NAVIGANT
RESEARCH

WHITE PAPER

Why Australia Is a DER Innovation Hot Spot

Expanding VPPs in the Asia Pacific Region: Part 2

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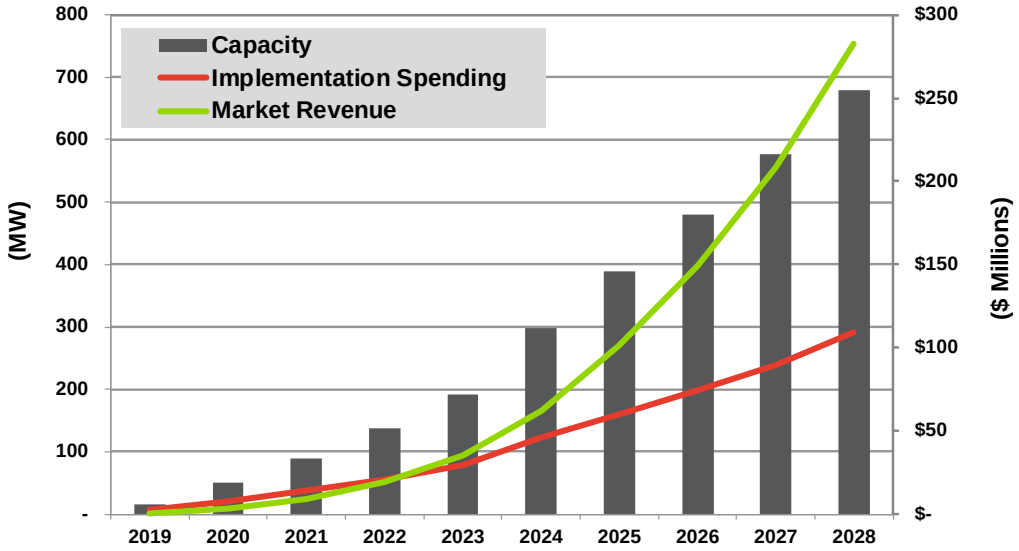
Section 1
EXECUTIVE SUMMARY

1.1 How Australia's DER Journey Led to Virtual Power Plants

Australia has been a global leader of distributed energy resources (DER) platforms such as remote microgrids[1] for decades. The country is now shifting its focus to the technologies necessary to manage grid-connected DER (such as rooftop solar PV) and to making real the value proposition that its prosumers will realize greater benefits staying connected to the network rather than abandoning the grid altogether. Recent power outages, high energy prices, and among the highest penetrations of distributed solar PV in the world have made Australia a focal point of innovation. Navigant Research views Australia as an incubator and a laboratory where DER opportunities from remote microgrids to virtual power plants (VPPs) and DER management systems (DERMSs) can be tested, validated, and commercialized. Like Japan, which Navigant Research profiled in a recent white paper,[2] Australia is leading the way in the Asia Pacific region, though its story has several twists.

Chart 1-1. VPP Capacity, Implementation Spending, and Market Revenue, Base Scenario, Australia: 2019-2028



(Source: Navigant Research)

[1] Navigant Research defines remote microgrids as self-contained standalone power systems installed where traditional power grids do not exist.

[2] Navigant Research, *Deregulation Drives Virtual Power Plant Expansion in Japan*, 2019, https://info.enbala.com/navigant2019wp2.

Section 2
AN EVOLVING DER MARKET IN AUSTRALIA

2.1 The Perfect Storm for Rapid DER Innovation

Australia consumers boast one of the highest per capita electricity consumption rates in the world—even greater than the US. These consumption levels translate into flexible load resources ideal for virtual power plant (VPP) manipulation, aggregation, and optimization.

Blackouts, skyrocketing retail power prices, and sizable increases in renewable energy generation are requiring new answers to reliability, flexibility, and cost challenges. As a result, both traditional and non-traditional market players are embracing solutions that are being rolled out sporadically in other parts of the world. In Australia, concepts such as prosumer-based VPPs and distributed energy resources management systems (DERMSs) have been called into immediate commercial applications. While AutoGrid has laid claim to creating the world's largest VPP in Japan (though the company has declined to provide an estimate of capacity), Tesla has made a similar claim for a project in Australia that is purported to reach 250 MW in size, aggregating DER assets from 50,000 residential prosumers.

Meanwhile, VPP innovators such as Enbala, Enel X, GreenSync, and others are laying the groundwork for a growing market. These companies are developing software solutions and forging new business models designed to provide bidirectional value, backing up the proposition that it is better to stay connected to the grid than to abandon it and go solo. Australians, like some Americans and other prosumers located around the globe, may be tempted to disconnect from the larger grid with their own small private energy islands. However, the value proposition of staying connected appears to win out. For example, Energy Networks Australia and CSIRO's 2017 *Electricity Network Transformation Roadmap* estimated the potential benefit of prosumers staying connected to the grid to be $1.4 billion in avoided network investment, lowering household electricity bills by $414 per year.

