×	×	×	×	×	✓	×	✓	×	✓	✓	✓
Resource Type														
Electric Vehicles	✓	✓	×	✓	×	×	×	×	×	×	×	✓	✓	×
Batteries	×	×	✓	×	✓	✓	✓	✓	✓	×	✓	✓	✓	✓
Solar + Batteries	×	×	×	×	×	×	✓	✓	×	✓	×	✓	✓	×
Grid Services														
Operational Flexibility	×	×	✓	×	×	✓	✓	✓	✓	×	×	×	×	✓
Energy	×	×	✓	×	×	×	✓	×	×	×	×	×	×	✓
Capacity	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Ancillary Services	×	×	×	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓
Program Outcomes														
MW Enrolled	4	0.55	32	3.6	10	3	7	36	28	47	21	22	129	20
System MW	10,340	18,010	17,066	6,819	3,059	704	1,897	4,498	704	1,060	2,597	2,597	2,597	158
% System Peak	0.03%	0.03%	0.19%	0.29%	0.33%	0.36%	0.38%	0.81%	3.93%	4.42%	0.82%	0.83%	4.95%	12.70%
Customers Enrolled	1,575	184	8,500	1,200	1,500	373	1,600	Unknown	3,076	4,000	3,096	84	886	3,200
Total Customers	2,055,937	2,428,460	3,144,748	3,295,894	583,291	225,952	761,361	108,191	225,952	308,841	2,293,865	220,401	220,401	29,161
% Enrolled	0.08%	0.01%	0.27%	0.04%	0.26%	0.17%	0.21%	N/A	1.36%	1.30%	0.13%	0.04%	0.40%	10.97%

- VPP programs with the largest relative capacity tend to have more ticks, but not always, especially if recently launched (e.g., PG&E, San Deigo)
- EV VPP programs are rare among the short-listed VPPs and not among the top programs in terms of relative capacity

Source: Energeia Research

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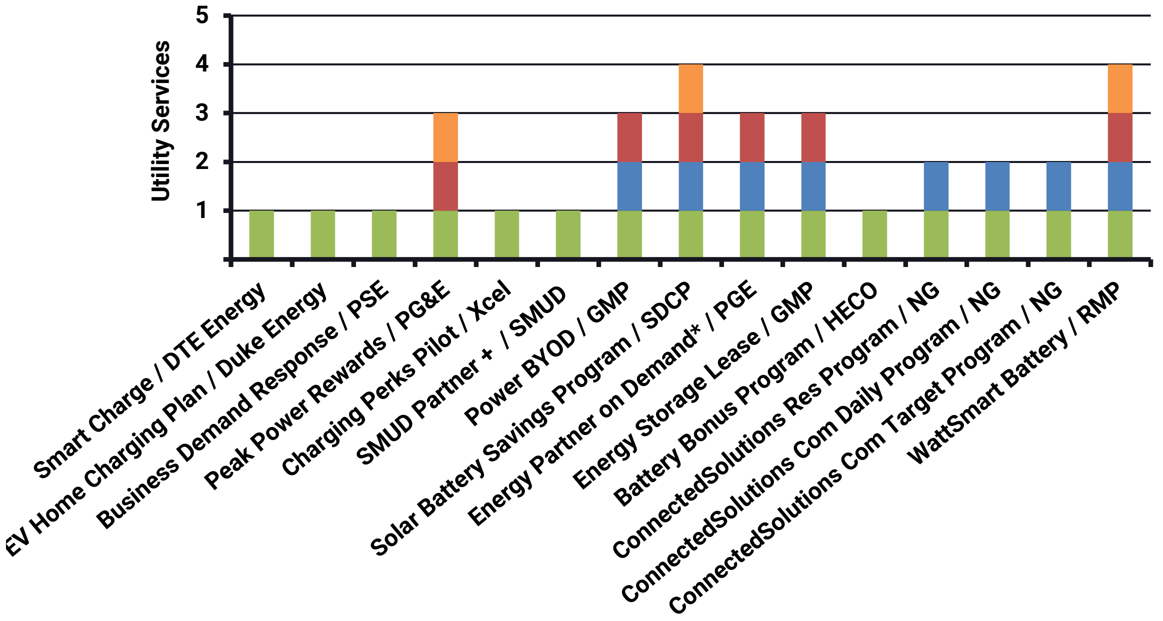
Legend

