NAVIGANT
RESEARCH

WHITE PAPER

Deregulation Drives Virtual Power Plant Expansion in Japan

Expanding VPPs in the Asia Pacific Region: Part 1

Published 2Q 2019

Commissioned by Enbala

Peter Asmus
Research Director

Section 1
EXECUTIVE SUMMARY

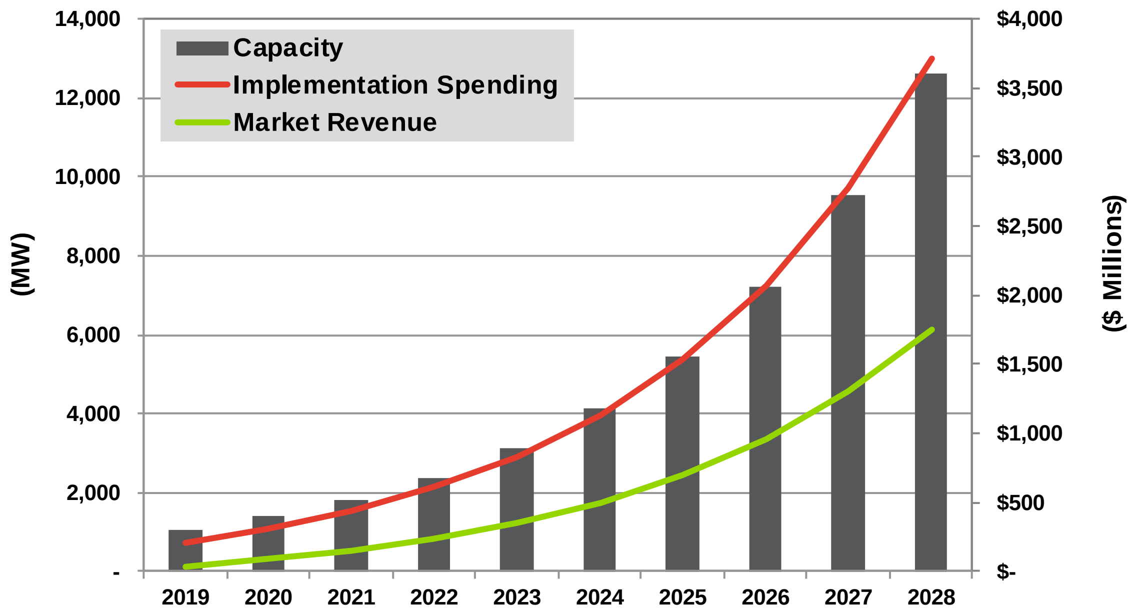
1.1 Japan Market Overview

Japan can be considered the most industrialized nation in Asia Pacific, with geographic, technology, and market dynamics all pointing toward greater reliance on renewable distributed energy resources (DER). Though the market for virtual power plants (VPPs) is nascent in Asia Pacific (see Chart 1-1), it has the potential to grow into a major hotbed of VPP innovation spanning both commercial and industrial (C&I) and residential customers. While Asia Pacific ranks third among major regions for VPPs according to Navigant Research,[1] it is expected to move into second place within the decade. A series of market reforms have set the stage for VPPs and other DER management platforms such as microgrids and DER management systems (DERMS).

This white paper is designed to put Japan's journey from VPPs to DERMS into a regional and global context. Being a series of densely populated and only partially interconnected islands, Japan is a great laboratory for technology and market design innovations. Its dependence on imported fossil fuels and centralized nuclear capacity reflected its isolation from renewable energy resources in the past. Though total renewable generation increased from less than 1 GW in 1992 to approximately 40 GW in 2015, the majority of this total renewable capacity comes from pumped hydro storage. In terms of the VPP market itself, the Asia Pacific region boasts 1,045.4 MW in 2019 and is expected to increase to 12,637.1 MW by 2029, a compound annual growth rate (CAGR) of 31.9%—the fastest growth of any region.

[1] Navigant Research, *Market Data: Virtual Power Plants*, 2019.