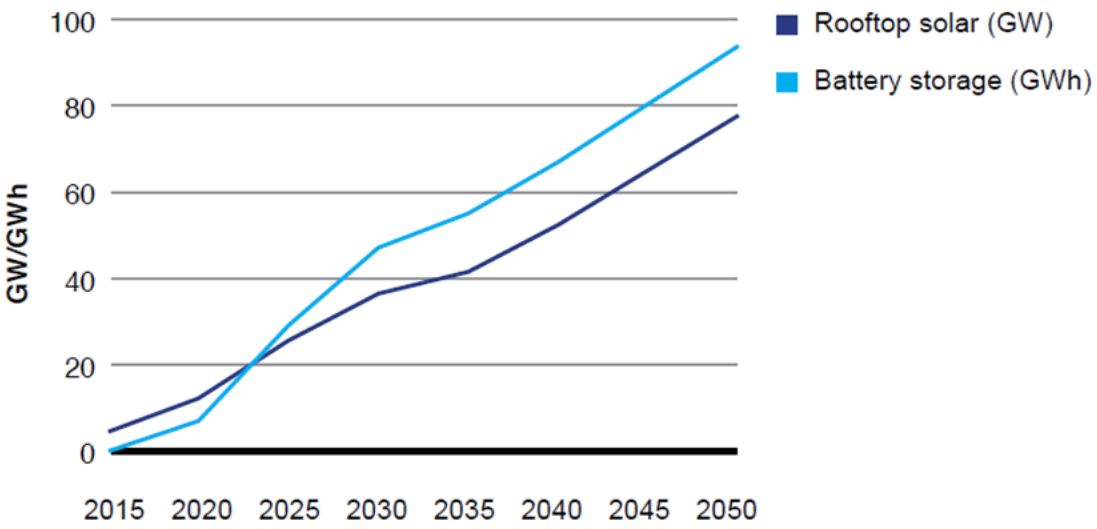
2.1.1 Highest Solar PV Capacity Per Capita in the World

Unlike more mature VPP markets such as the US and parts of Europe, the impetus for VPPs is coming from the need to manage behind-the-meter residential DER assets, especially solar PV. The cost of solar PV installations in Australia is about half that of the US, largely due to less regulation and cheaper labor. Uptake will continue to accelerate because retail power prices are also often higher than in the US. This gap creates an opportunity for consumers to reduce their own costs and, if coupled with a battery (made more affordable with government-backed financial incentives), become a dependable grid asset. VPPs are the epitome of energy ecosystem nirvana: lower costs, greater resiliency, and transforming what were problematic resources into grid service solutions.

2.1.2 Major Expansion of Residential and Mass Market-Scale Battery Deployments

Rooftop solar PV systems are being paired with distributed energy storage devices, allowing prosumers to mitigate high network fees while offering some level of resiliency. Fleets of residential solar plus energy storage systems remain the focus of the VPP market in Australia; the lessons learned from these systems will likely shape the design of future VPPs around the world.

Figure 2-1. Rooftop Solar PV and Battery Storage Adoption, Australia: 2015-2050



(Sources: Energy Network Australia and CSIRO)

2.1.2.1 Case Study: AGL Energy VPP

AGL Energy (AGL) is expanding its foray into the world of VPPs by aggregating the battery systems (from Tesla, SolarEdge, and LG Chem) of 1,000 households with rooftop solar PV in Adelaide, South Australia. The VPP, which totals 5 MW in capacity and cost $19.2 million, will rely on Enbala's Concerto platform to orchestrate and optimize DER coordination to maximize the overall benefits across customer, wholesale markets (energy and ancillary), and network service value streams. While not the largest VPP in terms of capacity or customer number, it is the most sophisticated due to variety of vendor assets involved and grid services rendered.