Outsourced Operations

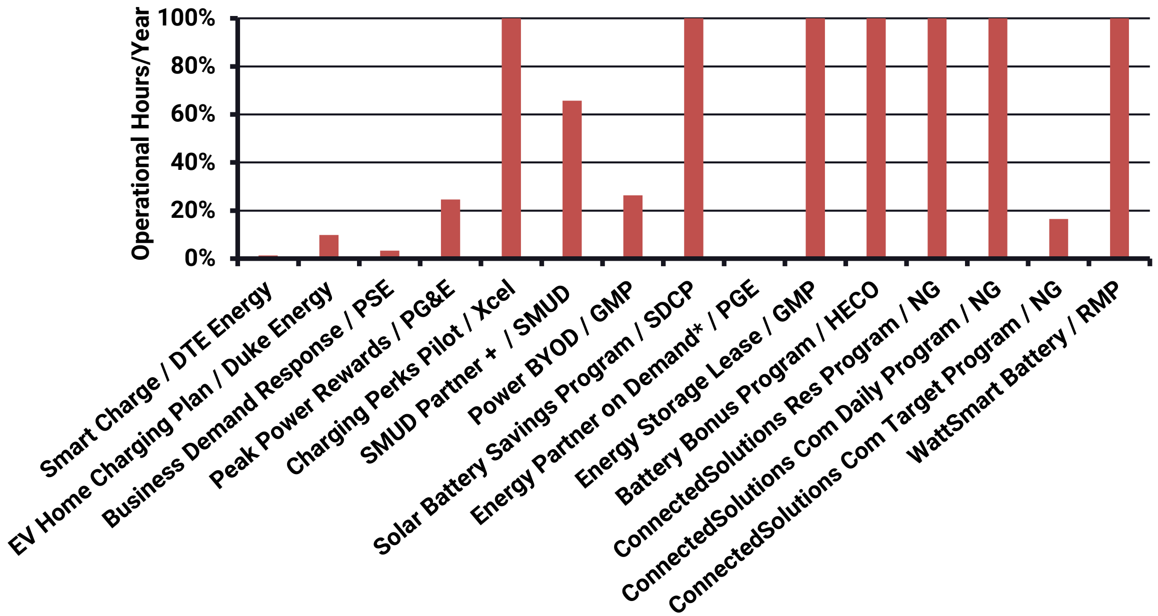
Services Delivered and Availability

Services Delivered



- All programs provide capacity / peak demand reduction
- There is also a growing trends towards multiple VPP services and away from a single one
- Ancillary and operational flexibility the most popular

Days / Year



- There is a growing trend towards smart charging and away from event counts and duration

Source: Energeia Research

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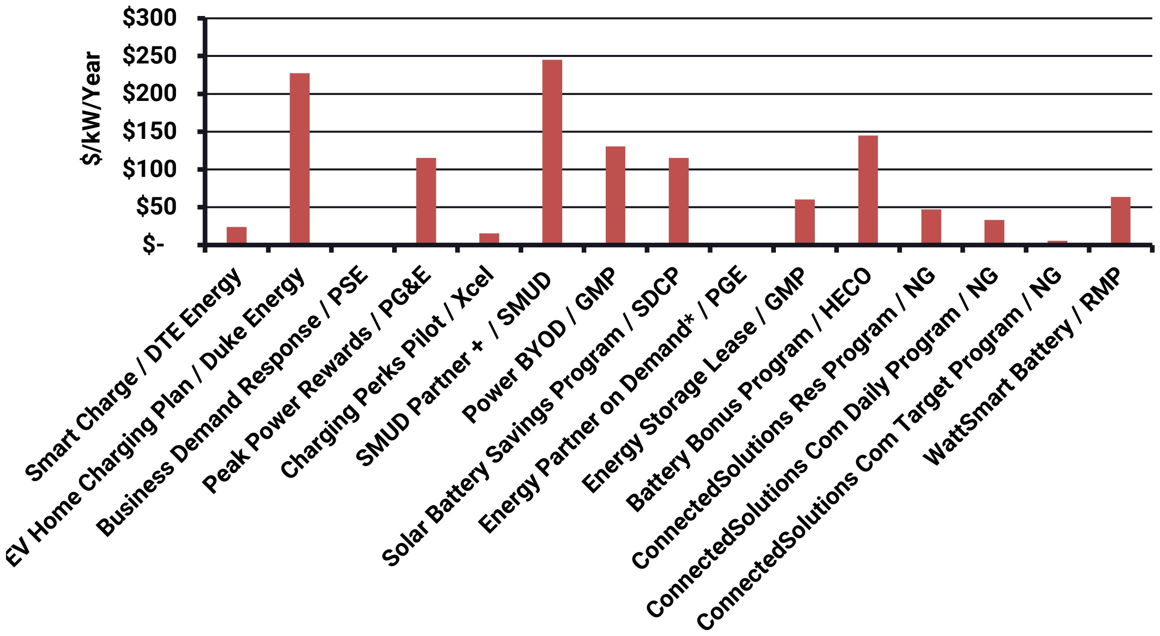
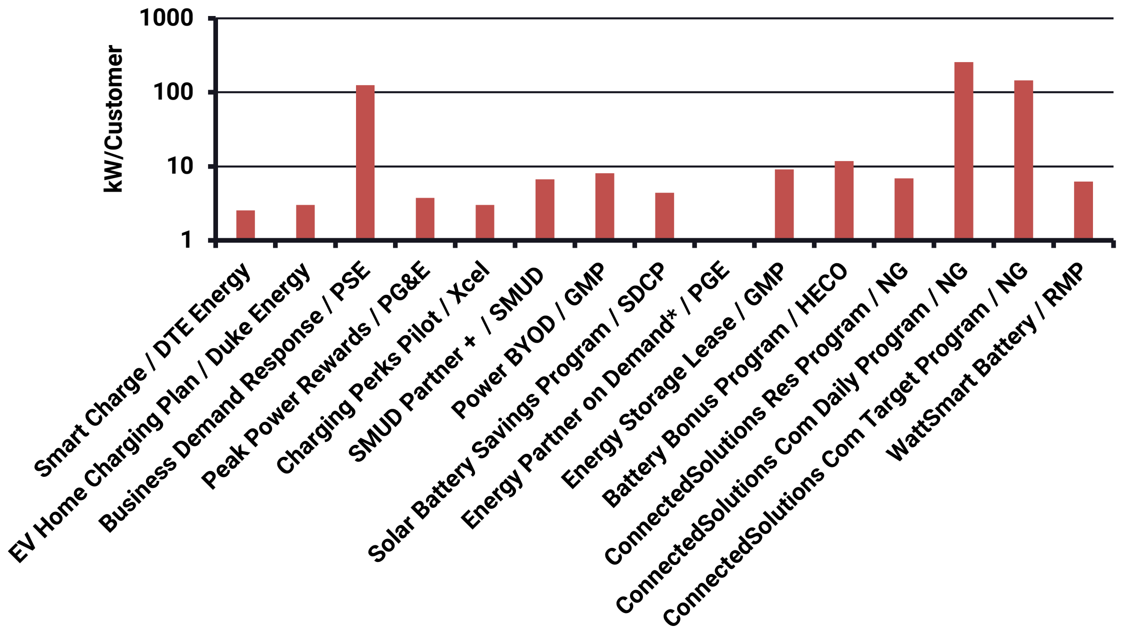
$ / kW / Year and kW / Customer