Chart 1-1. VPP Capacity, Implementation Spending, and Market Revenue, Asia Pacific: 2019-2028



(Source: Navigant Research)

1.2 Why Japan Is An Emerging Market for VPPs

Japan has limited domestic energy resources that have met less than 10% of the country's total primary energy use each year since 2012. As a result, Japan is the world's largest liquefied natural gas (LNG) importer and ranks in the top four countries for coal imports, net imports of petroleum, and crude oil and petroleum product consumption, according to the International Energy Agency. The country has set a 2030 target to meet its energy needs with following portfolio:

- LNG (27%)
- Coal (26%)
- Renewables (22%-24%)
- Nuclear (20%-22%)
- Oil (3%)

While Japan's renewable energy resources will include larger centralized facilities such as hydro, wind, and solar farms, the biggest challenge may come from customer-owned assets such as rooftop solar PV. The risk-averse nature of the nation's utilities will be tested by its proposed energy transformation. The biggest question mark remains the fallout from the 2011 Fukushima nuclear reactor accident.

Japan faces challenges since it will continue to rely on centralized nuclear capacity—if the nuclear program restart plans come to fruition—and centralized coal-fired capacity. In many ways, Japan seems to be moving in two directions at once: toward greater reliance on market forces and flexible resources while also turning back to its dependence on nuclear power. Strong public opposition to nuclear power and continued delays in restarting this fleet leaves the opportunity for innovation around the grid's edges. This dichotomy and other grid balancing challenges will allow Japan to begin its journey with VPPs, perhaps ultimately landing on DERMS. This journey is expected to be replicated in one form or another around the world.

Despite the country's expected continued reliance on centralized coal and nuclear resources, Japan remains one of the more interesting potential VPP markets in the Asia Pacific region because of its robust grid infrastructure. Much of the rest of the region relies on weak grids (India), lack of vibrant open markets (China), or the absence of traditional grid systems (much of Indonesia).

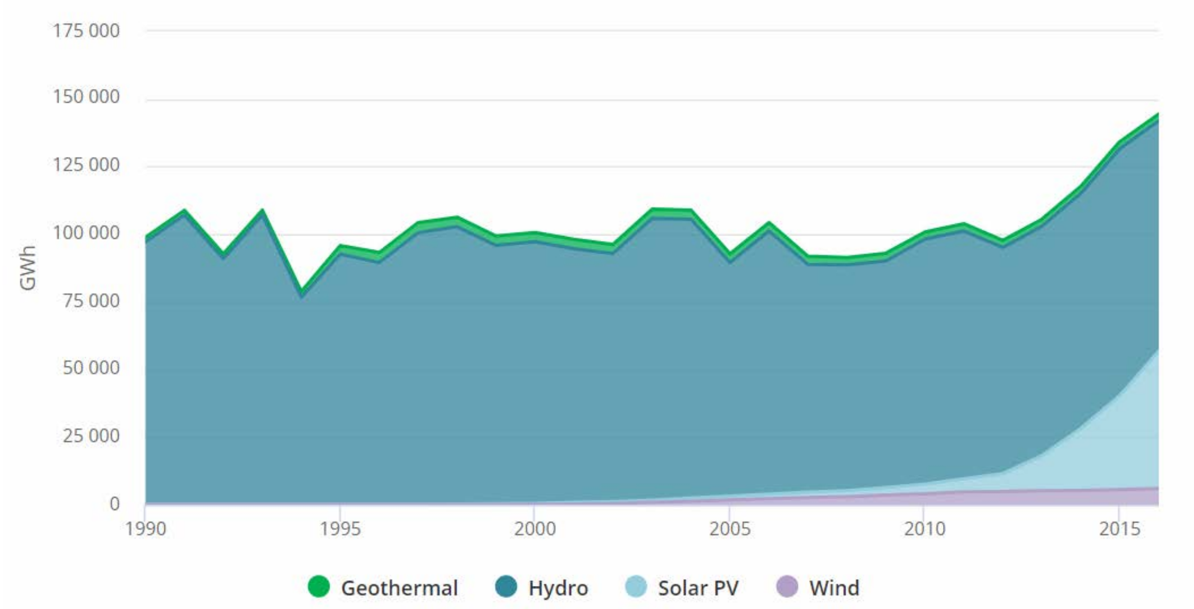
Section 2
JAPAN'S MARKET REFORMS SET THE STAGE FOR VPPS