According to AGL CEO Brett Redman, "Right now, generally customers can only use their solar systems to meet their own energy needs and sell any surplus back to the grid. The AGL VPP unlocks new benefits for customers, a partnership that allows customers to provide services to AGL to support the grid at times when energy is needed. The new VPP

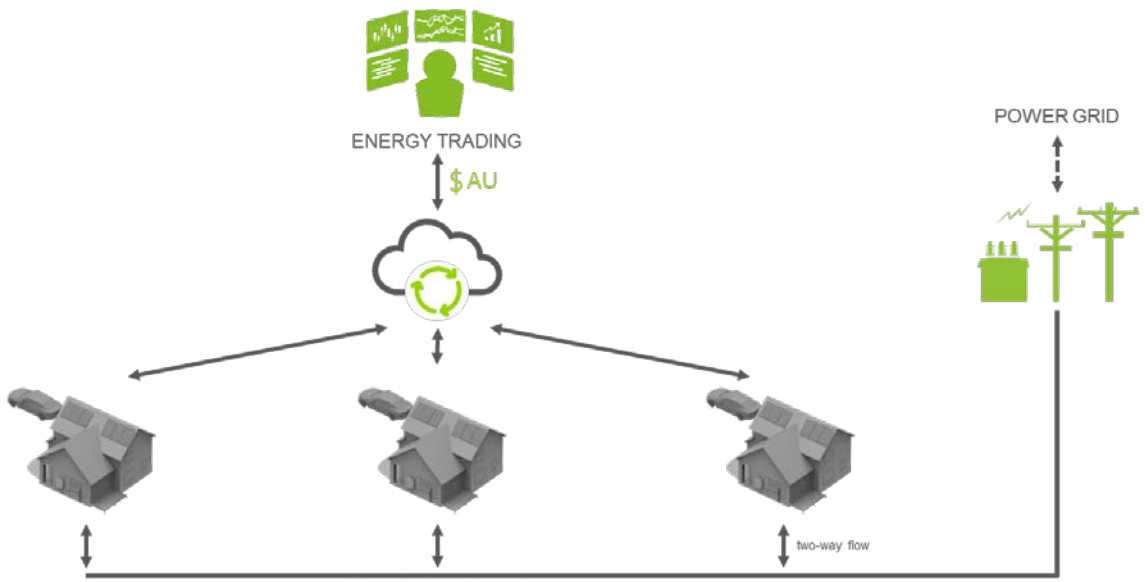
will enhance reliability and affordability, sharing the benefits and, in effect, allow customers to act as generators."

Almost 25% of homes located within AGL's service territory (1.7 million prosumers) feature rooftop solar PV systems, illustrating the scope of potential assets available to include in VPPs. AGL launched two separate offers to the residential sector:

- AGL offers a $1,000 upfront payment toward the cost of a battery system (in addition to a government grant of up to $6,000) for residents that are intent on joining the VPP.
- By joining the VPP program and agreeing to provide grid services when called on, these prosumers will be able to earn an additional $280 over the first 12 months. This deduction from their electricity bills is comprised of a $100 sign-on bonus and a quarterly $45 payment.

AGL is not the only company providing VPP offers in its service territory. Origin Energy is looking to aggregate 650 residential and commercial customers with solar plus energy storage systems into a 5 MW VPP in Victoria, and Simply Energy is building an 8 MW VPP, also in Adelaide.

Figure 2-2. Residential Solar PV plus Energy Storage VPPs



(Sources: Enbala, Navigant Research)

2.1.3 Blackouts and Other Grid Management Challenges

The story of Australia's evolving energy markets is not all good news. A catalyzing event occurred on September 28, 2016: a state-wide system blackout in South Australia. The blackout was blamed on high penetrations of variable renewable energy resources such as

wind and solar, which supply more than 50% of capacity in New South Wales (NSW). The blackout did not thwart efforts to continue to push for even greater deployments of renewable energy, however. The Australia Electricity Market Operator (AEMO) has put forward an integrated system plan looking out over the next two decades and predicts that the entire National Electricity Market (NEM) will reach similar levels of renewable energy by 2030—perhaps even higher.

An August 2018 outage underscored how new technologies fundamental to VPPs may be able to help prevent such blackouts in the future. In this case, twin lightning strikes and the sudden corresponding failure of two transmission lines posed a threat that could have led to widespread outages. While communities in NSW and Victoria were indeed blacked out and big consumers such as aluminum smelters and other industrials were cut off, the blackout never spread thanks to renewable-rich regional grids supported by advanced battery technologies. The ability of Queensland and South Australia to island themselves off akin to mega-microgrids also helped. An extreme heat wave in January 2019 led AMEO to ask Alcoa Australia, the largest electricity customer in Victoria, to slash power consumption to keep the grid up and running. This request highlights the value of demand response (DR) and other VPP-related grid services to maintain grid reliability.

Pushback from the fossil fuel industry is still in full force.[3] The regions most at risk to outages are NSW and Victoria due to their aging coal facilities, which are seeking government support to avoid closure. These blackouts, the effect of rooftop solar PV penetration on network reliability, the decline in coal generation, and rapid investment in large-scale wind and solar generation underscore the need for AMEO to have greater visibility into the energy assets interconnected to its grid. It also needs grid control upgrades to see and control both renewable and fossil fuel generators. AMEO views VPPs that control a diverse pool of resources ranging from utility-scale renewables, DER, and flexible thermal capacity as having the potential to fill an emerging reliability gap in available resources that could affect approximately 66% of Australia's population. Because of new software platforms being developed to support VPPs and DERMSs, grid operators such as AEMO have tools that can enable increased uptake of renewable energy while maintaining a reliable and affordable grid network.

