How Virtual Power Plants Can Advance Electrification and Mitigate Infrastructure Needs As We Race to Meet Our Climate Challenges

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ABSTRACT

This paper explores three contemporary case studies of how distributed energy resources have been aggregated into Virtual Power Plants (VPPs) to provide resilient, low carbon solutions for our climate challenge in a manner that can mitigate demands on our energy infrastructure. These recent case studies will analyze distributed energy resources and how they can be aggregated to participate in wholesale electric markets to reduce the demand for larger utility scale resources while also providing grid services locally. These case studies build on previous research on distributed energy resources we have performed at our Institute for Energy and the Environment. The cases will consider how Federal Energy Regulatory Commission ("FERC" or "Commission") Orders 841 and 2222 will help remove the barriers to effective participation in regional markets and explore the remaining conflicts with overlapping state and federal jurisdiction. We will conclude with lessons learned to promote the growth of VPPs in a manner that enhances electrification and promotes resilience as we transition to a low carbon future.

I. INTRODUCTION TO VIRTUAL POWER PLANTS

The effective path forward for the clean energy transition appears straightforward, at least from the 10,000 foot vantage point. Central to the success of this transition is expediting the growth in the electrification of buildings and transportation, while we simultaneously transition electric grid resources to low carbon sources. While some of those grid sources will remain on a multi-megawatt scale—particularly with the advancement of offshore wind and the continuing decline in costs for utility scale solar—distributed energy resources (DERs) appear likely to play an increasingly important role in this transition to help balance the intermittency of large-scale clean energy resources. At the same time, the clean energy transition must not be just about mitigating climate change, but also adapting the electric grid to increase grid resilience as climate change presents immediate severe weather challenges, such as super storms, wildfires, temperature fluctuations, flooding, and even polar vortexes across the United States. In confronting climate mitigation and adaptation simultaneously, the ability to harness the potential of DERs across the grid appears to be increasingly essential to the success of the transition.

In a recent report, Wood MacKenzie projects that "cumulative distributed energy resource capacity in the United States will reach 387 gigawatts by 2025."[1] Wood MacKenzie predicts residential installations will dominate the market at seventy-seven percent of new installations from 2016-2025, highlighting the truly distributed nature of the DER development trend.[2] While the U.S. electric grid—often described as one of the world's most complicated machines—has a long history of managing complexity, this growth of distributed resources presents a new challenge for how to coordinate all of these diverse resources in a low carbon, efficient, and reliable manner. Such distributed resources include rooftop solar, batteries, controllable thermostats, and electric vehicle (EV) charging equipment, located in residences and businesses. According to Omar Saadeh, business strategy manager at Accenture, "the fundamental question is who can manage and schedule distributed energy resources and how."[3]

A leading trend in planning for how the grid can harness these diverse and growing distributed resources is the virtual power plant (VPP). Recent world events have provided us all with a crash course in the virtual office, so the concept of a VPP, and some of its similar remote challenges, should not surprise us. A simplified definition of a VPP, from Sarah Golden, Senior Energy Analyst for GreenBiz, is "a collection of privately owned energy resources that can be interconnected and that operate together. While independently owned and operated, they can be controlled centrally, allowing dispersed resources to respond to energy supply and demand."[4] As Golden notes, the concept is not new (it has been around since the

1. Ben Kellison & Fei Wang, *What the Coming Wave of Distributed Energy Resources Means for the US Grid*, GREEN TECH MEDIA, (June 18, 2020), https://www.greentechmedia.com/articles/read/coming-wave-of-der-investments-in-us [https://perma.cc/44XQ-HU7R].

2. WOODS MACKENZIE, UNITED STATES DISTRIBUTED ENERGY RESOURCES OUTLOOK: EXECUTIVE SUMMARY SNAPSHOT 5 (2020).

3. Matthew Bandyk, *Propelling the transition: The battle for control of virtual power plants is just beginning*, UTILITY DIVE (Aug. 18, 2020), https://www.utilitydive.com/news/propelling-the-transition-the-battle-for-control-of-virtual-power-plants-i/581875/ [https://perma.cc/SS3E-74WN].

4. Sarah Golden, *We're having a virtual power plant moment*, GREENBIZ (July 31, 2021), https://www.greenbiz.com/article/were-having-virtual-power-plant-moment [https://perma.cc/9AQD-NSUG].

1990s), but it certainly has gained increase attention recently.[5] A critical element of managing VPPs are the control technology and software systems often referred to as distributed energy management systems (DERMS). DERMS are "a suite of software management tools that allow distribution utilities and wire operators to manage a wide array of DERs through near real-time control of grid assets."[6] Some analysts may define DERMS as being unique from VPPs but for our purposes we do not recognize a difference since DERMS are an essential component of a VPP.[7] With a well-developed DERMS, a VPP can be aggregated or disaggregated based on the location of the system needs to allow VPPs to address either a regional need or a local need as determined by the specific set of circumstances presented to the electric grid.

From a historical perspective, the concept of a VPP has roots in the planning and design for the "efficiency power plant," which was considered by clean energy advocates in the 1980's and 1990's as a clean and cost effective alternative to building more risky and polluting central station generation during increasingly controversial periods of electricity growth. Perhaps the poster child for how distributed resources can replace expensive traditional utility investments is the Brooklyn Queens Demand Management Program implemented by the New York utility, Con Edison. In essence, Con Edison, when presented with an expensive and challenging upgrade to its urban electric network, was able to defer a $1.2 billion substation upgrade by contracting for a combination of fifty-two megawatts (MW) of demand reductions and seventeen MW of distributed resource investments.[8] Similarly, a VPP can "aggregate flexible capacity to address peaks in electricity demand . . . they can emulate or replace natural-gas-fired peakers and help address distribution network bottlenecks, but usually without the same capital outlay."[9] In order to do so, the VPP model requires a more elaborate

5. *Id.*

6. ENBALA, CREATING A 21ST CENTURY UTILITY GRID WITH DERMS AND VPPS, 8 (2018), https://microgridknowledge.com/wp-content/uploads/2020/05/MGK-Report-Utility-Grid-with-DERMS-and-VPPs.pdf [https://perma.cc/A2D3-ABMF].

7. *See id.*

8. Robert Walton, *Straight Outta BQDM: Consolidated Edison looks to expand its non-wires approach*, UTILITY DIVE (July 19, 2017), https://www.utilitydive.com/news/straight-outta-bqdm-consolidated-edison-looks-to-expand-its-non-wires-appr/447433/ [https://perma.cc/M399-6N7G].

9. Jason Deign, *So, what exactly are virtual power plants?*, GREENTECH MEDIA (Oct. 22, 2020), https://www.greentechmedia.com/articles/read/so-what-exactly-are-virtual-power-plants [https://perma.cc/44S2-5C2C].

means of conducting these disparate resources across the utility's grid in order to maintain the harmonious balance of supply and demand.

In a short period of time, particularly for the electric utility industry, the VPP concept has evolved from theory to practice. According to Saadeh, "[it would] be hard to find a North American utility that [is not] considering some kind of DERMS."[10] VPP pilot projects are expanding, and more utilities and third-party providers are considering how they should invest in controlling these growing resources. As pilot projects develop, there are a variety of business models that are being explored, ranging from complete utility ownership and control to models allowing much more third-party development and innovation. The Electric Power Research Institute (EPRI) has defined three distinct VPP business models: (1) utility ownership and aggregation where the utility owns the asset and manages the customer relationship; (2) utility managed customer programs that leverage third party aggregation, allowing the utility to retain the customer relationship; and (3) utility purchased services from a third party with no direct utility customer relationship or ownership of assets.[11] This Article will look at how VPP programs are being implemented in the U.S. by (1) Southern California Edison (SCE) in California; and (2) the smaller but just as innovative, Green Mountain Power (GMP) in Vermont; this Article will further compare and contrast the beforementioned with (3) a unique effort at coordination that is being led by the system operator Australian Energy Market Operator (AEMO) in Australia. Generally, these three case studies will provide information on each business model discussed above. The GMP case study reflects the utility ownership and aggregation (model 1), SCE utility managed customer programs (model 2), and AEMO reflects purchasing services from third parties (model 3). Comparing and contrasting these efforts will allow us to take a snapshot of VPP implementation and identify some of the important successes and challenges along the way. While our first two U.S.-based case studies focus mostly on the utility level, it is important to note recent U.S. federal policy advancements are helping to sweep away existing barriers, so we will begin with a brief explanation of two important FERC orders that promise to facilitate the timely opening of wholesale electricity markets to distributed energy resources.

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10. Bandyk, *supra* note 3, at 2.

11. Ajit Renjit & Nick Tumilowicz, *Virtual Power Plant Evaluation*, SMUD BOARD COMMITTEE OF ENERGY & CUSTOMER SERVICES (June 16, 2021), https://www.smud.org/-/media/Documents/Corporate/About-Us/Board-Meetings-and-Agendas/2021/Jun/2021-06-21_ERCS_-Exibit-to-Agenda-Item-1_External.ashx [https://perma.cc/WG2F-WM2W].

A. FERC Order 841

On February 15, 2018, FERC Order 841 removed barriers to the participation of electric storage resources in the capacity, energy, and ancillary service markets operated by Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs).[12] FERC took this action under its legal authority through Section 206 of the Federal Power Act (FPA) to ensure that RTO/ISO tariffs were just and reasonable. The rule required each RTO and ISO to revise its tariffs to establish a participation model consisting of market rules that, recognizing the physical and operational characteristics of electric storage resources, facilitates their participation in the RTO/ISO markets; over the following months each RTO/ISO, through independent processes, filed revised tariffs.[13] Specifically, the model required RTOs/ISOs to (1) ensure that a resource using the model is eligible to provide all capacity, energy, and ancillary services that the resource is technically capable of providing in the RTO/ISO markets; (2) ensure that a resource using the model can be dispatched and can set the wholesale market clearing price as both a wholesale seller and wholesale buyer, consistent with existing market rules that govern when a resource can set the wholesale price; (3) account for the physical and operational characteristics of electric storage resources through bidding parameters or other means; and (4) establish a minimum size requirement for participation in the RTO/ISO markets that does not exceed 100 kilowatts (kW).[14]

Additionally, each RTO/ISO must specify that the sale of electric energy from the RTO/ISO markets to an electric storage resource, which the resource then sells back to those markets, must be at the wholesale locational marginal price.[15] In the Notice of Proposed Rulemaking (NOPR), the Commission also proposed reforms related to distributed energy resource aggregations, which in 2020 were addressed in the subsequent FERC Order 2222.[16] While the National Association of Regulatory Utility Commissioners and other groups challenged FERC's statutory authority under Order 841, the D.C. Circuit Court of Appeals ruled in June 2020 that the rule was

12. *See* Order No. 841, *Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators*, 162 F.E.R.C. ¶ 61.127 (2018), https://www.ferc.gov/media/order-no-841 [https://perma.cc/QFN4-B69J].
13. *Id.*
14. *Id.*
15. *Id.*
16. *Id.*

consistent with FERC's authority under the FPA.[17] Since that time, most RTOs/ISOs have shepherded through the regulatory process changes to their tariffs to implement most provisions of the rule to comply with the FERC order, with the exception of the Midcontinent Independent System Operator (MISO), whose compliance filing effective date has been postponed until June 2022.[18]

B. FERC Order 2222

On September 17, 2020, FERC issued the final rule Order 2222, which focused on increasing participation of distributed energy resource (DER) aggregations in the energy, capacity, and ancillary services markets operated by RTOs and ISOs.[19] Order 2222 requires that DERs be allowed to participate alongside traditional resources in the regional organized wholesale markets through aggregations, ensuring these aggregated resources have access to wholesale markets across the U.S.[20] In requiring the development of market rules for the participation by DER aggregations in RTO/ISO markets, Order 2222 addresses the barriers that individual DERs face due to their inability to meet the size and operational requirements necessary to qualify as market participants. These tariffs will allow the aggregators to register their resources under one or more participation models that accommodate(s) the physical and operational characteristics of those resources.[21] Importantly, each tariff must set a size requirement for resource aggregations that do not exceed the modest level of 100 kW. The tariffs also must address technical considerations such as:

- locational requirements for DER aggregations;
- distribution factors and bidding parameters;
- information and data requirements;
- metering and telemetry requirements; and

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17. *See Nat'l Ass'n of Regulatory Util. Comm'rs v. Fed. Energy Regulatory Comm'n*, 964 F.3d 1177, No. 19-1142 (July 10, 2020).

18. *Are We There Yet: Getting Distributed Energy Resources to Markets, The State Energy and Environmental Impact Center*, N.Y.U. SCHOOL OF LAW (July 2021), https://www.law.nyu.edu/sites/default/files/AreWeThereYet-GettingDistributedEnergyResourcestoMarkets-TheStateImpactCenter.pdf [https://perma.cc/3FR9-VANS] [hereinafter *Are We There Yet?*].