2.1 Utility and Energy Market Landscape

Unlike most other Asia Pacific markets, Japan's utilities are privately owned. These utilities are heavily regulated and historically have been quite conservative in their approach to resource planning and technology adoption. While Japan consists of 6,852 islands, 10 primary utilities serve the four major islands as well as several other smaller islands.

One exception to Japan's conservative nature was in its adoption of solar PV. The first solar cell was made in Japan in 1955; the first solar panel was connected to the grid in 1978. After launching a rooftop solar PV program in 1992, Japan emerged as the global leader in solar production in 1999 and solar generation in 2004. Though solar PV provided only a small portion of Japan's overall energy supply, it showed that the country's regulators were investigating distributed energy resources (DER) alternatives before other markets globally. Non-hydro renewables provided only 3% of the country's electricity in 2015. Still, solar PV is growing at a rapid pace, as illustrated in Figure 2-1.

Figure 2-1. Electricity Generation by Renewable Resource: 1990-2016



(Source: International Energy Agency)

Prior to the 2011 earthquake and Fukushima nuclear accident, Japan obtained approximately 27% of its electricity from nuclear power. In response to the accident, Japan's nuclear fleet was shut down. The country replaced this significant loss of power generation with imported natural gas, fuel oil, and coal. Substituting generation with more expensive fossil fuels (when compared to nuclear generating capacity) led to higher electricity prices and higher government debt losses for the nation's electric utilities. These dire consequences provided significant momentum to deregulate markets to introduce efficiencies from new technologies and business models.

2.1.1 Retail Deregulation Leads to Explosion of New Suppliers

Since 2016, Japan's retail market features more than 450 retailers, some of which are the retail arms of incumbent utilities. A new power exchange was created in 2005—Japan Electric Power Exchange (JEPX)—which is a primary source of generation resources for these retailers. On a volume basis, incumbent utilities still supply approximately 85% of the country's needs through power purchase agreements (PPAs) with these retailers. Over time, as DER penetrations grow, it will be revealing how the role of JEPX evolves. Will it, like the spot market exchange in Germany as overproduction of distributed renewables threatened grid stability, be a key enabler of virtual power plant (VPP) transactions? Or will the dominant position of incumbent utility supply throttle innovation and slow the pace of reform otherwise possible with smart deregulation?

2.1.2 Harmonizing Centralized and Distributed Power Sources

Like most VPP markets, the easiest opportunities will be tapping large commercial and industrial (C&I) loads for flexibility resources to balance the grid. However, two milestone events on the horizon will open up the Japanese market to VPPs:

- The pace of planned deregulation reforms affecting residential retail customers, opening up opportunities to tap diverse DER to help solve supply and grid constraints
- If regulators and the nuclear power industry are successful in regaining their previous market dominance or if they are thwarted by either public opposition or another accident

Balancing energy and capacity from wholesale renewables, including pumped hydro storage that offers significant flexibility, with DER such as rooftop solar PV is also a balancing act ripe for new VPP applications. This balancing act is multifaceted and requires automation and controls capable of sensing and optimizing both large and small resources, renewables, fossil-fueled technologies, and nuclear power.