[3] It should be noted that many blackstart fossil fuel generators failed during the state-wide system blackout, prolonging the outage.

Section 3

TECHNOLOGY ADVANCES VITAL TO VPP-DERMS MARKET MATURITY

3.1 Localized Issues Shape the VPP to DERMS Journey

These blackouts and emerging reliability and security risks have pushed Australia to move beyond VPPs to include DERMSs, which can address more localized issues such as voltage sags or hotspots on the distribution network. VPPs are focused on load aggregations for arbitrage and reserve scenarios while also being capable of addressing frequency; DERMS can stop grid issues from cascading up to the transmission system. The tools embedded in a DERMS solution that can solve grid problems in a more precise manner through active power management are here to address what is an inevitable reality. Key government and industry stakeholders are investigating a distribution system operator model, as has been done in Europe. The near-term focus, however, remains on VPPs to set the stage for future DERMS deployments by proving out control, aggregation, and optimization platforms that can extract value under current market rules and conditions.

3.1.1 Grid Modernization Sets the Stage

Telemetry that allows for the measurement and verification of energy services traded between regulated and unregulated entities is a necessary cornerstone to the Energy Cloud vision. [4] In the Energy Cloud, a variety of prosumer and utility assets work together to share value. Without smart meters, smart inverters, and other new forms of intelligence embedded into the grid itself (as well as motors, generators, and appliances at customer sites), innovative management frameworks such as the VPP would not be possible. In short, a smart grid is a basic and fundamental component in the chain of technology advancements that helps enable VPPs and are necessary for DERMS deployments.

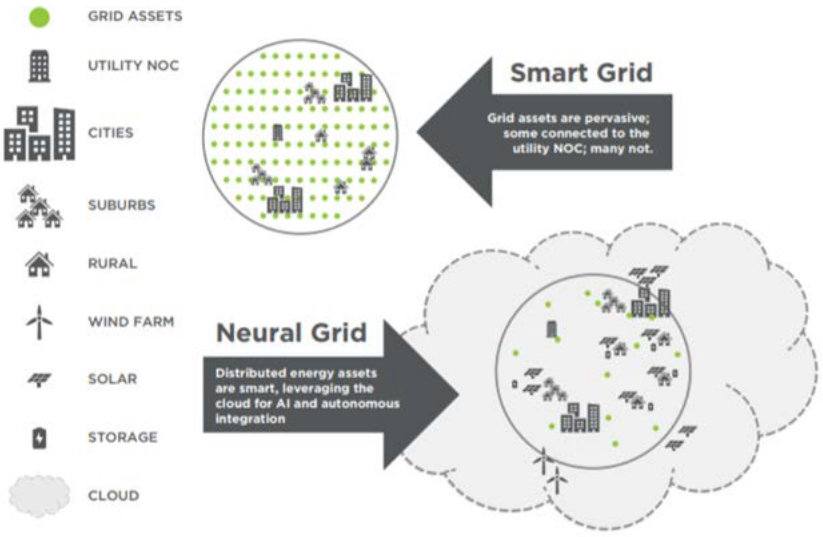
As DER portfolios continue to diversify and grow, a smart grid enabling two-way communication will not be enough to push VPPs into the mainstream. Instead, a Neural Grid[5] will be needed. The smart grid implies the legacy mechanical power transmission and distribution networks are enhanced by pockets of automation, connectivity, and centralized IT systems. In contrast, the Neural Grid implies a vastly more powerful platform of hard and soft assets leveraging ubiquitous connectivity, the cloud, robotics, artificial intelligence (AI), edge computing, and pervasive sensing. It is the endgame for grid

[4] Navigant Consulting, *Energy Cloud 4.0*: *Capturing Business Value through Disruptive Energy Platforms*, 2018, https://www.navigant.com/insights/energy/2018/energy-cloud-4.

[5] Navigant Consulting, *From Smart Grid to Neural Grid: Industry Transformations and the Top Five Technologies Poised to Bring the Grid Into the Cloud*, 2018, https://www.navigant.com/insights/energy/2018/from-smart-grid-to-neural-grid.

modernization, transforming legacy infrastructure into a platform that will support a fully mature Energy Cloud environment (see Figure 3-1).