$ / kW / Year



- In terms of incentives, the top, right most VPPs vary, from around $10/kW/year to over $50/kW per year
- Generally, speaking, the more that is paid, the higher the resources enrolled

kW/Customer (Log Scale)

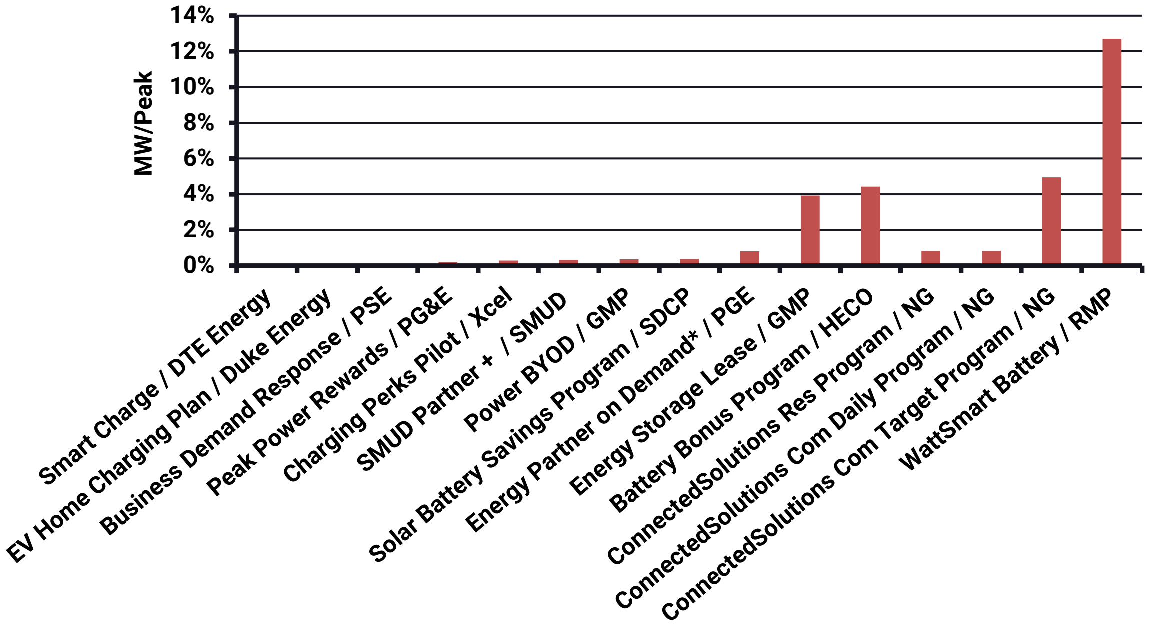


- Most programs delivering 4-10 kW for residential, and around 100 kW for commercial VPP programs

