

Global Microgrid Tour: All Signs Point to Australia

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GLOBAL DER SNAPSHOT: ALL SIGNS POINT TO AUSTRALIA

MICROGRID KNOWLEDGE CONFERENCE

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NAVIGANT

MICROGRIDS ARE PART OF AN EMERGING ENERGY CLOUD MADE UP OF A DIVERSE SUITE OF DER TECHNOLOGIES

- Emerging infrastructure is far more **integrated, dynamic, and complex**

DISTRIBUTED GENERATION (DG)

Includes the generation of electricity from many small energy sources, including renewables; typically mass-produced, small, and site-specific

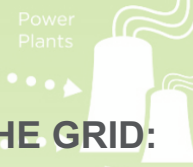


DIGITALIZATION OF THE GRID:

- Smart inverters
- Smart meters
- Advanced sensors, controls, and operation systems
- Behind-the-meter (BTM) technologies and solutions
- Demand response (DR)

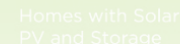
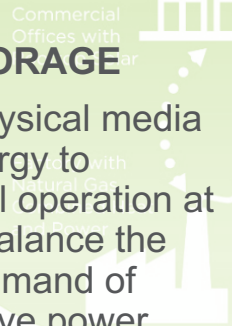
MICROGRIDS AND VIRTUAL POWER PLANTS

Applications or groupings of distributed energy resources (DER) that operate either connected or independent from a traditional centralized grid



ENERGY STORAGE

Devices or physical media that store energy to perform useful operation at a later time; balance the supply and demand of energy; improve power quality



BUILDING ENERGY MANAGEMENT SYSTEMS

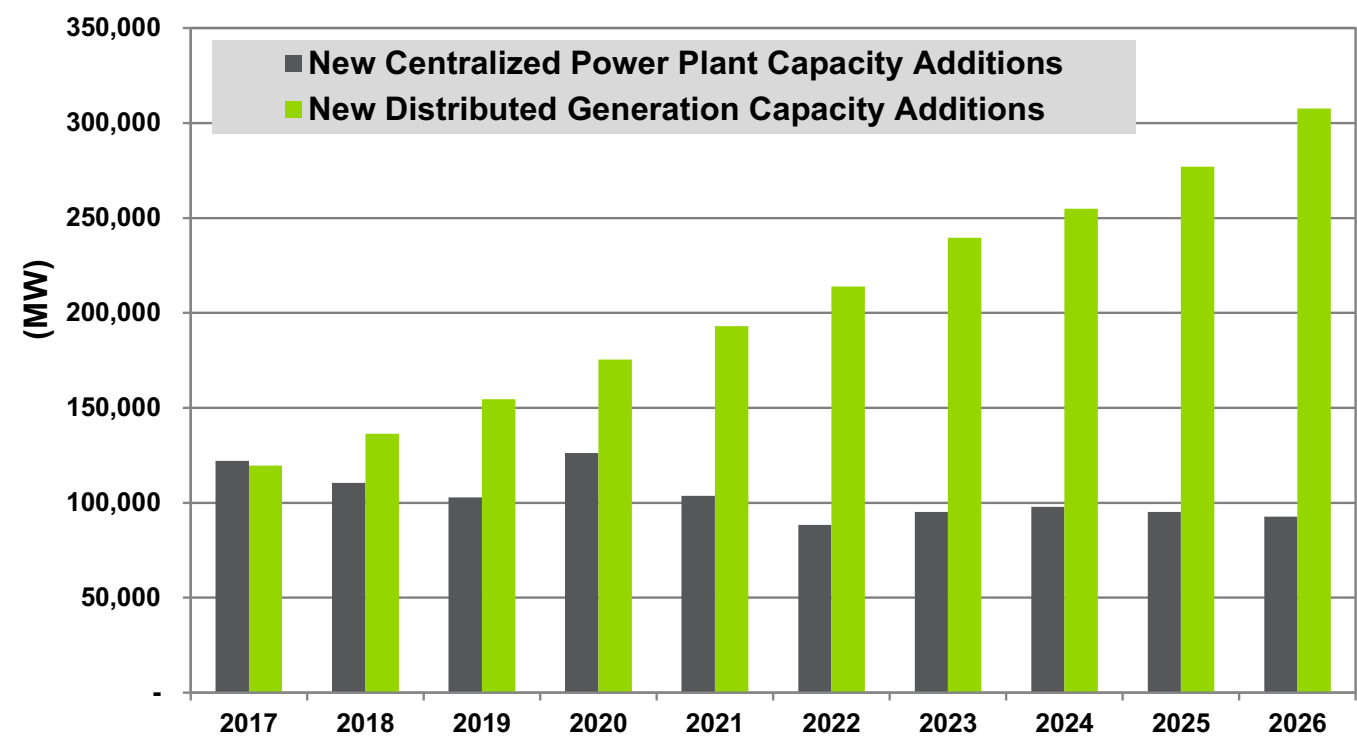
Digital control systems installed in buildings; enables energy efficiency, DR, and automated DR