Figure 3-1. Moving from Smart Grid to Neural Grid



(Source: Navigant Research)

In the Neural Grid, data and intelligence reside largely in the cloud, managing the intersection of generation assets and energy customers, buildings, transportation infrastructure, smart city integrated systems, and DER assets. Asset ownership is diverse. As a result, utility grid data and assets work synergistically with third-party data and assets to coordinate energy supply and demand—all in real time. While it might sound too good to be true, it is the end goal. The Neural Grid enables customer involvement and choice. It sets the stage for premium energy services and corresponding personalized pricing. One could argue that the VPP is a precursor of things to come, exploiting those opportunities that arrive during the transition from the smart grid to the Neural Grid.

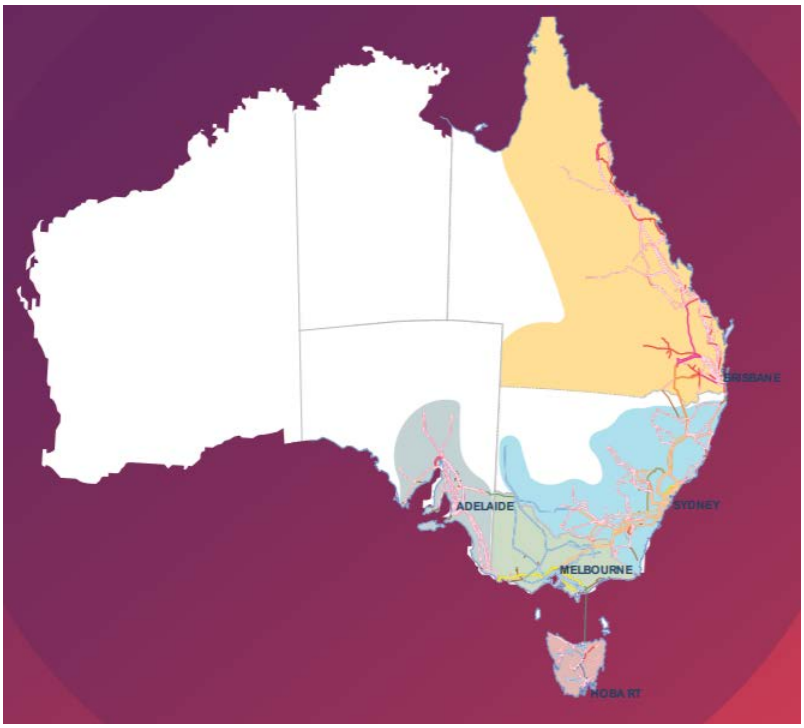
3.1.2 Market Reforms Designed to Open New Markets, Create New Value

Australian culture values independence and a number of consumers want to depart from the grid due to high prices, including interconnection network fees. However, most can have it both ways. Solar plus batteries can allow these consumers to reduce their own energy costs and have some level of resiliency during power outages. If aggregated into a VPP, they may also be able to participate in emerging grid services programs such as DR and frequency regulation.

Australia is pioneering one aspect of the VPP framework that is on the energy trading side of the equation. Recently, the Australian grid has been stressed due to heat waves, coal retirements, and the explosion of solar energy deployments. The need to harmonize

generation and load across Australian control areas concentrated in the eastern and southern parts of the country has made these the regions where VPPs are being viewed as vital to grid reliability (see Figure 3-2).

Figure 3-2. NEM: Primary VPP Opportunity Landscape



(Source: National Electricity Market)

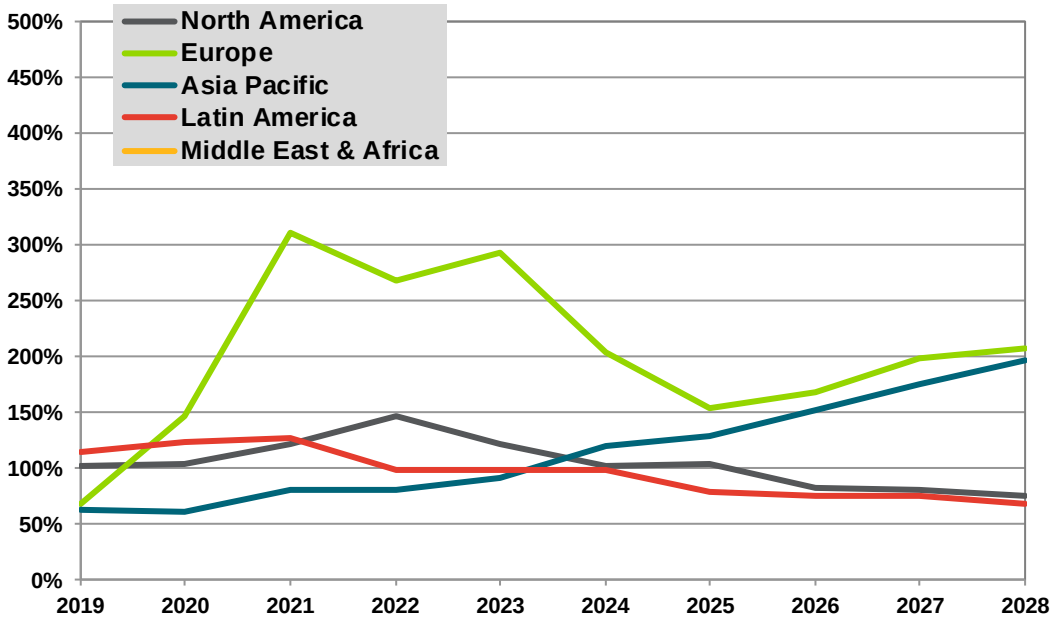
The opportunity in Australia is of global importance, as was signaled by Audrey Zibelman's decision to leave her top position at the New York Public Service Commission to become CEO at AEMO. Zibelman helped jump-start the New York Reforming the Energy Vision (REV) initiative and previously was the CEO of Viridity Energy, an early VPP innovator.