2.1.3 Need for Flexibility as DER Portfolio Grows and Wholesale Markets Open Up

The mixed asset VPP model is based on the notion that thousands, if not millions, of diverse DER assets can be fine-tuned in real time to offer bidirectional value to both asset owners and the larger grid. The key issue highlighted by Japan's specific resource mix is the ability to harmonize retail and wholesale resources, allowing first for economic optimization based on capacity needs. Over time, as the country's DER portfolio grows—and uncertainty that may continue to cloud its nuclear power fleet—it will allow for flexibility that can help balance both distribution and transmission systems. VPPs can serve as a bridge between these two previously largely disconnected markets. As DER portfolios reach threshold levels, advanced active power management capabilities inherent in the concept of DER management systems (DERMS) will come into play. These systems will target voltage hotspots and feeder-level issues, ideally with the same platform used to balance the transmission system in the most economically efficient way.

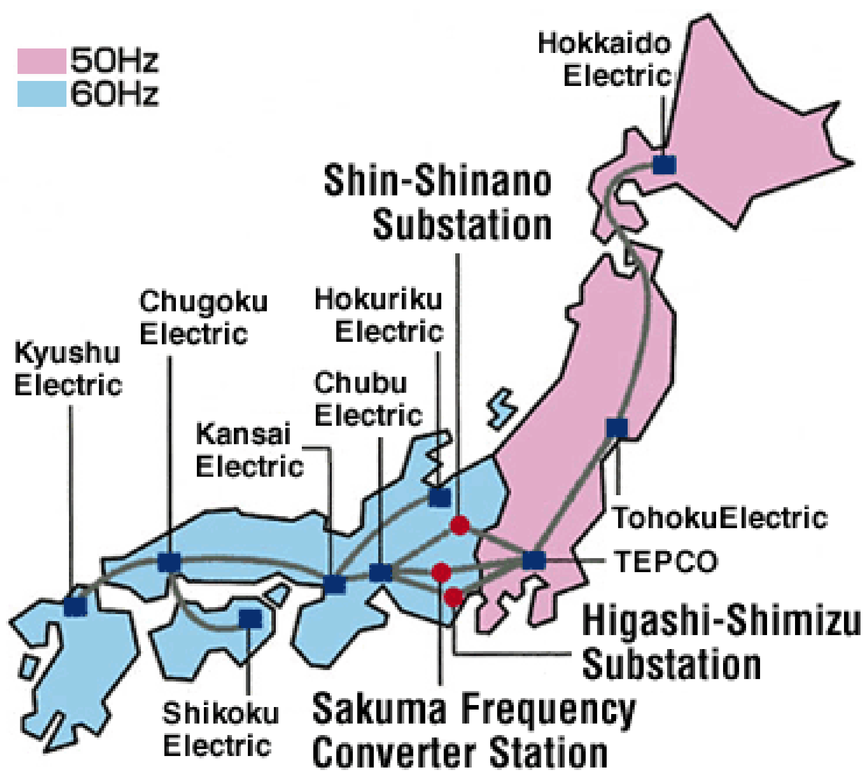
Section 3

HOW JAPAN'S GRID TOPOLOGY SHAPES GRID SOLUTIONS

3.1 Two Grids, One Country

Japan is the only country in the world that operates its power grid balanced on two different frequencies. Tokyo and the rest of the eastern side of Japan installed 50 Hz equipment from Germany, while their counterparts in Osaka and the western side of the country contracted with American companies installing 60 Hz equipment (see Figure 3-1). The end result? A national grid whose two separate grids cannot exchange alternating current (AC) power. This lack of exchange capacity resulted in rolling blackouts during the Fukushima accident. Additionally, Tokyo Electric Power Company (TEPCO), which serves Japan's largest city, cannot access sufficient supplies from the western half of the country, which represent 56% of the nation's installed power supply capacity.

Figure 3-1. Map of Japan's Two Frequency Power Grid



(Source: Tokyo Electric Power Company)

There are three interconnection points where converter stations use high voltage electronics to convert AC into direct current (DC) and then synthesize a novel AC wave to add power to the adjacent power grid. The limitation of transfers is 1.2 GW either way.

Each of the four major islands is only interconnected with the adjacent island, so there is a series of balancing areas that face major constraints. Therefore, each of these balancing areas need to rely on localized resources in a creative way to balance the grid. In short, this grid structure provides an opportunity to deploy first VPPs and then, as DER portfolios increase on the distribution grid, DERMS solutions.