19. *See* Order No. 2222*, Participation of Distributed Energy Resource Aggregations in Markets Operated by Regional Transmission Organizations and Independent System Operators*, 172 F.E.R.C. ¶ 61.247 (2020), https://www.ferc.gov/sites/default/files/2020-09/E-1_0.pdf [https://perma.cc/DCH8-NTE8].

20. *Id.*

21. *See FERC Order 2222 Fact Sheet: A New Day for Distributed energy Resources*, FED. ENERGY REGUL. COMM'N (Sept. 17, 2020), https://www.ferc.gov/media/ferc-order-no-2222-fact-sheet [https://perma.cc/WBB3-HPUB].

- coordination among the regional grid operator, the DER aggregator, the distribution utility, and the relevant retail regulatory authority.[22]

The rule also directs the grid operators to allow DERs that participate in one or more retail programs to participate in their wholesale markets and to include any restrictions necessary to avoid double counting.[23] A majority of the RTOs/ISOs have successfully requested extensions to their compliance filings into 2022 with the single state ISOs in California and New York being the exceptions, since they had previously implemented comprehensive DER aggregation models that required much more modest modifications to comply with the intent of Order 2222.[24] Jointly, FERC Orders 841 and 2222 are helping to remove barriers from distributed energy resources' participation in wholesale markets. This is a necessary initial step, but as our case studies will suggest, there is much more to be done to ensure the distributed energy resources are able to be cost effectively organized as VPPs in a timely manner and at the scale necessary to play a meaningful role in the challenges posed by climate change.

II. SOUTHERN CALIFORNIA EDISON VPP CASE STUDY

A. SCE Overview

As an early adopter and current U.S. leader in implementing distributed energy resources, California has some of the most aggressive renewable portfolio standards in the United States.[25] As a result, the state's electric utilities must help drive California's transition to clean energy resources. One of the state's three large investor-owned utilities, Southern California Edison (SCE), promotes its own carbon neutrality goals, projecting the grid will need eighty gigawatts (GW) of utility-scale clean energy and thirty GW of utility scale storage.[26] In regard to distributed resources, the utility predicts that fifty percent of single-family homes in California will

22. *Id.*
23. *Id.*
24. *Are we There Yet?*, *supra* note 18.
25. S.B. 100 (Cal. 2018) (requiring sixty percent renewable energy on the grid by 2030).
26. SOUTHERN CALIFORNIA EDISON, *Pathway 2045: Update to the Clean Power and Electrification Pathway* at 5 (Nov. 2019), https://download.newsroom.edison.com/create_memory_file/?f_id=5dc0be0b2cfac24b300fe4ca&content_verified=True [https://perma.cc/A2ZS-NENY].

have solar infrastructure by 2045, allowing for thirty GW of solar energy on the customer-side alone.[27]

In response to the need for cleaner energy sources, SCE has developed a variety of measures to implement more solar, EVs, and other distributed resources onto the grid.[28] Additionally, SCE offers a variety of demand response (DR) programs for both residential and industrial customers, including aggregator managed portfolios, capacity bidding programs, and demand bidding programs.[29] Essentially, in high demand events—particularly, in extreme weather events—DR helps utilities manage load by offsetting electricity needs. As technology has developed and regulatory frameworks are catching up, DR has more potential than ever before. Rather than one-way signals and an emphasis on large, commercial customers, distributed resources are now being aggregated into their own network to form virtual power plants.[30] Aggregating DER customer-side electric batteries, rooftop solar, and even thermostats provides SCE with sophisticated DR capabilities via network signaling to manage the VPP.[31]

Virtual power plants pose a specific advantage in California, where they have the potential to support emergency reliability in blackouts or power outages caused by wildfires and other extreme heat events by providing local energy support from these distributed resources. Blackouts in California have become rampant in recent years as climate change exacerbates these natural disasters.[32] In response to the widespread outages of August 2020, the California Public Utility Commission (CPUC) opened a proceeding "to identify and execute all actions within its statutory authority to ensure reliable electric service in the event that an extreme heat storm occurs in

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27. *Id.* at 6.

28. SOUTHERN CALIFORNIA EDISON, *Creating a Clean Energy Future*, https://www.scecleanenergy.com/ [https://perma.cc/5DJ6-8CSG].

29. SOUTHERN CALIFORNIA EDISON, *Incentive Programs for Your Business*, https://www.sce.com/business/demand-response [https://perma.cc/LT3J-Q94Z] (providing a capacity bidding program, critical peak pricing, and emergency load reduction as programs offered to business customers).

30. Michael Panfil & James Fine, *Putting Demand Response to Work for California*, ENV'T DEF. FUND 7 (2015), https://www.edf.org/sites/default/files/demand-response-california.pdf [https://perma.cc/8C87-BEYY].

31. *See* Jeff St. John, *Sunrun Lands Contract for 20MW Backup Battery-Solar Project in Blackout-Prone California*, GREENTECH MEDIA (July 30, 2020) (describing another SunRun solar-battery project to curb blackouts from wildfires in utility Pacific Gas & Electric's service territory).

32. *Id.* ("[T]his [2020] fire season is expected to be more dangerous than last year's due to reduced precipitation and drier conditions, making shutoff events potentially more likely this year.").

the summer of 2021."[33] In this proceeding, referred to herein as the "Reliability Proceeding," SCE and other California utilities have developed their DR programs to offer a wide range of options to present before the Commission, including VPP pilots. Coordinated customer-side battery storage offer utility operators a resource to call upon when major parts of grid infrastructure fail during catastrophic wildfires, or when utility operators are forced to shut down infrastructure to curb damage.[34]

B. *Regulatory Framework*

Despite the influx of DR programs proposed by California utilities, the regulatory parameters are generally not well-defined for VPP participants because of the newness of DER and the overall small percentage that it currently makes up on the grid. Furthermore, there is no one precise definition for a VPP, and understandings of the concept vary across California, and throughout the country generally. The CPUC has nonetheless begun to address these difficulties in proceedings focusing specifically on (1) the Resource Adequacy (RA) Program,[35] and (2) the Reliability Proceeding after the widespread blackouts in August 2020.[36] Participants to these proceedings are helping to frame the rules through analysis of the initial pilot programs. Because RA is currently the biggest value stream to VPPs, the RA proceeding contains the central regulatory framework for VPPs.

Prior to these proceedings, the CPUC sought to spur growth of DR through competition. In an effort to make DR more open and inclusive to third-party companies, the CPUC rolled out its Demand Response Auction Mechanism (DRAM) pilot program in 2016, allowing these companies to bid and integrate their DR resources directly into the California Independent

33. CAL. PUB. UTIL. COMM'N, Order Instituting Rulemaking to Establish Policies, Processes, and Rules to Ensure Reliable Electric Service in California in the Event of an Extreme Weather Event in 2021, R.20-11-003 (Nov. 20, 2020).

34. Jeff St. John, *Distributed Energy Helped Fight California's Grid Outages, But It Could Do Much More*, GREENTECH MEDIA (Aug. 28, 2020), https://www.greentechmedia.com/articles/read/california-outages-distributed-energys-grid-potential-barriers-to-access [https://perma.cc/BLQ7-988C].

35. *See* CAL. PUB. UTIL. COMM'N, Order Instituting Rulemaking to Oversee the Resource Adequacy Program, Consider Program Refinements, and Establish Forward Resource Adequacy Procurement Obligations, R.19-11-009 (Nov. 7, 2019).

36. *See* CAL. PUB. UTIL. COMM'N, ORDER INSTITUTING RULEMAKING TO ESTABLISH POLICIES, PROCESSES, AND RULES TO ENSURE RELIABLE ELECTRIC SERVICE IN CALIFORNIA IN THE EVENT OF AN EXTREME WEATHER EVENT IN 2021, R.20-11-003 (NOV. 20, 2020).

System Operator (CAISO) capacity market.[37] The DRAM pilot sought to test "the feasibility of procuring DR Supply Resources for RA from third party DR Providers through an auction mechanism."[38] The CPUC has continually amended and updated the DRAM pilot iterations over the years, and has authorized extensive independent research and evaluation regarding the DRAM.[39] Though the DRAM pilot program can be administratively burdensome due to its reporting requirements, its existence has allowed companies like OhmConnect and Tesla to enter their own DR programs into the California marketplace, with their own unique takes on VPP pilots. For example, OhmConnect's program is comprised entirely of thousands of aggregated thermostats.[40] The company works with the three major utilities in California to coordinate these systems in extreme heat events. Because of the novelty of these kinds of programs, OhmConnect invests a substantial amount of money in educating customers about its VPP program.

Recently, the CPUC continued efforts to better define the DR and DER space for aggregators in California. Within the past year, the CPUC opened a proceeding seeking to better integrate DER into the grid, improve distribution planning, and encourage grid investments that account for DER siting concerns.[41] Regulators are planning to address the implications of DER's rapid growth in California and its effect on electricity rates.[42] As the

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37. CAL. PUB. UTIL. COMM'N, Resolution E-5110 (Dec. 17, 2020) (approving the 2022 DRAM RFO).

38. *Id.*

39. CAL. PUB. UTIL. COMM'N, *Demand Response Evaluation and Research*, https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/demand-response-evaluation-and-research [https://perma.cc/FM7W-EGU3].

40. *See Revenue-Grade Analysis of the OhmConnect Virtual Power Plant During the California Blackouts*, RECURVE (Jan. 21, 2021), https://www.recurve.com/blog/revenue-grade-analysis-of-the-ohmconnect-virtual-power-plant-during-the-california-blackouts [https://perma.cc/5APU-SAFT] ("OhmConnect is a Residential Demand Response Virtual Power Plant (VPP) developer based in California with over 150,000 customers in the state. OhmConnect pays people to save energy in response to grid events and is in turn paid by utilities and CAISO for demand response and resource adequacy. During periods of peak usage, OhmConnect engages users through a combination of communication, gamification, economic rewards, and direct control of grid-edge devices to reduce demand.").

41. Kavya Balaraman, *California PUC opens 'mother of all proceedings' to prepare the grid for new wave of DERs*, UTILITY DIVE (July 6, 2021), https://www.utilitydive.com/news/california-puc-opens-mother-of-all-proceedings-to-prepare-the-grid-for-ne/602913/ [https://perma.cc/LPD7-F3KT].

42. *Id.; see also* Jeff St. John, *California's Latest Demand-Side Emergency Plan Draws Criticism From Providers*, GREENTECH MEDIA (Mar. 10, 2021), https://www.greentechmedia.com/articles/read/californias-latest-demand-side-emergency-plan-takes-heat-from-providers [https://perma.cc/PWY3-W6AR] (explaining how in recent years, the CPUC has receive criticism from clean energy advocates looking for rules to implement DER as quickly as possible and with attractive incentives from the state); *see also* Jeff St.

regulations presently stand, many uncertainties remain about how DR VPPs and other DER aggregation is valued in the capacity market, and the state lacks comprehensive structures for streamlining the coordination of distributed resources.

C. Project Overview

As one of its proposals in the Reliability Proceeding, SCE partnered with SunRun (a third-party solar and electric battery company) to aggregate its home battery systems in SCE territory.[43] SCE launched the yearlong VPP pilot program in May 2020.[44] SunRun, the largest rooftop solar and storage supplier in SCE's service territory, linked customers with its Brightbox home battery system for the pilot.[45] With SunRun's solar and battery technology, SCE is able to call on these home systems to provide load reduction in high-demand events.[46] The Pilot consisted of roughly 300 homes with battery technology already in SCE's service territory.[47] "Sixty-one of the recruited customers were not eligible to participate in the pilot because they [were] already enrolled in other existing DR programs."[48] SCE's partnership with SunRun offers the utility an advantage because the customer has already paid for the asset by contributing the Brightbox battery technology. In effect, SCE retains control of the program and "learn[s] what it would take to leverage [] customers to see if [SCE] could

John, *Seeking a Better Way to Pinpoint the Value of Demand Response in California* GREENTECH MEDIA (Jan. 25, 2021), https://www.greentechmedia.com/squared/dispatches-from-the-grid-edge/seeking-a-better-way-to-pinpoint-the-value-of-demand-response-in-california [https://perma.cc/ZF55-KWYW].

43. Andy Colthorpe, *Sunrun to put 5MW of home systems into VPP for California utility's resource adequacy programme* ENERGY STORAGE NEWS (Nov. 24, 2020), https://www.energy-storage.news/sunrun-to-put-5mw-of-home-systems-into-vpp-for-california-utilitys-resource-adequacy-programme/ [https://perma.cc/D4P5-29CQ]; *see also* Gheorghiu, *infra* note 46.

44. *Id.*

45. *SunRun Brightbox & Grid Services*, SUNRUN, https://www.sunrun.com/sites/default/files/brightbox-grid-services.pdf [https://perma.cc/R584-H6MX].

46. Iulia Gheorghiu, *SCE, Sunrun partner on solar+storage virtual power plant pilot to drive down peak demand*, UTILITY DIVE (June 17, 2020), https://www.utilitydive.com/news/sce-sunrun-partner-on-solarstorage-virtual-power-plant-pilot-to-drive-dow/579980/ [https://perma.cc/VS4J-EYX2].