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DISTRIBUTED VERSUS CENTRALIZED RESOURCES

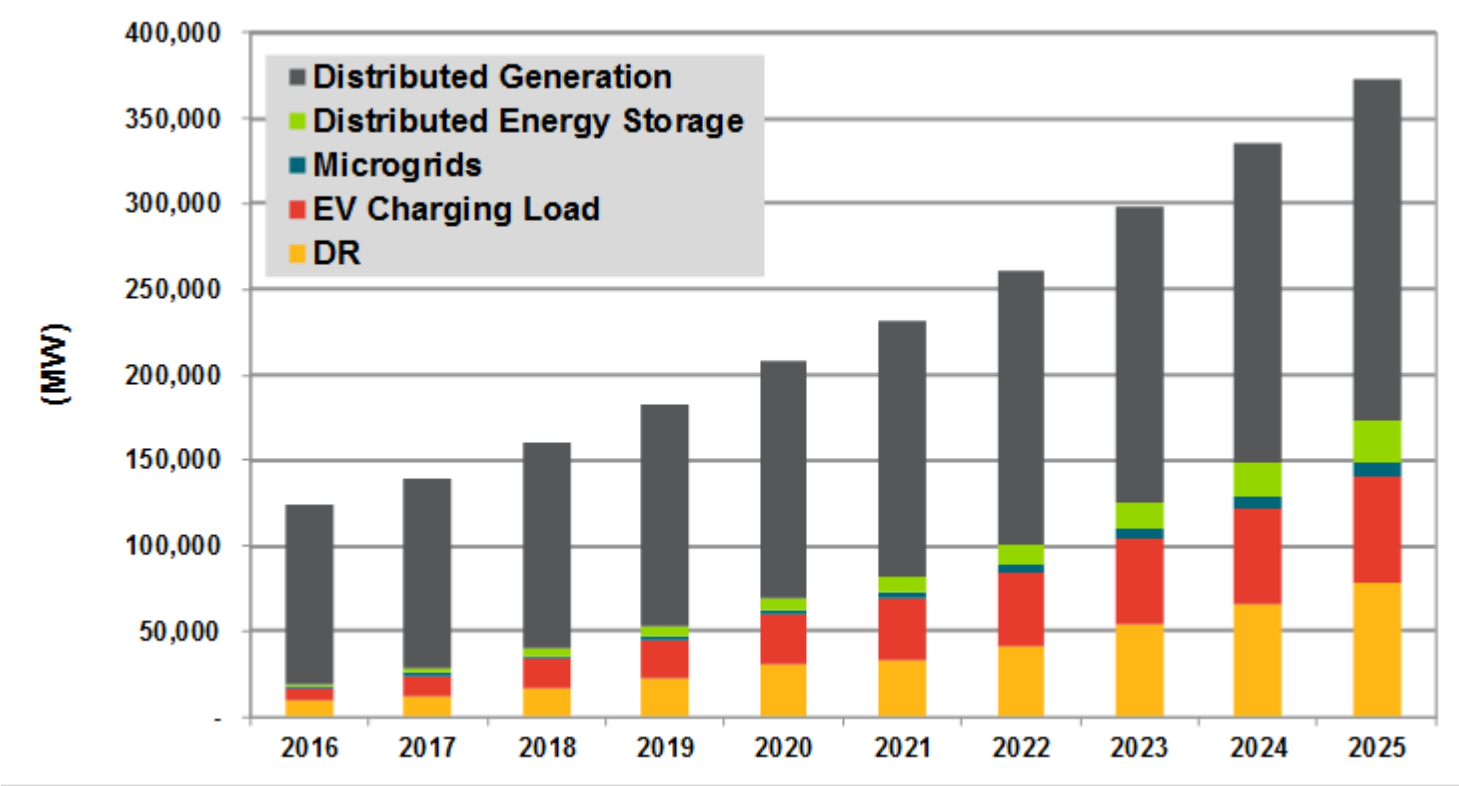
Annual Installed Centralized vs. Distributed Power Capacity, World Markets: 2017-2026