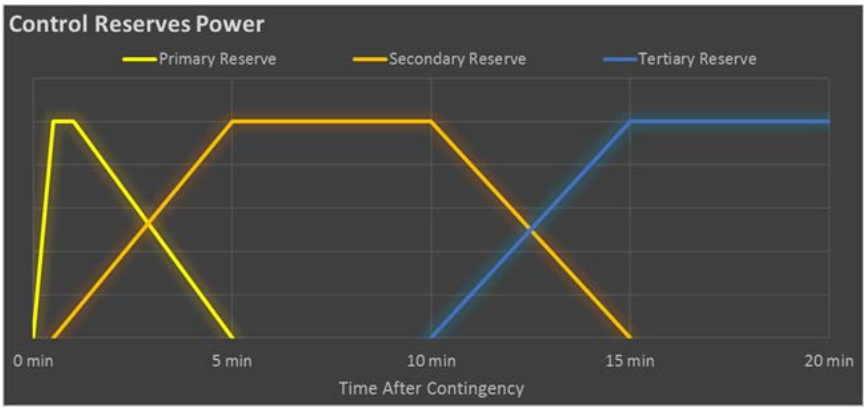
These are some of the basic physical constraints to the grid in Japan. How does the country intend to use new market structures to resolve some of these localized grid challenges?

3.2 Japan's Market Structure Mirrors Other VPP Markets

Japan's Ministry of Economy, Trade and Industry (METI) has been advancing system reforms on the electricity market in Japan. The wide area balancing market will launch in 2020, with the basic design of balancing power similar to other countries. The market will consist of primary reserves, secondary reserves, and tertiary reserves. Resource procurement is projected to commence in 2021.

As shown in Figure 3-2, primary reserves are dispatched automatically in a matter of seconds and are fully activated within 30 seconds after deviated from the reference frequency, whether 50 Hz or 60 Hz. Secondary reserves are remotely controlled to activate fully within 5 minutes to restore frequency back to the reference value. Tertiary reserves are replacement reserves, remotely controlled and activated within 15 minutes. The balancing market will also include Tertiary 2, or low speed reserves, that activate within 1 hour of notification.

Figure 3-2. Activation Times for Control Reserves



(Source: Ministry of Economy, Trade and Industry)

According to METI, the wide area balancing market will begin with the last of these market resources, Tertiary 2, which largely matches many demand response markets that exist in the US. Tertiary 1 and secondary will be traded in the market some time after 2020. There is less need for primary reserves in Japan in the near future, as the focus of VPP software innovation is to address the wide variability in markets where renewables are poised to become the leading source of electricity supply.

3.3 Japan's Retail Market Dynamics

Equally important to these wholesale market changes are the fervent reforms occurring at the retail level. The explosion of retail suppliers (discussed in Section 2.1.1) is just one aspect of this dynamic. Consider the following: 2.5 million homes enjoy lucrative feed-in tariff (FIT) rates for their solar PV production. However, because these payments were only guaranteed for 10 years, 540,000 residential customers will reach the end of their current FIT contracts in November 2019. This trend will continue, with several hundred thousand customers being released from contracts each year moving forward. While attractive, these FIT contracts also prevented these solar PV assets from providing onsite value or more customized grid services.

This market development of releasing customers from FIT payments will create excess power at the retail level and represents a huge opportunity to test market-based solutions. It will create incentives for these homes to optimize production by deploying batteries to store excess solar energy or to potentially buy EVs to soak up excess generation to optimize new forms of self-consumption. Others will simply sell their excess power to a retailer/aggregator that may also participate in VPP transactions. It really is an uncertain future in Japan, so all eyes will be watching on how consumers react. Will they embrace a more active prosumer approach, or will they prefer to be more passive?