47. *Id*.

48. CAL. PUB. UTIL. COMM'N, Direct Test. of Southern Cal. Edison, R. 30-11-003, 26:5-7 (Jan. 11, 2011). In California, dual enrollment in DR programs is prohibited.

take advantage of the energy that [customers are] producing."[49] Though participants in the Pilot will not see any difference on their end, the utility incentivized participation with a $250 one-time payment at the end of the year, rather than a pay-for-performance model.[50]

After the year-long pilot, SCE determined the VPP pilot met "[ninety-five] percent of the dispatch goals to date and [eleven] customers have contributed averages of 1.48 kW and 4.3 kWh per dispatch across the five most recent [twelve] dispatches."[51] As a result of these promising outcomes, SCE petitioned for the Commission to expand the program to reach/include more customers and vendors.[52] SCE estimates that "up to 1,500 customers will enroll in the VPP Phase II pilot and would be able to provide approximately 5 to 7.5 MW of additional capacity to the grid by the third quarter of 2021."[53] Like Phase I of the pilot, Phase II is intended "to evaluate performance reliability and characteristics, system integration, and technology to understand how to integrate a cohort of diverse technologies." In March 2021, the Commission issued D.21-03-056, approving SCE's VPP Phase II Pilot as proposed.[54]

After the Commission's approval to expand the program, SCE filed an advice letter to partner with Tesla to mobilize idle capacity from Tesla's Powerwall fleet.[55] Though Tesla already has its own voluntary VPP program in SCE territory, the partnership with SCE would permit compensation for customers for providing capacity services.[56] SCE hopes to learn what drives costumer enrollment, how customers will respond to a pay-for-performance model, whether the VPP will perform reliably across multiple dispatch scenarios, and to assess performance characteristics.[57] As of September 2021, Tesla invited more than 9,800 SCE customers to participate in Tesla's Beta VPP pilot. In partnership with SCE, Tesla would expect incentives to increase participation in a joint Tesla/SCE VPP Pilot,

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49. Gheorghiu, *supra* note 46.
50. *Id.*; CAL. PUB. UTIL. COMM'N, Direct Test. of Southern Cal. Edison, R. 30-11-003, 27:6-9 (Jan. 11, 2011).
51. *Id*.
52. *Id*. at 3:10-11.
53. *Id*. at 26:13-15.
54. *See* CAL. PUB. UTIL. COMM'N, Decision Directing Pacific Gas and Electric Company, Southern California Edison Company, and San Diego Gas & Electric Company to take Actions to Prepare for Potential Extreme Weather in the Summers of 2021 and 2022, D. 21-03-056 (Mar. 25, 2021).
55. CAL. PUB. UTIL. COMM'N, Advice Letter No. 4575E, Southern California Edison Company's Request for Fund Shifting to Expand its Virtual Power Plant Phase II Pilot in Partnership with Tesla (Aug. 25, 2021).
56. *Id*.
57. *Id*.

estimating an incentive may influence roughly half the 9,800 customers.[58] In Phase II, as in Phase I, dual participation in the VPP and another DR program is prohibited.[59]

Phase II incentives would potentially differ from the one-time payment of Phase I. In Phase II, SCE proposes a pay-for-performance design where Tesla will receive one dollar per kWh of incremental load reduction generated during a VPP event. The proposal includes that "incremental load reduction would include negative load or energy exports."[60] Under this structure, Tesla would pass this incentive to participating customers. At the end of the calendar year, SCE would calculate the incentive payment based upon each customer's incremental load reduction. Tesla would then review the calculation and invoice SCE for the customer incentive amount. Tesla would ultimately be responsible for passing incentives to the participating customers.[61]

D. Barriers

Though the CPUC has instituted the DRAM and its various versions to incentivize DR participation in the grid, regulatory barriers remain regarding the precise rules governing how DR resources are accounted for in the RA market, limiting potential for VPPs. The lack of consistent measurement for DR is a significant obstacle to utilities and third-party participants.[62] A common criticism within the RA market is undervaluing DR performance in peak events.[63] Because the Commission and CAISO determined the

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58. *Id.*

59. *Id.* at 3; *see also* CAL. PUB. UTIL. COMM'N, SELF-GENERATION INCENTIVE PROGRAM (SGIP) (2021), https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/self-generation-incentive-program [https://perma.cc/3ULP-UAY4]. Self-Generation Incentives are separate from the RA program. RA payments are payments for services, not incentive payments. SGIP incentivizes construction of distributed resources behind the customer meter.

60. *Id.*

61. *Id.*

62. *See* Jeff St. John, *California's Latest Demand-Side Emergency Plan Draws Criticism From Providers*, GREENTECH MEDIA (Mar. 10, 2021), https://www.greentechmedia.com/articles/read/californias-latest-demand-side-emergency-plan-takes-heat-from-providers [https://perma.cc/JP7T-K5YH] [hereinafter *Criticism of Demand-Side Emergency*] ("[D]emand-response providers say the problems are the complex and restrictive program rules, rather than their ability to deliver grid relief.").

63. *See* RECURVE, *supra* note 40.

general RA framework before widespread DER became available, there is no exact methodology to gauge their value.[64]

From a technical standpoint, determining baseline settlement amounts is difficult because utilities and third-party companies are not entirely certain how all battery systems will perform during these events. These VPP pilots are meant to give insight into these questions, along with insights into what will incentivize customers to join, but the success of VPP pilots can heavily depend on how their benefits are being calculated. Presently, there is a disconnect between what DR aggregators *can* deploy versus what they *actually* deploy and how its valued.[65]

Lastly, as the regulatory framework currently stands, VPPs are not compensated for excess energy exported to the grid. Because RA is the biggest value stream for VPPs, determining the exact methodology for these programs is crucial to encouraging more VPP coordination, and to ensure they are properly compensated for the capacity they provide.

E. Lessons Learned

A major takeaway from assessing VPP performance in California is the general lack of a clear pathway for aggregated resources to yield capacity value at the residential level. As it currently exists, DRAM is not a well-suited mechanism for residential storage aggregation because they are not currently compensated for excess energy supplied to the grid. A potential solution may be to create a special framework to realize resource adequacy value from aggregated storage outside of demand response.[66] For instance, capacity value can be based on all the batteries' power output, or power companies could treat battery dispatch similarly whether behind the meter or exported to the grid.[67] Standalone storage would also benefit from new rules to streamline interconnection and compensate its energy export.[68]

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64. Not to mention the slight tension between CAISO and the CPUC and the amorphous RA rules. Additionally, as with many state agencies, employee turnover and staffing concerns further hinder expeditious changes.

65. Jeff St. John, *Distributed Energy Helped Fight California's Grid Outages, But It Could Do Much More*, GREENTECH MEDIA (Aug. 28, 2020), https://www.greentechmedia.com/articles/read/california-outages-distributed-energys-grid-potential-barriers-to-access [https://perma.cc/2E7P-FCQT] (quoting Ted Ko, Stem's vice president of policy and regulatory affairs, "[w]e delivered about [fifty] megawatts of relief to the grid on Friday evening—but we could have deployed about 50 megawatts more if all the policies were in place.").

66. Damon Franz, Presentation at the California Efficiency & Demand Management Council's EM&V Forum 126 (Feb. 12, 2020).

67. *Id*.

68. *Id*.

Another pilot program from the Reliability Proceeding will likely affect the compensation structure as well. In March 2021, the CPUC created the Emergency Load Reduction Program (ELRP) as a new DR approach. The CPUC designed the program to allow the state's utilities and CAISO to rely on additional reductions in electric demand and compensate customers for voluntarily reducing demand on the grid when called upon by the CAISO in the event of a grid emergency.[69] The ELRP will serve as an "insurance layer" in addition to existing RA reliability planning separate from the CAISO wholesale market.[70] The initial pilot duration will last five years, starting in 2021. Similar to the existing framework, critics have pointed to the ELRP's lack of clarity on how it will credit participants.[71]

Though valuing capacity creates challenges, the current regulatory framework and DRAM program has spurred VPP growth and offers competitive choices to customers. The CPUC's framework allow companies like OhmConnect and Tesla to conduct their own independent VPP programs. Though utilities still have a higher percentage of the RA market because they have more streamlined access to their customers, these third-party programs foster more innovation and competition within the VPP market. This competition benefits customers through competitive deals,[72] a choice in the marketplace, and education about VPP programs generally.

Though SCE is still conducting its official evaluation for Phase I of the pilot by looking at ramp up time and duration performance, its utility is promising based on its customer interactions and enrollment.[73] One concern with aggregating resources like thermostats is that there can be substantial drop-offs after only one hour because customers may become uneasy letting a third party control the device. However, with battery aggregation, this drop-off concern is mitigated because the customer does not know when the device is being called upon. Additionally, SCE and Sunrun's

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69. CAL. PUB. UTIL. COMM'N, EMERGENCY LOAD REDUCTION PROGRAM (2021), https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/electric-costs/demand-response-dr/emergency-load-reduction-program [https://perma.cc/P5MV-B66M].

70. *Id*.

71. *Criticism of Demand-Side Emergency*, *supra* note 62 (discussing lack of clarity on ELRP credits).

72. *See Help End California Blackouts*, OHMCONNECT, https://www.ohmconnect.com/endcablackouts/?campaign=endcablackouts [https://perma.cc/Z4H3-VZHE] (offering free thermostats during peak heat months lasting from May 19 to Sept. 30).

73. Microsoft Teams Interview with Randy Robinson Jr., VPP Coordinator, Southern California Edison (Nov. 1, 2021). The authors would like to thank Randy for his helpful insights into SCE's VPP structure.

software does not allow the battery to be drained to more than twenty percent, so the customer is never left completely without any charge.[74] For SCE, one of the initial successes of Phase I is customer attrition, with customers generally feeling positive about utility's control of their device.[75] Phase I did not alert customers to the VPP signal, so the signal did not disrupt customers. The $250 incentive further encouraged customers, though in future VPPs, this may be reduced.

Additionally, partnerships are great for VPP pilots where partner companies have relationships with customers. The trust companies have fostered with customers bridges gaps between the customer's resource independence and the utility control of the VPP aggregation. Though companies have their own VPP execution models, the partnership pilots inform the utilities about proper incentives for customer participation and system performance. Often, larger companies show more success here because of their technical experience and more sophisticated infrastructure. Technology can pose many obstacles for VPPs, where resource response must be verified, and network issues can affect performance—though upon initial review, SCE has not run into these issues in Phase I. Where companies do not have the customer base, a partnership is not as helpful. At the same time, companies with a large customer base hold substantial leverage in the partnership.

Despite preliminary success from Phase I of the pilot, SCE foresees that any expansion of VPPs will require aggregating more resources to scale up these projects and automate signals. While technology issues are easier to mitigate as the utility gains more information about performance, the need for more assets remains a primary obstacle.[76] Currently, home batteries paired with solar panels still have high-cost barriers and are typically only seen within wealthier communities;[77] general affordability challenges also remain for typical households, although programs like the CPUC's Self-Generation Incentive Program (SGIP) seek to incentivize installation of more distributed resources in California.[78] Furthermore, SCE and other companies seek to incorporate more resources like heat pumps, and electric

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74. *Id.*

75. *Id.*

76. *Id.*

77. *See* Story Hinkley, *Coastal California has a Reputation as a Leader in Green Energy — but Only the Rich are Benefiting*, BUSINESS INSIDER (Feb. 11, 2018), https://www.businessinsider.com/only-the-rich-are-benefiting-from-green-energy-in-california-2018-2 [https://perma.cc/7WQB-7AZF] (noting how solar panels have "largely been a luxury for only wealthy, single-family homeowners").

78. CAL. PUB. UTIL. COMM'N, SELF-GENERATION INCENTIVE PROGRAM (SGIP), *supra* note 59.

vehicles and their charging equipment into the VPP framework.[79] Overall, SCE recognizes that VPPs should be a tool in a utility's toolbox because of their multiple use values and potential to mitigate power outages.