Section 4
AUSTRALIA CAN LEAD GLOBAL VPP-DERMS ADOPTION

4.1 Australia's Isolation Creates a Laboratory for Experimentation

Navigant Research has projected that distributed generation—defined as systems 1 MW and under—is already outpacing centralized generation globally. When factoring in the broader entire DER portfolio, including batteries, DR, EVs, etc., these decentralized resources are expected to represent the bulk of electricity supply moving forward, though adoption rates vary significantly between regions and countries.

Chart 4-1. Distributed Generation as Percentage of Central Generation by Region, World Markets: 2019-2028



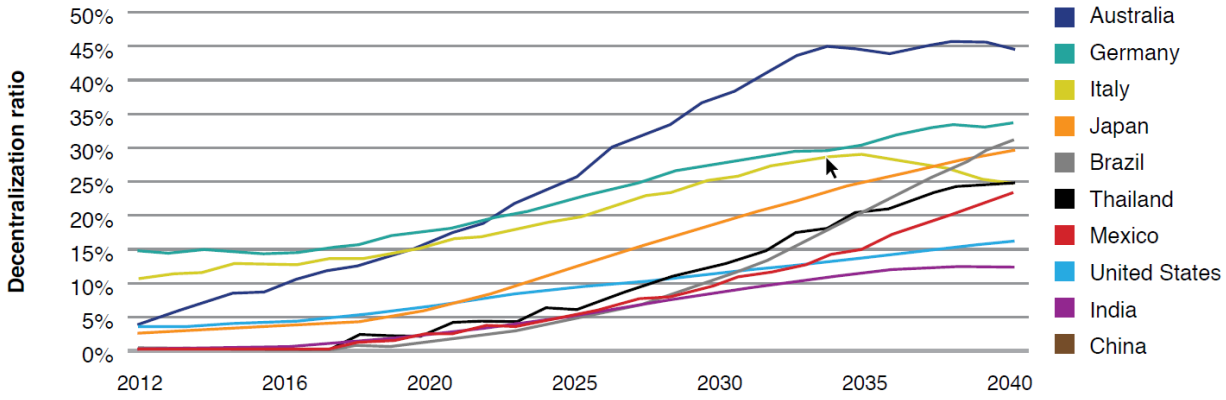
(Source: Navigant Research)

The Asia Pacific region, which includes Australia, already features just over half as much distributed generation (solar PV, combined heat and power, and diesel generators) as centralized generation (coal and nuclear power plants). By 2028, these distributed generation sources are forecast to represent over double the capacity of mostly legacy centralized power plants.

Another way to look at why Australia might lead global adoption of VPPs and then DERMSs is comparing it to other individual countries based on decentralization. If

measured this way, Australia is projected to emerge as the global leader in just a few years and maintain a major leadership role beyond 2030 (see Figure 4-1).

Figure 4-1. Decentralized Energy Ratio, Selected Global Country Markets: 2012-2040



(Source: AEMO-CSIRO)

4.1.1 Changing Political Winds Not Thwarting VPP Energy Reforms

A changing political landscape is one challenge for the private sector when planning energy strategy for the long term. Australia is an excellent illustration of this point. It also confirms that the pace of rapid innovation with clean and smart energy renders some past notions obsolete.

In May 2019, the conservative Liberal Party took over the reins of government in South Australia. In the past, elections sent mixed signals on whether Australia would mandate carbon reductions or not, changing policy within subsequent election cycles, for example. In the most recent election, the new government proposed an alternative to Tesla's VPP by offering subsidies for residential batteries but excluded low-income consumers. Facing a public backlash, the government switched gears and announced support for the original VPP structure, though it is pushing its own subsidy plan in parallel.