(Source: Navigant Research)

DER PORTFOLIO IS DIVERSE AND GROWING

Annual DER Capacity, World Markets:
2016-2025



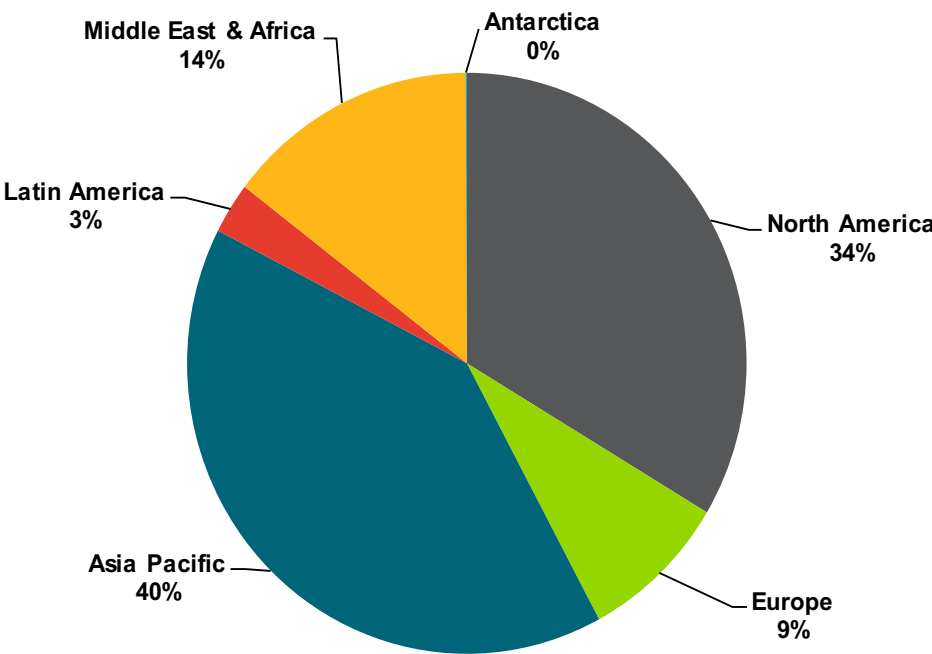
(Source: Navigant Research)



GLOBAL MICROGRID MARKET SUMMARY

MICROGRID DEPLOYMENT TRACKER: CUMULATIVE IDENTIFIED PROJECT AND PORTFOLIOS BY REGION

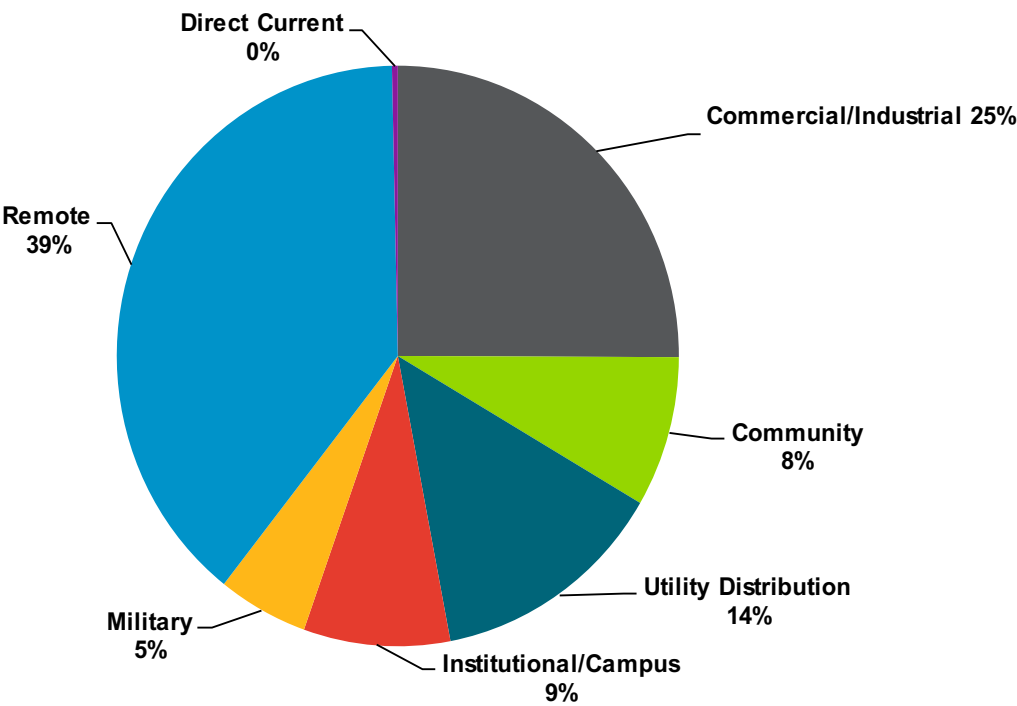
Total Microgrid Power Capacity Market Share by
Region, World Markets: 4Q 2017