III. GREEN MOUNTAIN POWER – VPP CASE STUDY

A. Green Mountain Power Overview

Green Mountain Power is Vermont's largest electric utility company.[80] The company serves over 265,000 customers in Vermont.[81] Green Mountain Power is a vertically integrated utility which owns and manages its own generation, transmission, and distribution assets.[82] The company sets aggressive goals for their clean power, and promotes itself as providing one hundred percent carbon-free power, which is sixty-eight percent renewable.[83] Green Mountain Power is engaged in addressing cost pressures impacting the state; including increasing regional transmission costs, capacity costs, and net metering costs.[84] The utility is using distributed resources to resolve these issues.[85]

B. Regulatory Framework

Vermont stands alone in New England as the only state which has not adopted retail competition.[86] The Vermont electric utilities are "regulated monopolies and operate under a Certificate of Public Good (CPG) granted by the Vermont Public Utility Commission ("Vermont PUC" or "Commission"). As regulated monopolies, rates and policies are subject to review by the Department of Public Service (PSD) with approval by the Commission."[87] Normally, a utility would be controlled by "cost-of-service regulation,"

79. Microsoft Teams Interview with Randy Robinson Jr., VPP Coordinator, Southern California Edison (Nov. 1, 2021).
80. GREEN MOUNTAIN POWER, *2018 Integrated Resource Plan* at 6-1.
81. *Id*.
82. *Id*
83. *Energy Mix*, GREEN MOUNTAIN POWER, https://greenmountainpower.com/energy-mix/ [https://perma.cc/2CFA-WQ59].
84. Memorandum from Josh Castonguay to Judith C. Whitney, Clerk, Vermont Public Utility Commission, 1 (Apr. 15, 2019) (on file in ePUC).
85. *Id*.
86. *Electric*, VERMONT DEP'T OF PUB. SERV., https://publicservice.vermont.gov/electric [https://perma.cc/QXE9-LX8Y].
87. *Id*.

where regulators approve just and reasonable rates which remain stable until the utility requests a change.[88] The regulators would then investigate the request and approve or deny the new rates.[89] Since 2006, The State of Vermont Public Utility Commission has allowed regulation under an "alternative regulation" plan.[90] An alternative regulation plan allows a utility to update parts of its rates without going through the entire review process.[91] Green Mountain Power's (GMP's) rate regulation is controlled by their Multi-Year Regulation Plan (MYRP).[92] This Plan is an alternative form of regulation under 30 Vermont Statutes Annotated Section 218d.[93] The MYRP has a three-year term and sets the conditions for tariff offerings made during that timeframe.[94] The Plan historically has authorized "New Initiatives" in the form of an "Innovative Pilot, traditional tariffed offerings, or other capital projects."[95] Because of this structure, GMP is in a unique position to quickly implement new pilot initiatives.

C. Project Overview

GMP's virtual powerplant program began in 2017 with their Tesla Powerwall Grid Transformation Innovative Pilot (Pilot).[96] The Pilot was the first of its kind, and used Tesla Powerwall 2.0 batteries along with Tesla's Gridlogic software.[97] GMP now offers a variety of ways to participate in their home-battery programs. Currently, they are offering an Energy Storage System service, as well as a Bring Your Own Device service.[98] GMP Energy Storage System participants lease two Tesla Powerwall batteries and a gateway device that is owned by Green Mountain Power.[99]

88. *Electric Alternative Regulation*, VERMONT DEP'T OF PUB. SERV., https://puc.vermont.gov/electric/electric-alternative-regulation [https://perma.cc/67L2-C49V].
89. *Id*.
90. *Id*.
91. *Id*.
92. *Multi-Year Regulation Plan,* GREEN MOUNTAIN POWER, Case No. 18-1633-PET (June 7, 2019 am. Sept. 3, 2020), at 3, https://greenmountainpower.com/wp-content/uploads/2021/06/Exh.-GMP-ER-1-Second-Amended-Multi-Year-Regulation-Plan-Redline.pdf [https://perma.cc/G24D-D4YM].
93. *Id*.
94. *Id*.
95. *Id*. at 15–16.
96. *Innovative Customer Programs*, GREEN MOUNTAIN POWER (2019), at 2–9, https://greenmountainpower.com/wp-content/uploads/2019/03/IRP-Innovative-Customer-Programs.pdf [https://perma.cc/2KL2-5L5M].
97. *Id*.
98. *Tariff Approval Final Order*, VERMONT PUBLIC UTILITY COMMISSION, Case No. 19-3167-TF & 19-3537-TF (May 20, 2020), at 1.
99. *Id*. at 8.

The homeowner gains backup power during a power outage.[100] The Tesla battery system is a 10 kW capacity system that can provide approximately 27.5 kWh of energy, which roughly translates to eight to twelve hours of backup power to a residential home.[101]

In this program, GMP pays the installer $16,300 for the Powerwall system.[102] Homeowners lease the systems from Green Mountain Power for either $55 per month for a period of ten years or an upfront one-time lease payment of $5,500.[103] GMP uses the energy stored in the battery systems during peak power use times.[104] This energy is discharged back into the grid to reduce transmission costs and capacity expenses.[105] GMP's monthly transmission costs are calculated based on GMP's hourly demand at the time of the statewide peak transmission hour.[106] The annual capacity charge is calculated based on the demand during the New England regional peak demand hour for the year.[107] This price is set by ISO-NE's Forward Capacity Market (FCM).[108]

D. Project Analysis

Green Mountain Power developed a model for projecting costs and benefits from the original Powerwall Pilot program. The model projected that the original program would cost consumers money in the first year.[109] However, according to GMP's recent analysis, the program produced a net benefit for customers in the first year.[110] Some specific metrics in the model were projected conservatively, and GMP has since found a significant difference between the parameters in their model and the actual values.[111] The Tesla batteries were able to hit the peak for the Forward Capacity

100. *Id*.
101. *Id*.
102. *Id*. at 9.
103. *Id.* at 8.
104. *Id.* at 9.
105. *Id*.
106. Susan Schoenung et al., *Green Mountain Power (GMP): Significant Revenues from Energy Storage.* Sandia NATIONAL LABORATORIES REPORT (May 2017), at 12, https://www.cesa.org/wp-content/uploads/SAND2017-6164.pdf [https://perma.cc6WTM-U23K].
107. *Id*.
108. *Id*.
109. *Tariff Approval Final Order*, VERMONT PUBLIC UTILITY COMMISSION, Case No. 19-3167-TF & 19-3537-TF (May 20, 2020), at 10.
110. *Id*.
111. *Id.*

Market (FCM) one hundred percent of the time, compared to the model's assumption they would only hit the FCM peak eighty percent of the time.[112] GMP also overestimated some communication issues with the Tesla Powerwall batteries which could lead to periods of unavailability.[113] The availability of the batteries was found to be six percent higher than projected.[114]

The Pilot provided data on Regional Network Service (RNS) peaks from February 2018 to February 2019; of the thirteen months, the batteries reduced the RNS peak nine times.[115] GMP also successfully reduced the Independent System Operator—New England (ISO-NE) annual FCM peak during this period.[116] Several factors impacted GMP's decision on when to deploy the batteries to hit the peak events. In an attempt to get maximum value out of the batteries, GMP chose not to pursue the RNS peaks in the summer of 2018.[117] Instead, they chose to save the energy in the batteries to pursue the more valuable ISO peaks.[118] GMP also chose not to pursue monthly RNS peaks in the event customers would need the backup power in the batteries for personal use in their homes.[119] This resulted in not hitting the monthly peak in February 2019 because of the possibility of power loss due to a winter storm.[120]

In November 2018, Vermont experienced a major storm, which tested the backup power capabilities of the Powerwall systems.[121] Of the participants in the Pilot, 217 of them experienced a loss of grid power.[122] During this time, the Powerwall systems supplied 2,901 hours of backup power.[123] The range of backup power supplied varied from one hour to eighty-nine hours.[124]

Looking to the financials, GMP's model predicts that if their Energy Storage System Tariff offering is taken by 500 consumers a year for three years, the customers will see a net present value of approximately $3.8 million in an eighteen-year period.[125] In 2020, Green Mountain Power had

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112. *Id.*
113. *Id.*
114. *Id.*
115. Memorandum from Josh Castonguay to Judith C. Whitney, Clerk, Vermont Public Utility Commission, 3 (Apr. 15, 2019) (on file in ePUC).
116. *Id*.
117. *Id*.
118. *Id*.
119. *Id*.
120. Memorandum from Josh Castonguay to Judith C. Whitney, Clerk, Vermont Public Utility Commission, 3 (Apr. 15, 2019) (on file in ePUC).
121. *Id*. at 2.
122. *Id*.
123. *Id*.
124. *Id*.
125. *Tariff Approval Final Order*, VERMONT PUBLIC UTILITY COMMISSION, Case No. 19-3167-TF & 19-3537-TF (May 20, 2020), at 11.

already reported a savings of around $3.0 million in costs by using their total stored energy network to cut demand during peak hours.[126]

E. Regulatory Barriers

In moving from the Pilot programs to tariff offerings, GMP faces a number of regulatory and policy barriers. GMP submitted their proposed tariff offerings to the Vermont Public Utility Commission (Vermont PUC).[127] Under 30 Vermont Statutes Annotated, Sections 218 and 225 require the proposed tariffs to conform to a "just and reasonable" standard.[128] The Energy Storage Solutions (ESS) and Bring Your Own Device (BYOD) tariffs are subject to some criticism concerning competitive fairness. The Vermont Department of Public Service and Renewable Energy Vermont (REV) both expressed objections in the tariff proceedings.[129]

The Vermont Department of Public Service (the Department) represents the public interest in energy utility matters.[130] The Department is involved in advocacy and planning with a focus on reliability, sustainability, and cost efficiency.[131] They have jurisdiction over rates, quality of service, and financial management of the public utilities in Vermont.[132] The Vermont Department of Public Service recommended that the State Public Utility Commission should deny the ESS and BYOD Tariffs.[133] When looking to the just and reasonable standard, the Department argued that GMP's tariffs would not meet the standard as they "unfairly stifle competition within a competitive marketplace."[134] The Department recommended a single pay-

126. *GMP's Energy Storage Programs Deliver $3 Million In Savings for All Customers During 2020 Energy Peaks*, GREEN MOUNTAIN POWER, (Sept. 29, 2020), https://greenmountainpower.com/gmps-energy-storage-programs-deliver-3-million-in-savings/ [https://perma.cc/U84Q-WFCZ].

127. *Tariff Approval Final Order*, VERMONT PUBLIC UTILITY COMMISSION, Case No. 19-3167-TF & 19-3537-TF (May 20, 2020), at 3.

128. *See* 30 VT. STAT. ANN. TIT. 30 §§ 218 and 225.

129. *Tariff Approval Final Order*, VERMONT PUBLIC UTILITY COMMISSION, Case No. 19-3167-TF & 19-3537-TF (May 20, 2020), at 1–2.

130. *About Us*, STATE OF VT. DEP'T OF PUB. SERV., https://publicservice.vermont.gov/about_us [https://perma.cc/6548-PT76].

131. *Id*.

132. *Regulated Utilities*, STATE OF VT. DEP'T OF PUB. SERV., https://publicservice.vermont.gov/content/regulated-utilities [https://perma.cc/X9E7-4WZV].

133. Brief of the Dep't. of Pub. Serv., State of Vt. Pub. Util. Comm'n, Tariff filing of Green Mountain Power Corp. for approval of an Energy Storage Sys. tariff Case No. 19-3167-TF & 19-3537-TF at 11.

134. *Id*.

for-performance tariff for both GMP and privately owned batteries, and further suggested GMP should use "below-the line" accounting for the batteries owned by the utility.[135] Renewable Energy Vermont is a non-profit trade organization with members that provide and receive renewable energy services.[136] Renewable Energy Vermont recommended that the State Public Utility Commission should deny the Energy Storage System Tariff and approve the Bring Your Own Device Tariff.[137] In their motion to intervene in the Vermont PUC tariff proceedings, REV expressed their interest in "ensuring that the terms and conditions of Green Mountain Power's tariffs do not unfairly protect Green Mountain Power from competition in unregulated markets."[138]

Green Mountain Power made a number of revisions based on the feedback from the Department and REV.[139] The three revisions of note were a time limit, a removal of lease terms, and a revision for increased flexibility regarding new battery technologies for the BYOD tariff.[140] GMP revised the time frame of the tariff offerings to be limited to September 2022.[141] This is when the current GMP Multi-Year Regulation Plan ends.[142] The update to lease agreements resulted in the Customer Lease Agreement and BYOD Customer Agreement being removed from the tariffs.[143] The tariffs include essential terms, and the customer is referred to separate customer agreement forms.[144] This change responded to feedback regarding streamlining, and eliminating the belief that customers are limited to Commission dispute resolution.[145] The BYOD tariff offering was modified to encompass a greater

135. VT PUC Order, Tariff filing of Green Mountain Power Corporation for approval of an Energy Storage System tariff, Case No. 19-3167-TF & 19-3537-TF, 5.

136. Renewable Energy Vt. Motion to Intervene, State of Vt. Pub. Util. Comm'n, Tariff filing of Green Mountain Power Corp. for approval of an Energy Storage Sys. tariff Case No. 19-3167-TF & 19-3537-TF at 11.

137. *See* Renewable Energy Vt. Motion for Summary Judgment, State of Vt. Pub. Util. Comm'n, Tariff filing of Green Mountain Power Corp. for approval of an Energy Storage Sys. tariff Case No. 19-3167-TF & 19-3537-TF at 11.

138. Renewable Energy Vt. Motion to Intervene, State of Vt. Pub. Util. Comm'n, Tariff filing of Green Mountain Power Corp. for approval of an Energy Storage Sys. tariff Case No. 19-3167-TF & 19-3537-TF at 2.