4.1.2 Deregulation Creates a Hypercompetitive Trading Market

Australia's NEM market, which commenced operations in 1998, supplies approximately 9 million customers with over 54,421 MW of generating capacity. Trades among the over 300 buyers of electricity surpass $16 billion annually. The NEM market is an energy-only market, with no capacity or day-ahead market; it is largely deregulated, which facilitates intense market competition.

Deregulation reforms have created what one VPP vendor described as a "free market on steroids." NEM participants can change their market offers as late as 5 minutes before dispatch, which suits highly flexible resources and algorithmic trading strategies. This also

increases the level of risk that AEMO manages as the operator, putting a premium on operational visibility and sophisticated forecasting techniques.

Bidders can sell into eight different grid service markets and market prices clear every 5 minutes. Batteries deployed in this market can be allocated in 18 different ways and can be compensated via 10 different pricing bands. This level of complexity can stimulate innovation but can also result in unintended consequences. AEMO is collaborating with industry leaders to evaluate whether the NEM design should evolve to manage the increasing variability of supply and demand in the future.

NEM set a market cap price of $14,200 per megawatt-hour (MWh), a figure that will be adjusted annually for inflation. The minimum spot price (the floor) is -$1,000 per MWh. These prices are reviewed every 4 years by the Australian Energy Market Commission's Reliability Panel. As a result of this structure, NEM participants need to manage the financial risks that result from such a wide spread in pricing and such frequent price changes. Participants typically use financial contracts that lock in a firm price for electricity produced and consumed at a given time in the future. These arrangements typically take the form of derivatives that may include swaps or hedges, options, and futures contracts. VPPs take on the role of serving not only as gateways for sending value upstream from prosumer assets, but as vehicles to help navigate a trading market characterized by wild swings and big gains—and just as big losses.

To make sense of this potential chaos, AI, buy and sell options modeling, and supply stack bidding strategies all rise to the top in importance. It is this emphasis on real-time trading that may be Australis's biggest impact on DER innovation, driving increasingly sophisticated VPPs while creating demand for DERMSs to resolve the grid stability impacts that flow from such rapid-fire energy buy and sell transactions.

4.1.3 Challenges to VPP-DERMS Remain

Australia represents fertile ground for VPP-DERMS innovation, but there are some quirks that can frustrate market growth. Among them is that market operators are disaggregated from retailers. This creates split incentives, which can be counterproductive to optimal outcomes. Furthermore, market trading can be brutal on the receiving end. The total cost of wholesale electricity traded in Victoria on January 24, 2019 was 14% of the total amount of wholesale electricity traded in Victoria in the previous year, with 89% of the cost occurring between 4 p.m. and 9 p.m. There were several underlying drivers for this incredible price spike:

- Reduced output from hydro generators due to dry conditions
- Higher wholesale natural gas prices
- Price increases in offers from black coal-fired generation
- Hot summer conditions increasing demand

Non-traditional approaches such as VPPs can support risk management by managing and moving demand en masse to lower cost periods or curtailing demand to reduce exposure to higher priced energy services.

Massive investments in grid infrastructure have also had a downside. The resulting cost of connectivity is high, which is why some consumers seek to abandon the network altogether and join the western side of the country in receiving electricity through off-grid networks such as remote microgrids.[6] Some argue the power grid was overbuilt to meet air conditioning demand spikes in January/February (the peak of summer in the Southern Hemisphere), and there may have been a more efficient solution. Horizon Power is authorized to disconnect customers served by long feeder lines, replacing them with standalone power systems. These are exceptions, not the rule, throughout Australia.

AEMO expects VPPs that consist of solar PV, storage, and embedded existing generation to be considered by retailers as a means to create flexible, cost-effective physical hedges in support of traditional financial hedging techniques. This is especially so for smaller electricity retailers that have no generation capacity. Given their size and profile, financial hedges available to them are relatively costly. In addition, the introduction of tighter price regulation in July 2019 increases financial pressure on these retailers. Market observers predict significant retailer market consolidation in the coming years, which could reduce the number of retailers by two-thirds. This pressure to reduce retailer energy costs will lead to a greater emphasis on optimizing operations and maintenance of flexible DER assets as well as new customized services offerings for grid-connected customers.

[6] For those consumers being served by Horizon Power, the largest utility service territory in the world with the fewest customers per square mile, remote, off-grid microgrids are a necessity, not a choice.

Section 5
CONCLUSION

5.1 Australia Is Not an Island

Australia's isolation has necessitated grid topologies unique to its circumstances. Yet, from the perspective of regulatory reform and technology advancement, it is merely a stage upon which the future of the entire electricity industry is being played out. The upside for VPPs can be substantial. In April 2019, the Hornsdale battery—at 100 MW, the apparent largest battery in the world supporting a 315 MW wind farm—captured $500,000 in grid support revenue in just 15 minutes.