Section 4

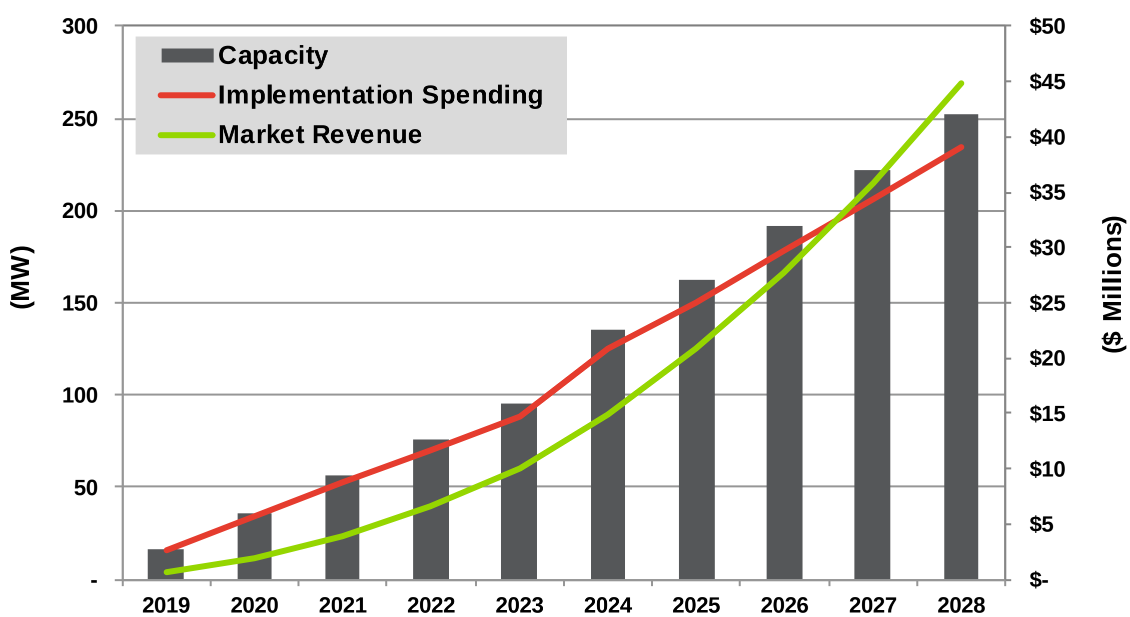
FUTURE VPP MARKET TRENDS

4.1 Despite Reforms, Uncertainty Persists in Japan's Energy Future

Japan is a fascinating market, not necessarily because of its scale but due to its unique grid topology, new deregulation reforms, and the huge uncertainty surrounding nuclear power. While much of the rest of the world is shutting down nuclear reactors due to costs and liabilities, Japan intends to go into the opposite direction. Will it succeed?

Navigant Research's base scenario for VPPs in Japan shows modest future growth, as seen in Chart 4-1. This scenario assumes the nuclear program does move forward with full implementation, and the country continues to rely on coal, liquefied natural gas (LNG), and other resources to meet the 2030 targets. It also assumes that delays in meeting some government targets continue, as has often been the case in the country. Cumulative capacity is projected to exceed 626 MW over the next decade.

Chart 4-1. Annual VPP Market Capacity, Implementation Spending, and Market Revenue, Base Scenario, Japan: 2019-2028