139. Brief of the Dep't. of Pub. Serv., State of Vt. Pub. Util. Comm'n, Tariff filing of Green Mountain Power Corp. for approval of an Energy Storage Sys. tariff Case No. 19-3167-TF & 19-3537-TF at 3.

140. *Id.*

141. Green Mountain Power's Resp. to Pub. Util. Comm'n's Tech. Hr'g Info. Req. at 4, Feb. 21, 2020, Case No. 19-3167-TF & 19-3537-TF, https://epuc.vermont.gov/?q=node/64/143817/FV-ALLOTDOX-PTL [https://perma.cc/7DJ5-QCQU].

142. *Id.*

143. *Id.*

144. *Id.*

145. *Id.*

range of products as they become available.[146] The tariff references current approved systems, but was updated to include a web page which will show new eligible systems.[147] This allows GMP to add new battery technologies to the BYOD program without a full tariff amendment process.[148]

F. New Services – Frequency Regulation

In a January 6, 2021 email to its Powerwall VPP customers, GMP offered additional payment to its customers who volunteer for a new service. According to GMP, if the customer agrees to "share your stored energy with GMP on a more continual basis, [GMP will] provide a credit to [their] account. [GMP will] be sharing that energy with ISO-New England for what is called frequency regulation."[149] The company further explained that "GMP's new pilot will demonstrate how clean, stored energy can be a useful and cost-effective alternative to fossil-fuel power generators, which ISO-New England uses now to constantly balance the grid."[150] GMP explained how this program differs for customers:

> now, you share energy during peak energy use times, reducing energy demand on the grid during high energy, which helps to reduce costs and carbon emissions for all GMP customers. This new pilot will use energy to help balance the grid's energy flow - so the battery will be used at different times depending on what the grid needs.[151]

If customers choose to participate in the program GMP will credit them:

> $13.50 per month on your energy statement ($5 for sharing for frequency regulation, $8.50 for the battery cycling on and off that happens). Plus, you're also helping all other GMP customers because after you're credited, any other financial benefits from this program flow to them to help lower costs. Partnering with us will still ensure your Powerwalls are available for you over their 10-year warranty.[152]

146. *Id*.
147. *Id*.
148. *Id*.
149. E-mail from Green Mountain Power to existing Powerwall VPP customers (Jan. 6, 2021) (on file with author).
150. *Id.*
151. *Id.*
152. *Id.*

G. Lessons Learned

All parties in the tariff proceedings agreed that battery storage has benefits for GMP and the ratepayers in terms of finances and resiliency.[153] The Vermont Department of Public Service recognized GMP's efforts to mitigate the impacts of climate change.[154] The Department further recognized GMP's efforts to respond to the concerns expressed by the Department and REV.[155] The revisions made by GMP did not change the Department's recommendation that the tariffs be denied, but the Department appreciated the changes as providing meaningful ratepayer protections.[156] The Department further recognized that residential battery storage in Vermont is largely due to GMP's efforts, and that GMP has an important role in stimulating markets for new technologies[157]

The Vermont PUC recognizes GMP's value to the immature battery market in Vermont.[158] In the discussion of GMP's unique position, the Commission listed a number of factors which make GMP well suited to deploying battery programs.[159] The Commission listed "unique access to capital, software platforms that can optimize the charging and discharging of batteries to maximize value, and distribution grid congestion data that can be used to deploy storage to alleviate congestion caused by distributed renewable generation."[160] The Commission anticipates a time when the market is mature and GMP will have to alter its offerings, but stresses that the market has not reached this point.[161]

IV. Australian National Energy Market VPP Case Study

A. Australian Energy Market Overview

Australia has the most decentralized energy grid in the world, primarily due to high penetration of residential solar energy systems.[162] Australia's renewable energy capacity is growing ten times faster than the world average

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153. Brief of the Dep't. of Pub. Serv., State of Vt. Pub. Util. Comm'n, Tariff filing of Green Mountain Power Corp. for approval of an Energy Storage Sys. tariff Case No. 19-3167-TF & 19-3537-TF at 3.
154. *Id*.
155. *Id.* at 4.
156. *Id*.
157. *Id.*
158. Final Order at 16, May 20, 2020, Case No. 19-3167-TF & 19-3537-TF, https://epuc.vermont.gov/?q=node/64/143817/FV-ALLOTDOX-PTL [https://perma.cc/V7EV-24NU].
159. *Id.*
160. *Id.*
161. *Id.* at 25.
162. Rewired, *The energy revolution in our homes*, Australian Renewable Energy Agency (Feb. 18, 2020), https://open.spotify.com/show/0DS9nbIZ4X8EyHSyc5Pjnd.

on a per capita basis.[163] High uptake of distributed solar in Australia is attributed to a combination of factors beyond favorable sun exposure. Some of the main drivers of the exponential growth of Australia's solar sector include: high residential electricity prices as a result of weather events during summer months, attractive state subsidies, incentives, feed-in tariffs for small-scale behind-the-meter photovoltaic (PV) systems, and high rates of homeownership and single dwelling residences.[164] One in four Australians have solar panels installed on their rooftops, which is the highest per capita installation rate (but not the highest capacity rate) of anywhere in the world.[165]

Some regions in Australia with high portions of intermittent solar capacity have been challenged by grid stability and security issues. South Australia, Australian Capital Territory, Victoria, New South Wales, and Queensland have high levels of solar penetration, and the rapid pace of rooftop solar installations in South Australia in particular has threatened grid security at certain times when low electricity demand coincides with high solar production. This is a major concern during periods where South Australia's ability to export to eastern states is thwarted.[166] As a result, regulations were introduced in South Australia in 2020 to allow grid authorities to intentionally curtail existing solar panels during times of peak grid stress to avoid widespread service interruption.[167] The Australian Energy Market Operator (AEMO) has suggested comparable measures be applied in Victoria and Queensland as well.[168] All of the aforementioned territories belong to the cohesive National

163. Jason Deign, *What Other Countries Can Learn From Australia's Roaring Rooftop Solar Market*, GREENTECH MEDIA (Aug. 3, 2020), https://www.greentechmedia.com/articles/read/what-the-us-can-learn-from-australias-roaring-rooftop-solar-market [https://perma.cc/M2HN-H9FS].

164. *Id.*

165. Kate Cranney, *Australia installs record-breaking number of rooftop solar panels*, COMMONWEALTH SCIENTIFIC AND INDUSTRIAL RESEARCH ORGANIZATION (CSIRO) (May 13, 2021), https://www.csiro.au/en/news/news-releases/2021/australia-installs-record-breaking-number-of-rooftop-solar-panels [https://perma.cc/2FGJ-LQ6E].

166. Nick Harmesen, *Electricity provider authorised to switch off rooftop solar in SA in emergencies, ABC NEWS* (Aug. 27, 2020), https://www.abc.net.au/news/2020-08-27/authorities-power-to-switch-off-south-australia-solar-panels/12602684 [https://perma.cc/2LZK-K2JC].

167. Daniel Keane, *Solar panels switched off by energy authorities to stabilise South Australian electricity grid,* ABC NEWS (Mar. 21, 2021), https://www.abc.net.au/news/2021-03-17/solar-panels-switched-off-in-sa-to-stabilise-grid/13256572 [https://perma.cc/NT7W-DJBY].

168. Nick Harmesen, *Electricity provider authorised to switch off rooftop solar in SA in emergencies,* ABC NEWS (Aug. 27, 2020), https://www.abc.net.au/news/2020-08-

Electricity Market (NEM), which comprises about eighty percent of Australia's energy consumption.[169] Western Australia also has considerable solar adoption and associated grid instability; there, curtailment regulations went into effect for new and upgraded solar panels in February 2022.[170] Although Western Australia and the Northern Territory are completely independent and mostly regulated markets with smaller populations, they do not participate in the NEM.

B. *The Role of Government and Government Incentives in Australia*

The Australian government supports the growth of distributed energy resources and virtual power plants in particular, as a means of providing more reliable and affordable power.[171] In 2019, the Australian Energy Market Operator (AEMO) forecasted that there was potential for 700 MW of VPP capacity to be live and to integrate into the NEM by 2022.[172] While ultimately only 168 MW of residential battery capacity was recorded as of June 2021, the consolidated structure of Australia's grid operation and the formation of key efforts, such as the Distributed Energy Integration Program (DEIP) collaborative group to share knowledge and insights, have supported the acceleration of these efforts.[173] The DEIP, a unique collaborative effort, is led by the clean energy finance corporation, The Australian Renewable Energy Agency (ARENA), the grid operator, AEMO, and Energy Networks Australia, the national industry body representing transmission and distribution networks.[174] Government pilot projects at the federal level (through ARENA) and incentives at the state level have been particularly instrumental

27/authorities-power-to-switch-off-south-australia-solar-panels/12602684 [https://perma.cc/53J7-ZN4U].

169. *National Electricity Market,* AUSTRALIAN GOVERNMENT DEPARTMENT OF INDUSTRY, SCIENCE, ENERGY AND RESOURCES (last visited Mar. 10, 2022), https://www.energy.gov.au/government-priorities/energy-markets/national-electricity-market-nem.

170. Daniel Mercer, *As household solar stresses the grid, WA and South Australia will have the power to turn it off*, ABC NEWS (Feb. 13, 2022), https://www.abc.net.au/news/2022-02-14/household-solar-power-to-be-switched-off-to-prevent-overload/100820354 https://perma.cc/TQJ4-MJYH].

171. *AEMO trial integration of virtual power plants*, THE HON ANGUS TAYLOR MP MINISTER FOR INDUSTRY, ENERGY AND EMISSIONS REDUCTION (Apr. 5, 2019), https://www.minister.industry.gov.au/ministers/taylor/media-releases/aemo-trial-integration-virtual-power-plants.

172. *Id.*

173. AUSTRALIAN ENERGY MARKET OPERATOR, AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, 4, and 16 (Sept. 2021).

174. *Id.* at 16.

to market growth, especially because the available revenue streams have been lucrative, yet complex from a financing perspective.[175]

1. State Incentives

States in both regulated and deregulated markets have created programs to incentivize battery adoption to mitigate the effects of the residential solar market boom. Key incentives are described for each state in the paragraphs below with the noted exception of Western Australia, which currently does not offer battery incentives nor rebates. For example, in August 2018, the Victorian government established the Solar Homes Program, which provides a maximum discount of $3,500 at point-of-sale to install a residential solar battery.[176] Eligibility requirements include a combined household taxable income of less than $180,000 per year and the property already having solar PV panels with a capacity greater than or equal to five kW.[177] Similarly, since 2016, the Australian Capital Territory government has provided discounts to homes and businesses in the Canberra region to install a battery storage unit coupled with either a new or existing rooftop solar PV system that is connected to the grid and has not already received a rebate through the program.[178] Installations must be done by a pre-approved provider.[179] The rebate amounts to the lower of $3,500 or fifty percent of the battery price.[180] Residents of the Australian Capital Territory, who are either (1) homeowners, or (2) hold a current driver's license and meet specified lending criteria, can receive a loan from $2,000 - $15,000 to purchase energy efficient products, including household battery storage systems.[181]

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175. Oliver Forsyth, *Australia's energy storage installed base to grow more than five times by 2030*, PV MAGAZINE (May 31, 2021), https://www.pv-magazine.com/2021/05/31/australias-energy-storage-installed-base-to-grow-more-than-five-times-by-2030/ [https://perma.cc/U3KN-8KYA].

176. *Solar Battery Rebate*, SOLAR VICTORIA, https://www.solar.vic.gov.au/solar-battery-rebate [https://perma.cc/TLR7-LR5T].

177. *See id.*

178. *See Next Gen Energy Storage Program*, ACT GOVERNMENT, https://www.climatechoices.act.gov.au/policy-programs/next-gen-energy-storage [https://perma.cc/24RP-AEVT].

179. *See id.*

180. *Id.*

181. *Sustainable Household Scheme*, ACT GOVERNMENT, https://www.climatechoices.act.gov.au/policy-programs/sustainable-household-scheme [https://perma.cc/AH9X-T9RY].

In South Australia, the Home Battery Scheme provides subsidies and low-interest loans provided through the Clean Energy Finance Corporation of up to $2,000 for home battery installation and new solar, if required.[182] The subsidy is $150 per kWh, and it is calculated on the kWh capacity of the battery purchased.[183] Those approved for Energy Bill Concessions are eligible for a higher subsidy of $250 per kWh, in an effort to improve accessibility to low-income households.[184] In New South Wales, the Empowering Homes solar battery loan pilot program provides interest-free loans to specified Hunter region residents with a maximum household income of $180,000 per year to install solar PV and battery storage systems.[185] Residents can receive up to $14,000 for the installation of a solar PV and battery storage system, or up to $9,000 for retrofitting a storage battery to an existing solar PV system.[186] As of July 2021, Northern Australia's Home and Business Battery Scheme provides a grant of $450 per kWh of battery system capacity, with a maximum of $6,000 for homeowners, businesses, not-for-profits, and community organizations to purchase and install either (1) solar PV with an eligible battery and inverter, or (2) just an eligible battery and inverter if solar PV is already installed.[187] New installations will receive the standard feed-in-tariff from Jacana Energy.[188] In a number of regions, there are similar restrictions placed on participation. For example, Victoria,[189] New South Wales,[190] and Northern Australia limit their incentives to battery systems from an approved list.[191]

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182. *About the Scheme*, GOVERNMENT OF SOUTH AUSTRALIA, https://www.homebatteryscheme.sa.gov.au/about-the-scheme [https://perma.cc/2T6M-GPNS].