Lessons learned in Australia may not always be directly transferable to other markets. However, they do reveal how open markets can open doors to new opportunities while creating hyper volatility in pricing. The lessons learned also highlight sometimes unforeseen consequences when one moves from staid monopoly constructs to vibrant trading in complex transactions involving multiple stakeholders.

5.2 If Network Value Perspective Wins in Australia, Message May Resonate Globally

A report by Energy Network Australia and CSIRO[7] projects that by 2050 almost two-thirds of all customers in Australia will feature some form of DER, highlighting the DER integration challenge facing Australia and the relative size of the DER integration opportunity to create VPPs and then DERMSs. From the report:

> *Traditional strategies to respond to such exponential growth in DER at the distribution network level include limiting exports from DER to the grid, upgrading the network and reforming tariffs. While important, these approaches affect a large area over a long period, whereas these specific challenges are localized and for very defined periods of the year. These challenges require more active responses…Flexibility and rapid response will be an important operational characteristic as the power system transforms, and distributed energy resources (DERs) such as storage and demand side response can provide competitive sources of energy and system services. Unlocking the potential of DER can smooth the profile of grid demand and increase the utilization network resources, resulting in a more productive and efficient power system for consumers – at both local and whole of system levels.*

[7] Energy Networks Australia and CSIRO, *Electricity Network Transformation Roadmap: Final Report,* April 2017 https://www.energynetworks.com.au/sites/default/files/entr_final_report_april_2017.pdf.

This white paper proposes that the solutions to Australia's (and other countries') DER integration challenges include VPPs and DERMSs. These control and automation platforms generate economic benefits that can be shared by the prosumer and network while solving the reliability issues attached to this new level of complexity challenging distribution and transmission networks.

Section 6
ACRONYM AND ABBREVIATION LIST

AEMO ..... Australia Electricity Market Operator

AI ..... Artificial Intelligence

CSIRO ..... Commonwealth Scientific and Industrial Research Organisation

DER ..... Distributed Energy Resources

DERMS ..... Distributed Energy Resources Management System

DR ..... Demand Response

EV ..... Electric Vehicle

IT ..... Information Technology

MW ..... Megawatt

MWh ..... Megawatt-Hour

NEM ..... National Electricity Market (Australia)

NSW ..... New South Wales

PV ..... Photovoltaic

REV ..... Reforming the Energy Vision (New York State)

US ..... United States

VPP ..... Virtual Power Plant

Section 7

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SCOPE OF STUDY

This white paper was commissioned by Enbala and focuses on the current and future potential VPP and DERMS market in Australia. This is the third in a four-part series exploring how new software control systems can show near-term value within the VPP market and sets the stage for additional applications under a DERMS framework. It is also Part 2 in a series of white papers focused on Asia Pacific markets; the next white paper will focus on Europe. These white papers have been developed in parallel with updates to Navigant Research's overall market forecast of VPP segments.

Navigant Research white papers are designed to be objective, third-party documents. As such, Navigant Research does not endorse any specific company or products.

SOURCES AND METHODOLOGY

Navigant Research's industry analysts utilize a variety of research sources in preparing Research Reports. The key component of Navigant Research's analysis is primary research gained from phone and in-person interviews with industry leaders including executives, engineers, and marketing professionals. Analysts are diligent in ensuring that they speak with representatives from every part of the value chain, including but not limited to technology companies, utilities and other service providers, industry associations, government agencies, and the investment community.

Additional analysis includes secondary research conducted by Navigant Research's analysts and its staff of research assistants. Where applicable, all secondary research sources are appropriately cited within this report.

These primary and secondary research sources, combined with the analyst's industry expertise, are synthesized into the qualitative and quantitative analysis presented in Navigant Research's reports. Great care is taken in making sure that all analysis is well-supported by facts, but where the facts are unknown and assumptions must be made, analysts document their assumptions and are prepared to explain their methodology, both within the body of a report and in direct conversations with clients.

Navigant Research is a market research group whose goal is to present an objective, unbiased view of market opportunities within its coverage areas. Navigant Research is not beholden to any special interests and is thus able to offer clear, actionable advice to help clients succeed in the industry, unfettered by technology hype, political agendas, or emotional factors that are inherent in cleantech markets.

NOTES

Figures are based on the best estimates available at the time of calculation. Annual revenues, shipments, and sales are based on end-of-year figures unless otherwise noted. All values are expressed in year 2019 US dollars unless otherwise noted. Percentages may not add up to 100 due to rounding.

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