Source: Energeia Research

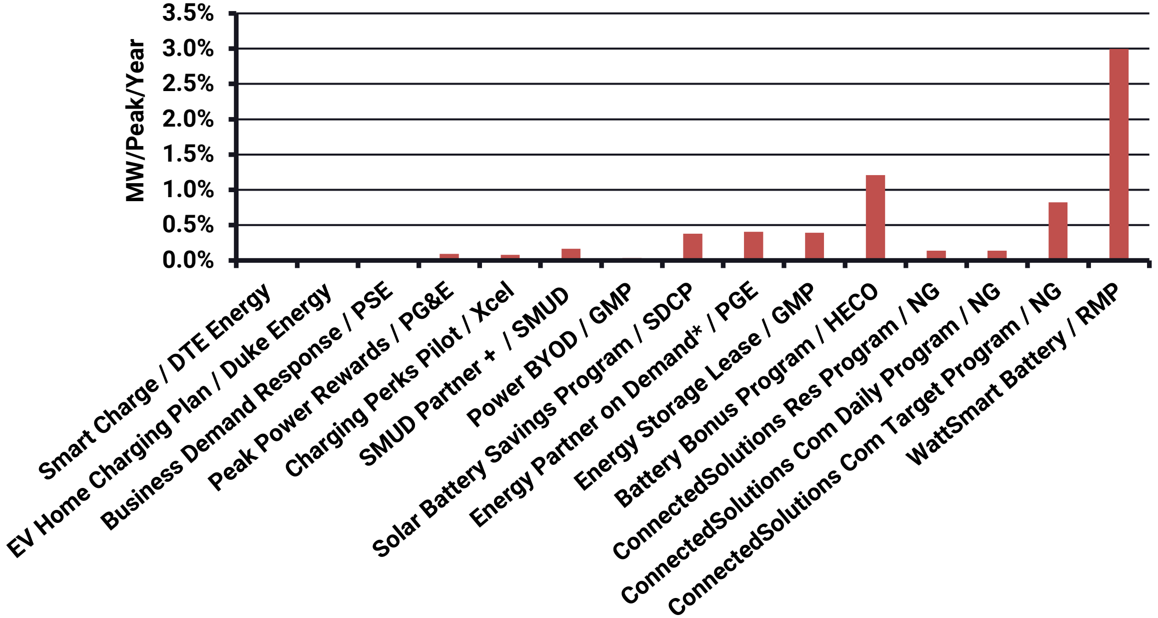
Nameplate Capacity Development

Capacity / Peak



- 4 VPPs stand out for their peak normalized capacity
- They also largely stand out for the annual rate of enrollment

Capacity / Peak / Program Year



- We have normalized by number of years to account for growth over time
- These results highlight a maximum year on year rate of growth across review VPPs

Source: Energeia Research

Key Takeaways and Recommendations

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Key Takeaways and Recommendations

- **Key Takeaways**
  - Decarbonization will drive substantial investment in peak demand, utility scale resources, T&D costs, which will increase bills substantially
  - DER, effectively planned, delivered and operated, estimated to reduce investment costs by $100 billion in California *alone*
  - DER includes flexible loads, rooftop generation and battery storage, can offer a lower cost alternative
  - There are two main business models emerging to develop, operate and manage distributed energy resources: VPPs and HEMS
  - For VPPs, the trend appears to be away from lock-in contracts and towards bring-your-own-device, 100% managed, multiple services delivered
  - Current VPP positioning is wide-ranging, with some consistency in the value paid per kWh, if not the hours reserved
  - The VPP market is immature but growing rapidly, with players evolving their strategies, business models, offers, products and services
  - It remains to be seen if the low risk, low reward VPP or high risk, high reward HEMS model, or a hybrid, will be the most successful longer-term
- **Key Recommendations**
  - Understand the long-term cost of service and DER potential to enable targeting of the best (i.e. material) opportunities
  - Consider trialing VPP and HEMS business models to keep options open
    - VPPs can be hard to communicate to customers, and there can be social license issues
    - HEMS requires real-time wholesale and, ideally, T&D prices
  - Monitor best practices and lessons learned as the industry matures, and ensure offers keep pace, e.g. multiple services, 100% management, etc.
  - Ensure utility organizational capability and capacity in place to enable and support DER integration and monetization
    - Ensure impacts and controls are included in operations and forecasts and plans, to lock in the benefits
    - Early lessons learned show DER much less likely to be seen as viable / desirable by T&D planning, engineering and operational personnel

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Charging Aheads

Q & A

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