183. *Id.*

184. *Id.*

185. *Apply for the Empowering Homes solar battery loan offer*, NSW GOVERNMENT ENERGY SAVER, https://www.energysaver.nsw.gov.au/browse-energy-offers/household-offers/apply-empowering-homes-solar-battery-loan-offer [https://perma.cc/5JRM-JAUU].

186. *Id.*

187. *Home, business and community organisation solar PV and battery grants*, AUSTRALIAN GOVERNMENT DEPARTMENT OF INDUSTRY, SCIENCE, ENERGY AND RESOURCES, (last visited Mar. 10, 2022), https://www.energy.gov.au/rebates/home-business-and-community-organisation-solar-pv-and-battery-grants.

188. *Id.*

189. *Approved Products*, SOLAR VICTORIA, https://www.solar.vic.gov.au/approved-products#solar-batteries [https://perma.cc/W2Q2-U33R].

190. *Apply for the Empowering Homes solar battery loan offer*, NSW GOVERNMENT, https://www.energysaver.nsw.gov.au/browse-energy-offers/household-offers/apply-empowering-homes-solar-battery-loan-offer#approved-suppliers-information [https://perma.cc/ZUC2-JKL7].

191. *Home and Business Battery Scheme*, NORTHERN TERRITORY GOVERNMENT, https://nt.gov.au/industry/business-grants-funding/home-and-business-battery-scheme#:~:text=Eligible%20homeowners%20and%20businesses%20can,as%20virtual%20power%20plant%20capable.

2. The Australian Renewable Energy Agency

The Australian Renewable Energy Agency (ARENA) has played a central role in VPP development in Australia. ARENA is a government agency that was established by statute in 2012, and funded through 2032 by the Federal Budget process.[192] ARENA's overarching goal is to increase the supply and competitiveness of renewable energy across Australia through investing in projects that augment pre-commercial innovation and pave a pathway to commercialization.[193] ARENA grants have financed multiple projects and invested millions of dollars to study and improve the integration environment for VPPs.[194]

3. Distributed Energy Integration Program

The formation of the Distributed Energy Integration Program (DEIP) in 2018 sent a clear message that distributed resource advancement is a top priority for the Australian energy system's governing entities and stakeholders. DEIP recognized that batteries and other distributed technologies are a necessary complement to increased solar uptake. Led by ARENA, DIEP brings together a total of thirteen market bodies including market authorities, regulators, industry associations, and consumer associations. DIEP functions as a platform for sharing information with the goal of improving alignment between key entities to expedite the changes to system planning, operations, markets, regulatory frameworks, and industry business models necessary to effectively integrate DERs into the Australian energy system at scale. DIEP also develops various initiatives to target specific obstacles identified as impeding DER integration.

4. Australian Energy Market Commission

The Australian Energy Market Commission (AEMC) is the independent statutory entity that acts as the rule officiating body for the National Electricity Market (NEM). The rules that govern the NEM are the National Electricity Rules (NER) and the National Energy Retail Rules (NERR), which dictate the operation of the national electricity system, competitive

192. GENERAL FUNDING STRATEGY 2021/22 – 2023/24, AUSTRALIAN RENEWABLE ENERGY AGENCY 3.
193. *Our Purpose*, Australian Renewable Energy Agency (Austl.), https://arena.gov.au/about/ [https://perma.cc/C7JJ-WB3D].
194. *Id.*

wholesale electricity market, and the activity of market participants, as well as govern the economic regulation of services provided by vertically integrated transmission and distribution utilities in regulated territories, and provide consumer rights.[195] The Australian Energy Regulator (AER) enforces rules set by the AEMC. In February 2021, AEMC approved an amendment, initially submitted by AEMO in May 2020, to the NER and NERR, effective December 2021, setting minimum technical standards for distributed resources.[196] In August 2021, AEMC released a final rule determination introducing a number of changes to the NER and NERR to improve DER implementation and clarify the role of distribution providers. Prior to this time, the regulatory framework neglected to recognize bi-directional energy flows, so the responsibilities of distribution providers to provide DER export services were unclear despite many successful demonstrations of the benefits in controlled pilot scenarios.[197]

The final rule included a number of important changes for implementation. Going forward, the NER will explicitly define that export services are a core service that Distribution Network Service Providers (DNSPs) must provide, formally legitimizing the bi-directional flow of energy, as well as the value of DER resources to the distribution system and distribution planning.[198] Static export limits were partially eliminated.[199] Previously, AEMC instituted a limit of five kW of export at any given moment for DER systems, and when the system was at capacity, DNSPs had the option to set the limit to zero, meaning DER owners would not receive any export benefit from their feed-in-tariffs.[200] Following AEMC's rule changes, DNSPs will no longer be able to offer a static export limit to a small customer seeking to connect DER to the network unless requested by the customer, or an

195. *Regulation*, Australian Energy Market Commission (Austl.), https://www.aemc.gov.au/regulation [https://perma.cc/EFD8-9FXN]; *National Electricity Rules*, Australian Energy Market Commission (Austl.), https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules [https://perma.cc/EQX2-US57]; *National Energy Retail Rules*, Australian Energy Market Commission (Austl.), https://www.aemc.gov.au/regulation/energy-rules/regulation [https://perma.cc/9PEP-ML4E].

196. Australian Energy Market Commission, *Technical standards for distributed energy resources, Rule determination* (Feb. 25, 2021) (Austl.), https://www.aemc.gov.au/sites/default/files/documents/technical_standards_for_distributed_energy_resources_final_determination_0.pdf.

197. Australian Energy Market Commission, *Access, pricing and incentive arrangements for distributed energy resources, Rule determination* (Aug. 12, 2021) (Austl.), https://www.aemc.gov.au/sites/default/files/2021-08/Final%20determination%20-%20Access%2C%20pricing%20and%20incentive%20arrangements%20for%20DER.pdf [https://perma.cc/G9A2-7UYE].

198. *Id*.

199. *See id*. at ii.

200. *Id*.

exception in the AER's connection charge guidelines is applicable.[201] But a caveat remains: DNSPs are still allowed to impose static zero export limits if deemed necessary on a discretionary basis.[202]

Another important change, which was a controversial compromise among competing interests, is that export tariffs going forward will allow DNSPs to voluntarily develop exporting pricing charges to the grid.[203] Any proposed export tariffs will be required to include a minimum export level which would allow customers to export without charge, and there is a moratorium on placing existing customers on such a tariff until July 1, 2025.[204] The new rules also require DNSPs to provide consumers with an export option that involves no charge for a period of ten years, but at a considerably reduced export level.[205] AEMC hopes that DNSPs will set the export limit at a value where exporters can participate efficiently without additional distribution investments.[206]

Additionally, these reforms require AER to publish a guideline specific to export services by July 1, 2022, and develop customer export curtailment values, which will guide efficient levels of network expenditure and planning for investment and incentive arrangements required by the increased role of export services.[207] These reforms are considered to be pivotal, and amount to significant changes for DNSPs, consumers, and owners of DER, by establishing clear obligations on Distribution Network Service Providers to provide export services, enabling new network tariff options, and strengthening consumer protections and regulatory oversight.

C. AEMO NEM VPP Demonstration Project (NEM Demonstration Project)

The AEMO Virtual Power Plant Demonstrations commenced in March 2019 and concluded towards the end of 2021.[208] ARENA has funded $3.46

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201. *Id.* at iii.
202. *Id.*
203. Mike Foley, *Rooftop solar export charging scheme to open in 2025*, THE SYDNEY MORNING HERALD (Aug. 12, 2021), https://www.smh.com.au/politics/federal/rooftop-solar-export-charging-scheme-to-open-in-2025-20210811-p58hst.html.
204. *Id*. at vi.
205. *Id.*
206. *Id.*
207. *Id*. at ix-x.
208. AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173.

million of the total $7.03 million in project costs.[209] The NEM Demonstration Project was initiated by AEMO in collaboration with ARENA, AER, AEMC, and DIEP.[210]

1. *Overarching Objective*

The objective of the NEM Demonstration Project was to test the operational and technical feasibility of allowing VPPs to deliver energy and Frequency Control Ancillary Services (FCAS) to the National Electricity Market.[211] The project concluded alongside the completion of the Market Ancillary Services Specification (MASS) consultation, which happened in conjunction with the project to review the ongoing arrangements for the DER participation in FCAS markets. A consultation is required by the NER when AEMO seeks to amend or add to the MASS, which determines the delivery and verification requirements for FCAS participation.[212] AEMO very clearly stated aspirations to harness the capacity of VPPs for energy, system security, and local network support services.[213] AEMO viewed the pilot as a first step of NEM coordination towards the integration of large-scale VPPs.[214] At the close of the VPP Demonstrations, the total capacity of the residential VPP sector in the NEM was below fifty MW, but is growing rapidly, and operational visibility is approaching a point where system efficiency and security are essential.[215]

2. *Pilot Participants*

AEMO invited existing pilot-scale projects to participate and operate their portfolios under AEMO's monitoring scheme. While nine portfolios

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209. AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173.

210. *Amendment of the Market Ancillary Service Specification (MASS) – DER and General Consultation*, Australian Energy Market Operator (Austl.), https://aemo.com.au/en/consultations/current-and-closed-consultations/mass-consultation [https://perma.cc/75V3-QZC3].

211. AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173, at 18.

212. *Id.*

213. Press Release, Austrl. Renewable Energy Agency, AEMO to trial integrating Virtual Power Plants into the NEM (Apr. 5, 2019) (Austl.), https://arena.gov.au/news/aemo-to-trial-integrating-virtual-power-plants-into-the-nem/.

214. *AEMC announces significant changes for distributed energy resources Ashurst*. ASHURST (Aug. 27, 2021), https://www.ashurst.com/en/news-and-insights/legal-updates/aemc-announces-significant-changes-for-distributed-energy-resources [https://perma.cc/WS7A-ACM5].

215. AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173.

of VPPs were operating independently at the time of project initiation, AEMO possessed very little visibility over any of the VPPs.[216] Ultimately, eight VPP portfolios and seven total operators signed on to the pilot.[217] Participants included retailers, a solar installer, a utility, a battery provider, and an energy generation company. The sizes of the portfolios ranged from one to sixteen MW, the largest being the Tesla/Energy Locals pilot. AEMO required all participants to be at least one MW in capacity.[218] All VPPs involved one specific brand of battery and no alternative technologies due to a number of barriers, including the minimum portfolio size, Application Programming Interface (API) requirements, and lack of broader educational materials.[219] In terms of the financial compensation structure available under each participant's scheme:

- Two used a "Bring Your Own Battery" approach.
- Two offered their own installment rebates for those customers where state battery installment incentives were not an option.
- Three offered a periodic direct payment up to a set amount.
- Two offered a sign-on bonus.
- One offered a 100% return on sales to the grid above the customer's feed-in rate.
- Five had the option of a feed-in tariffs, either through a retailer or utility.
- None of the participating retailers subjected customers to a lock-in contract.[220]

Whether a customer utilized a state installation incentive or an installation incentive specific to the VPP, all of the VPPs allowed customers to take advantage of post-installation state rebates in addition to the post-installation scheme offered under the particular VPP.

D. Participant Deeper Dive: Energy Locals/Tesla

In 2018, Tesla negotiated with the South Australian Labor Party to proceed with a Virtual Power Plant proposal to entirely fund and install solar arrays

216. *Id.*
217. *Id.*
218. *Id.*
219. *Id.*
220. *Id*

and Tesla Powerwall batteries on up to 50,000 homes in South Australia.[221] The South Australian government pledged an initial thirty million dollar loan and a two million dollar grant from its Renewable Technology Fund.[222] The state initially sought private investment for the remainder of the project's $800 million price tag, but so far an additional $10 million from the state government, $8.2 million from ARENA, and another $30 million dollar loan from the federal green bank, the Clean Energy Finance Corporation, was allocated in late 2020.[223] Phase I and II of the trial covered installations for up to 24,000 households classified as Housing Trust properties, a low-income public housing designation, which established a complementary relationship between the existing $2,500 solar subsidy provided by the state.[224]

The utility South Australia Power Networks (SAPN) recognized the opportunity to test whether supporting a dynamic export limit for Tesla's DER systems, rather than a fixed limit, would affect local distribution network integrity or supply quality.[225] In 2019, SAPN partnered with Tesla to form the Advanced VPP Integration Project, funded with one million dollars from SAPN and a one million dollar grant from ARENA. The project applied to 1,000 of Tesla's customer sites rolled out during Phase II of the VPP.[226]

The project has reached a capacity of sixteen MW, by far the largest operating VPP in Australia. Tesla—in partnership with retailer Energy Locals—offers an upfront battery subsidy on a new Tesla Powerwall battery purchase, which is separate from the rebate offered by the government in South Australia through the Home Battery Scheme, along with $220 in Grid Support Credits on an annual basis, dispersed monthly.[227] A feed-in tariff is

221. Nick Harmesen, *Elon Musk's Tesla and SA Labor reach deal to give solar panels and batteries to 50,000 homes,* ABC NEWS (Feb. 3, 2018), https://www.abc.net.au/news/2018-02-04/elon-musk-tesla-to-give-solar-panels-batteries-to-sa-homes/9394352 [https://perma.cc/DLS5-R9K9].