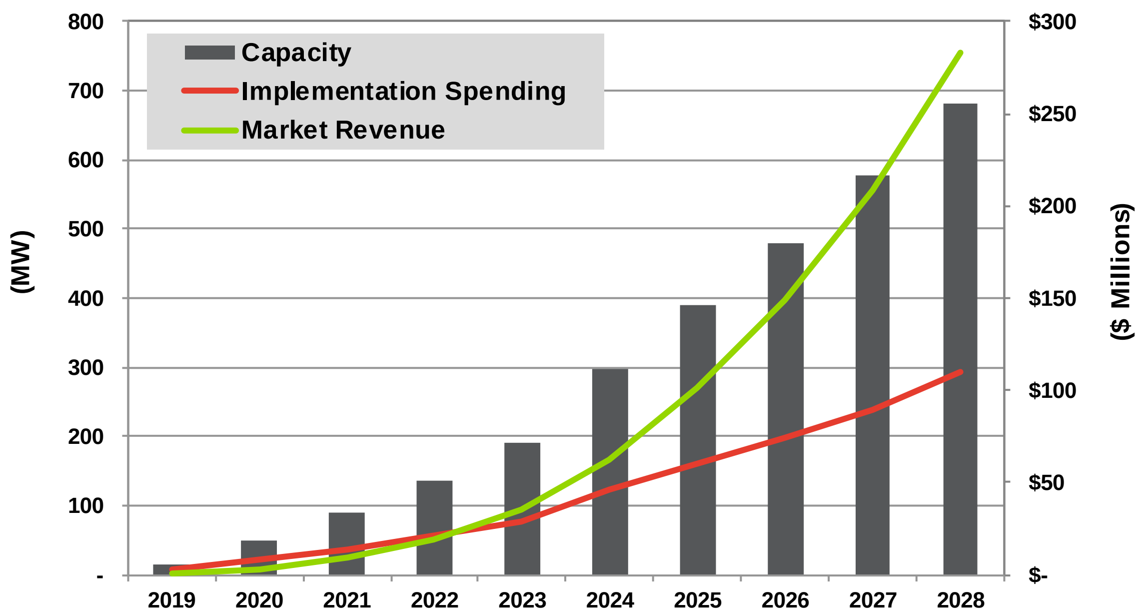


(Source: Navigant Research)

Though this forecast is labeled a base scenario, one could consider this the conservative view. With little track record to go on in terms of managing high penetrations of DER except for an early leadership role in solar PV, the future of the Japanese electricity market is at a major crossroads in terms of its energy future. The conservative nature of its utilities makes it difficult to judge how fast the pace of reforms will progress.

Because of the market's uncertainty given its history of nuclear power as well the growing momentum of VPPs, Navigant Research also developed an aggressive market forecast. The aggressive forecast (see Chart 4-2) assumes the full nuclear fleet does not come back online, more standardized software solution platforms enter the market to reduce cost and go-to-market timeframes, and Japan views VPPs as a key solution to balancing both retail and wholesale markets. In Japan's case, wholesale capacity is balanced with VPPs given the limitations this nation of islands faces in terms of smaller balancing systems and the inability to easily import capacity or export overproduction. Note that in this aggressive scenario, cumulative capacity is anticipated to exceed 2,911 MW over the decade. While the base scenario forecasts annual market revenue of almost $45 million annually in 2028, the aggressive scenario forecasts $283 million during that same year.

Chart 4-2. Annual VPP Capacity, Implementation Spending, and Market Revenue, Aggressive Scenario, Japan: 2019-2028



(Source: Navigant Research)

Section 5

FROM PEER-TO-PEER TO DERMS, JAPAN'S ENERGY FUTURE

5.1 Looking Forward or Looking Back?

Six Japanese consortiums are moving forward with VPP pilots. All told, there are over 40 individual VPP pilot projects underway. Though many of these pilots are modest in scope, they demonstrate significant interest in this platform among both incumbents and startups. These consortiums include retail arms of incumbent utilities seeking to better understand the new energy landscape. Their focus is on retail opportunities, including residents who will be losing attractive FIT payments and will, therefore, see greater value in onsite energy storage. Like Germany, which went through a similar change a few years ago, this could open up the Japanese market to VPPs.

5.1.1 Transactive Energy Trends and VPPs

There is a lot of hype in the marketplace about concepts such as transactive energy, including blockchain technology and its ability to enable peer-to-peer energy trading. Japan is at the forefront of some of these concepts, but they are not the focus of this white paper. Though Navigant Research believes there is possible synergy with peer-to-peer trading within a VPP consisting of residential customers with solar plus storage plus EVs, that opportunity is longer term. VPP operators are essentially resource aggregators that can monetize those assets for the asset owners. In this way, VPPs are a potential stepping stone to a peer-to-peer trading market. The VPP market will instead be led by C&I loads blending with residential solar plus energy storage capacity, creating bridges to new incremental supply and value.