222. *AEMO Virtual Power Plant Demonstrations*, AUSTRL. RENEWABLE ENERGY AGENCY (Feb. 1, 2022), https://arena.gov.au/projects/aemo-virtual-power-plant-demonstrations/.

223. *South Australia's Virtual Power Plant to boost capacity*, GOV'T OF S. AUSTRL. DEP'T FOR ENERGY AND MINING (Sept. 4, 2020), https://www.energymining.sa.gov.au/latest_updates/south_australias_virtual_power_plant_to_boost_capacity [https://perma.cc/D3KW-M53X].

224. *AEMO Virtual Power Plant Demonstrations*, AUSTRL. RENEWABLE ENERGY AGENCY (Feb. 1, 2022), https://arena.gov.au/projects/aemo-virtual-power-plant-demonstrations/.

225. SA POWER NETWORKS, ADVANCED VPP GRID INTEGRATION FINAL REPORT, (2021), https://arena.gov.au/assets/2021/05/advanced-vpp-grid-integration-final-report.pdf.

226. Press Release, Austrl. Renewable Energy Agency, AEMO to trial integrating Virtual Power Plants into the NEM (Apr. 5, 2019), https://arena.gov.au/news/aemo-to-trial-integrating-virtual-power-plants-into-the-nem/.

227. *Tesla Energy Plan*, TESLA (2022), https://www.tesla.com/en_AU/ tep?redirect=no [https://perma.cc/3YBM-YGHT].

available as well as a Time of Use (TOU) usage tariff rate scheme, and Tesla also limits discharge cycles to fifty per year.[228]

1. Project Insights

The utilization of flexible export limits enabled the VPP to take local constraints into account when responding to energy prices or bidding into wholesale markets, and mitigated concerns about breaching network limits during times of high congestion.[229] Energy Locals/Tesla was able to accomplish this through the use of Flexible Connection Agreements, which allowed units to export up to ten kW at times when network capacity was available by using "dynamic operating envelopes" provided by the DNSP, rather than the standard five kW export maximum.[230] This alleviated the concern established in a separate ARENA pilot with supplier AGL, which identified that distribution network constraints, particularly local power quality issues in areas with high PV saturation, limited VPP performance and capability to deliver market services.[231]

E. NEM Demonstration Value Streams

1. Energy

VPPs operated as unscheduled resources in the energy market via Application Programming Interfaces (APIs) that allowed the projects to submit operational forecasts and actual performance data to AEMO.[232] VPPs are able to respond freely to energy market spot prices, but current regulatory arrangements exempt VPPs from participating in the energy market dispatch process, even if the portfolio exceeds 100 MW in size.[233]

2. Frequency Control Ancillary Services (FCAS)

Prior to the VPP Demonstration Project, only one behind-the-meter battery device was delivering Frequency Control Ancillary Services (FCAS), and

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228. Harmesen, *supra* note 221.
229. Press Release, *supra* note 226.
230. *Id.*
231. AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173, at 7.
232. *Id.* at 18.
233. *Id.* at 36.

no residential-scale VPPs were participating in FCAS markets.[234] Large-scale batteries have participated in live FCAS markets, and Behind-the-Meter (BTM) batteries have participated in controlled settings during various ARENA pilot projects over the past few years. FCAS revenues have historically comprised the primary source of revenue for Front-of-Meter battery resources in the NEM in aggregate, though revenues fluctuate as FCAS revenue is based on discrete grid events.[235] The NEM Demonstration Project aimed to further understand the technical standards necessary for successful and efficient small-battery FCAS participation.[236] All VPPs participated in the contingency FCAS markets, which focus on large deviations, as opposed to the regulation FCAS markets, which handle natural deviations.[237] Grid contingency events represent a revenue opportunity for batteries and VPPs delivering frequency services, dependent on the nature and duration of such events.[238] Batteries are especially positioned to out-perform other resources in FCAS markets because of their inherent speed and accuracy qualities.[239]

3. *Local Network Services*

Provision of local network services was not in scope for the NEM Demonstration Project, but AEMO utilized insights from SAPN's Advanced VPP Integration Project to better understand a VPP's capability to stack multiple value streams and the effect of multi-service participation on the distribution network.[240]

F. *NEM Demonstration Project Results: Primary Successes*

1. *Performance During Contingency Events*

VPPs have demonstrated value during multiple major frequency contingency and energy price events, including major trips of generating units and separation events between South Australia and Victoria.[241] These events are key to understanding the role VPPs can play in grid reliability and resilience in Australia. In the first Knowledge Sharing Report of the NEM Demonstration Project published in March 2020, AEMO reported that the Energy Locals/Tesla VPP intervened in five incidents occurring in the

234. *Id.* at 23.
235. *Id.* at 67.
236. *Id.* at 23.
237. *Id.* at 21.
238. *Id.* at 6.
239. *Id.*
240. *Id.* at 7.
241. *Id. at 5.*

South Australia region between September 2019 and January 2020.[242] Two large FCAS events, which led to wholesale energy prices hitting the price cap of $14,700/MWh for a duration of between one and two hours, resulted in $110,041 AU in revenue for the VPP.[243] One of the events involved risk of the state becoming islanded, while an interconnector tripping caused the other incident and did actually lead to the state becoming islanded for approximately five hours.[244] The most lucrative of the events resulted from an event that ran from January 31, 2020 to February 17, 2020, when transmission towers in South Australia were damaged in a storm.[245] VPP batteries had pre-charged in response to elevated price signals from the period of January 9, 2020 through January 15, 2020, and that preparation allowed the systems to respond to elevated prices, resulting in $1,033,303 of revenue in a period of less than two weeks.[246] These results demonstrate the association between FCAS revenue and power system events, as well as a VPP's ability to charge and discharge in response to energy spot prices.[247] These insights about VPP reliability are useful to DNSPs for integrated system planning considerations.[248]

G. Future Regulatory Developments

Now that VPPs have demonstrated their value, the next step is to ensure that the regulatory rules cater to full participation of VPPs in Australia's energy markets.[249] Various reforms are currently in progress to set the stage for that participation without affecting reliability.

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242. AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173, at 7–10.

243. *South Australia's Virtual Power Plant to boost capacity*, GOVERNMENT OF SOUTH AUSTRALIA DEPARTMENT FOR ENERGY AND MINING (Sept. 4, 2020), https://www.energymining.sa.gov.au/latest_updates/south_australias_virtual_power_plant_to_boost_capacity [https://perma.cc/RX7P-JSAM].

244. *Id.*

245. *See* AUSTRL. ENERGY MKT. OPERATOR, FINAL REPORT – VICTORIA AND SOUTH AUSTRALIA SEPARATION EVENT ON 31 JANUARY 2020 (Nov. 2020).

246. *South Australia's Virtual Power Plant to boost capacity*, GOVERNMENT OF SOUTH AUSTRALIA DEPARTMENT FOR ENERGY AND MINING (Sept. 4, 2020), https://www.energymining.sa.gov.au/latest_updates/south_australias_virtual_power_plant_to_boost_capacity [https://perma.cc/RX7P-JSAM].

247. *Id.*

248. *Id.*

249. *See generally* AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173.

1. *Integrating Energy Storage Systems (IESS) Rule Change*

The Integrating Energy Storage Systems (IESS) Rule change addresses the integration of storage into the NEM, and is currently at the draft stage with AEMC. The central proposal of the IESS is the creation of the Integrated Resource Provider (IRP) category, which will allow storage and other flexible bi-directional resources to be classified as Integrated Resource Units (IRUs) at market registration.[250] This classification will increase VPP market access because it will allow IRUs to be connected to a separate load connection point without requiring registration as a separate market participant and then aggregated for wholesale market settlement.[251] The IESS also proposes the adoption of a bi-directional Ancillary Services Unit, updated from the current import-only treatment for load and export-only treatment for generation resources, that will allow for raise and lower contingency FCAS to be provided by VPPs.[252] At the moment, the VPPs are operating in FCAS markets according to an interim Market Ancillary Services Specification (MASS) solution established by AEMO exclusively for the NEM Demonstration Project, which recognized the bi-directionality of VPPs in order to allow net exports to be authorized to raise FCAS without requiring separate market registration for the load and generation activities.[253] The IESS lays the foundation for the Flexible Trader Model that will be adopted in the Energy Security Board (ESB) reforms discussed below.

2. *MASS Consultation*

AEMO launched the MASS Consultation in early 2021, and it concluded, alongside the culmination of the NEM Demonstration Project, at the end of 2021. Through the consultation, AEMO's intention was to use the lessons learned from the NEM Demonstration Project to determine the ongoing arrangements for handling FCAS delivery from distributed resources.[254] The current MASS requires fifty millisecond metering to verify delivery of Fast FCAS, and most residential battery systems capture data at a resolution slower than fifty milliseconds, but faster than four seconds.[255] This resolution is not an issue for delayed FCAS, but presents an issue for Fast FCAS. The current MASS also measures FCAS response "at or close to the connection point", which causes confusion with load and PV activity for residential

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250. *Id.* at 63–64.
251. *See generally* AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173.
252. *Id.*
253. *Id.* at 5.
254. *Id.*
255. *Id.* at 23.

VPPs.[256] Through the NEM Demonstration Project, AEMO is testing whether verification of FCAS delivery is appropriate at the device level, and also is testing a time sampling scheme of less than or equal to one second at every meter identifier, coupled with a rate of less than or equal to fifty milliseconds for one meter identifier in the portfolio from a high speed meter.[257] Any final determination by AEMO for the MASS will need to go through the Australian Energy Market Commission (AEMC) process for incorporation into the official NER and NERR regulatory rules.[258]

3. ESB Post-2025 Reforms

In July 2021, the Energy Security Board provided guidance on reforms for demand-side participation in the energy and FCAS markets that would be implemented post-2025.[259] The ESB suggestions include the "scheduled lite" model that would update the current dispatch scheduling process to increase operational visibility and dispatchability for VPPs, and also includes a pathway for VPPs to be exposed to the energy spot price through Flexible Trading Arrangements.[260] The IESS sets the stage for these ESB post-2025 reforms, through enablement of bi-directional resource providers to be able to participate bi-directionally in the NEM energy market as an IRP.[261] The proposed initiatives will require both a Rule consultation process and Rule changes. If the 'scheduled lite' model proposed by the ESB reforms moves forward, VPP behavior may be predictable enough to the point where participation in central dispatch may not be necessary until VPPs reach a certain threshold, if VPPs can also diligently follow forecast schedules.[262]

256. *See generally* AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173.
257. *Id.* at 34.
258. *Id.*
259. *Id.* at 65.
260. *Id.* at 66.
261. *Id.* at 36.
262. *See generally* AEMO NEM VIRTUAL POWER PLANT DEMONSTRATIONS: KNOWLEDGE SHARING REPORT #4, *supra* note 173.

H. NEM Demonstration Project Results: Identifying Challenges

1. Forecasting

Providing accurate forecasts has been difficult for most VPP operators in comparison to large-scale solar farm forecasting accuracy.[263] The final AEMO Knowledge Sharing Report states, "the current level of forecasting error indicates that VPPs are not currently capable of being integrated into market systems as forecastable/dispatchable resources without changes to their operational behavior, control methodology, uplift of forecasting capability and/or incentives for following forecast schedules."[264] Due to the complex operating patterns of VPPs, VPP operators are also better suited in comparison to AEMO to forecast the behavior of these assets.[265] Therefore, it should be a priority for VPP operators to optimize forecasting and achieve consistency between forecast schedules and system behavior. Forecasts that adapt to changing conditions and incentives/disincentives for following forecast schedules will also be pivotal.

2. Internet Outages

VPPs present a new challenge to energy supply in comparison to conventional centralized generation schemes, as the data reported by the systems and appliances that will be aggregated as a VPP are dependent on internet signals. VPPs currently rely a combination of Wi-Fi, 3G and 4G networks, and public internet to send data to DNSPs and AEMO.[266] Some of the websites of AEMO's VPP participants even mention that a 3G or 4G internet signal is insufficient to participate.[267] Telemetry data from the NEM Demonstration Project showed that at any given time the data receipt percentage was between seventy percent and ninety-eight percent and the variability was largely due to cloud communication outages.[268] These outages impacted up to thirty percent of VPP portfolios in some instances.[269] Communication dropouts are also problematic as they interfere with monitoring and forecasting of systems.[270] These challenges present a necessity

263. *Id.* at 8–9.
264. *Id.*
265. *Id.*
266. *Id.*
267. *Virtual Power Plant Energy Plan*, SIMPLY ENERGY, https://www.simplyenergy.com.au/residential/energy-efficiency/simply-vpp/new-solar-battery/smart-energy-answers [https://perma.cc/9R54-SVQV].
268. *Id.*
269. *Id.* at 34.
270. *Id.*

for increased collaboration and coordination with internet providers going forward as VPP participation grows.

3. *Barriers to Fast FCAS*

A primary goal of the NEM Demonstration Project was to eliminate barriers of Fast FCAS, which involves responsiveness within a six second time frame.[271] In order to achieve that successfully, fifty millisecond metering at every site is necessary, but that is very onerous to implement for every household and lower than the data capture of most residential batteries.[272] The NEM Demonstration Project tested at a one second sampling rate, which is insufficient to implement live.[273] The draft determination of the MASS, published during the consultation, proposed to maintain the fifty millisecond requirement for Fast FCAS as well as the response measurement point "at or close to the connection point," both of which will continue to be an obstacle to large-scale VPP participation in FCAS.[274]

4. *Cost of API Development*

For the NEM Demonstration Project, AEMO set up four APIs to allow for receipt of large amounts of continuous data in the form of operational forecasts and actual performance data of VPP participants. Multiple VPPs expressed that the APIs required by AEMO for the pilot were costly to develop and maintain. Removing that requirement would have made the prospect of joining more achievable.[275]

5. *Prioritization of Distribution System Reliability*

During the Advanced VPP Grid Integration Project, VPP operator, Tesla, noted that it is important for VPPs to prioritize distribution network services over market services.[276] In other words, aggregators and DNSPs must be in agreement on a control hierarchy where distribution network security is centered in value stacking rather than a VPP's response to revenue-

271. *Id.* at 23.
272. *Id.*
273. *Id.* at 24.
274. *Id.* at 34.
275. *Id.* at 61.
276. *Id.* at 31.

generating events. [173] For example, services such as volt/var should be ahead of FCAS.[277]

6. *Large-Scale System Security Concerns from FCAS Participation*

AEMO identified a variety of power system security concerns within the MASS consultation draft document relating to DER provisions of FCAS at large-scale.[278] Key concerns identified include: security risks in frequency recovery if inverters are unexpectedly disconnected due to a local network fault and the disconnections are not properly accounted for; risk of under-delivery during local distribution network disturbances as a result of inverter requirements that do not prioritize distribution services over revenue-generating services; risk of exceeding secure local network limits as a result of rapid power injection from FCAS delivery; and unexpected responses from inverters during instances of voltage or frequency disturbances that result in an inconsistent response within a non-high-speed response window, such as one second.[279] AEMO's suggested resolutions for these concerns include reaching agreement on control hierarchy of distribution services versus FCAS services, successful integration of flexible connection agreements as was demonstrated during the Advanced VPP Integration Project and also initiated in the most recent AEMC rule change, and ability for VPPs to meet the fifty millisecond response performance requirements.[280]

V. ADVANCING VPP POLICY

These three case studies provide a close examination of three different models for allowing Virtual Power Plants (VPPs) to be a viable resource. They further demonstrate that VPPs, rather than an abstract theory, are a tested and workable model for aggregating distributed energy resources and managing them as a controllable resource. VPPs today are a demonstrated, localized resource that (1) reduce carbon emissions; (2) replace the costs of both expensive, centralized generation, and new transmission and distribution assets; and (2) is poised to be a local resource that can be deployed to improve the resilience of our energy system, which is facing unprecedented severe weather events.

At the same time, while the promise of the VPP resource is apparent, there are multiple challenges—structural, technological, and regulatory—to scaling VPPs up to become a meaningful contributor, both locally and

277. *Id.* at 61.
278. *Id.* at 35.
279. *Id.*
280. *Id.*

regionally, for future resource planning and management of severe weather events. These three distinctive case studies, while providing insight in how VPPs are being successfully implemented in California, Vermont, and Australia, also contribute to the very early research on what challenges lie ahead as we both sprint toward the clean energy transition and prepare our essential services for what will undoubtedly be increasingly severe and unpredictable weather.

A. EPRI VPP Evaluation and Findings

In preparing us to understand the results of the case studies, we searched for similar research that can help inform our results. Unsurprisingly, given its historical roots with the electric industry and the depth of its expertise and resources, the best public analysis of the opportunities and challenges for VPPs comes from the Electric Power Research Institute (EPRI).[281] The EPRI evaluation identifies key lessons learned from utility pilots and barriers to VPP adoption from an aggregator's perspective, both of which are useful to summarize.

EPRI identifies six lessons learned from utility pilots it has analyzed including:

1. Investments in foundational technologies are needed to fully enable the potential of VPPs;
2. there is a lack of standard communication protocols between utilities and DER aggregators;
3. cost of DER management through aggregators challenges project economics for utilities,
4. growing interest from DER developers on utility managed operation;
5. need for standard solutions (gateways/site controllers) to integrate diverse DER types with VPP operations; and
6. methods for verification, settlement, and penalties for services provided by DER aggregations are yet to be defined.[282]

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281. *See* Ajit Renjit & Nick Tumilowicz, *Virtual Power Plant Evaluation*, SMUD BOARD COMMITTEE OF ENERGY AND CUSTOMER SERVICES, https://www.smud.org/-/media/Documents/Corporate/About-Us/Board-Meetings-and-Agendas/2021/Jun/2021-06-21_ERCS_-Exibit-to-Agenda-Item-1_External.ashx [https://perma.cc/8XFP-6NXW].
282. *Id.*

The EPRI analysis then defines six barriers to VPP adoption from an aggregator perspective including:

1. Lack of consistency in every other project deployment;
2. VPPs do not yet fit nicely into traditional utility business processes;
3. economic optimization at the distribution level for VPP requires a cost basis against which to optimize (in contrast to regional level);
4. consistent telemetry and access to an up-to-date network model at the right level are not always available;
5. energy storage is one of the most capable DER assets due to its dispatchability, but its deployment is limited due to costs since batteries are still relatively expensive; and
6. cyber security becomes more challenging as the number of bi-directional communicating devices on the grid edge increases.[283]

The EPRI analysis and findings provide additional perspective on the challenges facing utilities, their regulators, and third-party aggregators, as workable business models and an appropriate regulatory framework are developed. It is also useful as we consider what we can learn from our case studies and consider what challenges lie ahead for this emerging resource.

B. Analysis of Case Study Findings, Potential Lessons, and Future Considerations

1. Is There a Business Model That Will Better Facilitate the Clean Energy Transition?

While EPRI defines the various business models, and identifies pros and cons of each model, it stops short of identifying uncertainty over business model types, or any particular model, as a barrier to adoption. Our research demonstrates that there are strongly held—and divergent—views on the topics of (1) whether utilities should be able to own VPPs (particularly behind the meter batteries) and (2) what the regulatory treatment should look like for these programs. In Vermont, both the state public advocate and a major renewable energy trade association had strong concerns about utility ownership of batteries and encouraged below the line treatment (treatment as an unregulated business where cost recovery would not be guaranteed by ratepayers) of costs. The state public advocate argued for a

283. *Id.*

single pay-for-performance tariff for both Green Mountain Power and privately owned batteries. GMP defends its VPP approach as necessary and important to scale up the program and offers internal analysis demonstrating that nonparticipating customers saw financial benefit from the program.[284] The Vermont Public Utility Commission ultimately approved the GMP program, noting that the market was not yet mature and that the GMP pilot offered several advantages. In contrast, California's Public Utility Commission has generally been more hesitant to allow utilities to enter competitive services such as behind the meter provision of batteries. The SCE case study, in contrast, demonstrates a path forward where the utility can successfully provide a utility platform for third party owned and/or aggregated batteries.

At this stage, it is not clear that our case studies offer any substantial evidence for or against a particular approach. The arguments against public utilities entering competitive services are well defined. What is less clear is whether there are meaningful benefits to allowing utility ownership of DERs to help expedite the transition toward these technologies in the short term. Our analysis of the SCE pilot identified concerns that aggregating enough resources to scale might be a challenge and that affordability of batteries remains a problem. Important to the evaluation of business models is whether utilities actions will hinder or preclude the future competitive provision of these services once the business case become more compelling for market entry.

As demonstrated in our case studies, utilities have been able to aggregate DERs to reduce monthly utility peaks and save both regional network service charges and regional capacity market charges. In addition, as VPP services become more localized (e.g., wildfire and distribution system peak mitigation) utilities become central to valuing and managing these services. While our Australian case study offers some hope that a development of centralized wholesale markets for VPPs could provide needed revenues for VPP aggregators without significantly relying on the utility programs, our research finds that the utility managed value streams are currently more important sources of revenue. More research on this question is needed, while also exercising policy caution that utility actions or state policy does not preclude alternative approaches that could be more optimal in the long term.

284. Memorandum from Josh Castonguay to Judith C. Whitney, Clerk, Vermont Public Utility Commission, 3 (Apr. 15, 2019) (on file in ePUC).

2. *Are There Technological Barriers That Limit the Growth of VPPs?*

The need to overcome technological barriers, both with communication technologies and the interoperability of systems, is a challenge that seems to be more universally recognized. The Electric Power Research Institute's recommendations, from both the utility and aggregator perspective, identified challenges with system hardware, software, and standards. EPRI identified the need to invest in foundational technologies, a lack of standard communication protocols, and the need for standard technology solutions. Similarly, our case studies identified that telemetry data for VPPs is not as robust and reliable as internal utility standards. VPP's use of Wi-Fi and cellular data networks can pose obstacles for VPPs. The reliability of internet communications compared to typical utility resource communication methodologies presents real and cultural challenges. Historically, technology issues presented cost barriers for utility adoption of smart technology as well as reliability barriers, since utilities tend to have higher reliability standards than commercial cellular or Wi-Fi providers; thus, utilities were hesitant to invest in or rely on existing commercial services. Both reliability of communications technology and interoperability of utility and third party equipment was previously identified as a challenge for the industry.[285] Our case studies demonstrate that utilities and DER aggregators have been able to work around these challenges but as programs scale up from pilots to larger resource portfolios, and parties search for additional revenue streams (such as regional frequency regulation markets), resolving these technological challenges will continue to be priority.

3. *Should We Standardize Market Rules, State Regulations and Industry Protocols?*

The final area of concern identified in our case studies and the EPRI analysis falls within the broad categories of regional market rules, state regulations and program protocols. EPRI identified the lack of consistency between VPP programs as a barrier to growth. Similarly, our case studies identified numerous specific program challenges and inconsistencies from utility export limits placed on DERs (such as the challenge of providing accurate forecasts compared to central station/utility scale resources, and uncertainty over control hierarchy, including whether, to prioritize distribution network services over regional market services like frequency regulation). The AEMO's work to resolve some of these issues from a top down perspective

285. KEVIN B. JONES & DAVID ZOPPO, A SMARTER, GREENER GRID: FORGING ENVIRONMENTAL PROGRESS THROUGH SMART ENERGY POLICIES AND TECHNOLOGIES, 37–41 (Praeger 2014).

offers promise for VPPs to be able to cost effectively access regional markets as do FERC Orders 841 and 2222. Much work remains at the state policy level as well as with the forever present concerns at the state and federal jurisdictional divide. While pilot programs have allowed individual utilities to overcome some of these challenges, as we scale these pilots to larger scale programs with nondiscriminatory access to third party aggregators, there is significant regulatory policy work ahead in each of the fifty U.S. states, as well as internationally. As just one example, while concerns have been expressed with scaling access to residential batteries (particularly given their high cost), there is currently significantly untapped opportunity for the much larger supply of electric vehicle (EV) batteries if policy makers, the EV industry, and utilities can successfully work together. This kind of policy work must be a present and future priority if we hope to take advantage of a meaningful VPP resource in a timely manner as we seek to expedite the clean energy transition.

VI. CONCLUSION

Our case study analysis demonstrates that from California to Vermont to Australia, Virtual Power Plant pilots have been developed, implemented, and evaluated. These pilots have helped reduce carbon emissions, reduced costs from traditional resources, and offered possibilities to make the local grid more resilient to climate change. While challenges have been identified regarding business models, technology, and market and program design, VPPs have proven they can be a clean, flexible, and resilient resource that can support the clean energy transition. Working out the policy and programmatic kinks and learning how to most effectively scale this important resource at the state, regional and federal levels is imperative to VPPs continued and future success.