Although the pace of deregulation is a bit slower in Japan than some would like, there is an existing opportunity to combine VPP operation with retail energy sales and control one's own cost structure more effectively. Additionally, such a player can sell excess wholesale electricity to other retailers—essentially a private capacity market. With the JEPX pricing becoming more unpredictable, the VPP platform may be a highly economical means of cornering a supply that can be used today. As the ancillary services markets are formally established over the next few years, the embedded value of the VPP platform will only increase over time.

5.1.2 DERMS Use Cases for Japan

Given the grid topology described in Section 3.1, the DERMS applications in Japan are inevitable. Regions such as Hokkaido (the northern island) have an urgent need, as they have been highly susceptible to grid balance challenges. The abundance of high capacity solar and wind renewables together with relatively low demand has made the grid particularly vulnerable in this region. Blackouts caused by specific natural disasters in 2018 choked transmission capacity and had a domino effect of failures, which caused wild grid frequency swings.

Grid operators will need to integrate with a dizzying array of retailers, requiring precise active power management of the distribution grid. One challenge includes the interplay between slow ramping nuclear and coal and the fast dispatch of DER. The conservative nature of Japan's utilities and their past focus on making rooftop solar PV as dispatchable as possible implies that DERMS is a logical next step in the evolution of automation and control in Japan.

5.1.3 Can Japan Become an Exporter of VPP Solutions?

Because Japan lacked its own fossil fuel supplies, it developed expertise in technologies to refine, import, and transport fossil fuels. The country sought to generate economic development benefits from importing fossil fuels. Can something similar happen by partnering with innovators such as Enbala in the VPP space? Perhaps Japan can become a laboratory of VPP and DERMS solutions that wrestle with its hybrid grid idiosyncrasies, its push and pull between nuclear, fossil, and renewable energy systems, and the persistent push for efficiency. To date, most Japanese vendors have focused on detailed, customized solutions. The key for scalability rests with a different approach: a more standardized platform—such as Enbala's Concerto—that can accommodate diversity while simultaneously reducing implementation costs and timeframes. A flexible platform is where the VPP market in Japan, and elsewhere, needs to go.

Section 6
ACRONYM AND ABBREVIATION LIST

AC .... Alternating Current

C&I .... Commercial and Industrial

DER .... Distributed Energy Resources

DERMS .... Distributed Energy Resources Management System

DC .... Direct Current

EV .... Electric Vehicle

FIT .... Feed-in Tariff

GW .... Gigawatt

Hz .... Hertz

JEPX .... Japan Electric Power Exchange

LNG .... Liquefied Natural Gas

METI .... Ministry of Economy, Trade and Industry (Japan)

PPA .... Power Purchase Agreement

PV .... Photovoltaic

TEPCO .... Tokyo Electric Power Company

US .... United States

VPP .... Virtual Power Plant

Section 7
TABLE OF CONTENTS

Section 8

TABLE OF CHARTS AND FIGURES

Section 9
SCOPE OF STUDY

This white paper was commissioned by Enbala and focuses on the current and future VPP and DERMS markets in Japan. This is the second 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 1 in a series of white papers focused on specific Asia Pacific markets, with the next focused on Australia. 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

CAGR refers to compound average annual growth rate, using the formula:

$$CAGR = (\text{End Year Value} \div \text{Start Year Value})^{(1/steps)} - 1.$$

CAGRs presented in the tables are for the entire timeframe in the title. Where data for fewer years are given, the CAGR is for the range presented. Where relevant, CAGRs for shorter timeframes may be given as well.

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.

Published 2Q 2019

1375 Walnut Street, Suite 100
Boulder, CO 80302 USA
Tel: +1.303.997.7609
http://www.navigantresearch.com

Note: Editing of this report was closed on June 27, 2019.