(Source: Navigant Research)

TRACKER: REMOTE MICROGRIDS GLOBAL SEGMENT LEADER

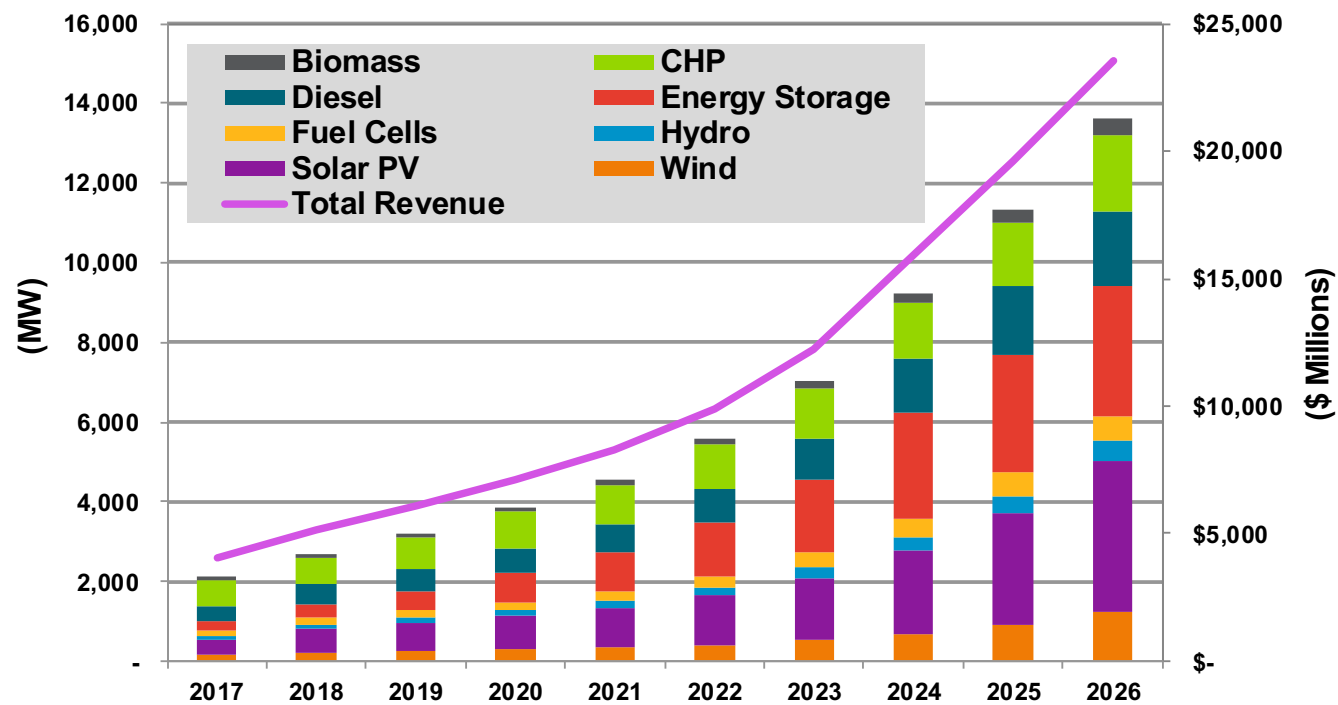
Total Microgrid Power Capacity Market Share by Segment, World Markets: 4Q 2017



(Source: Navigant Research)

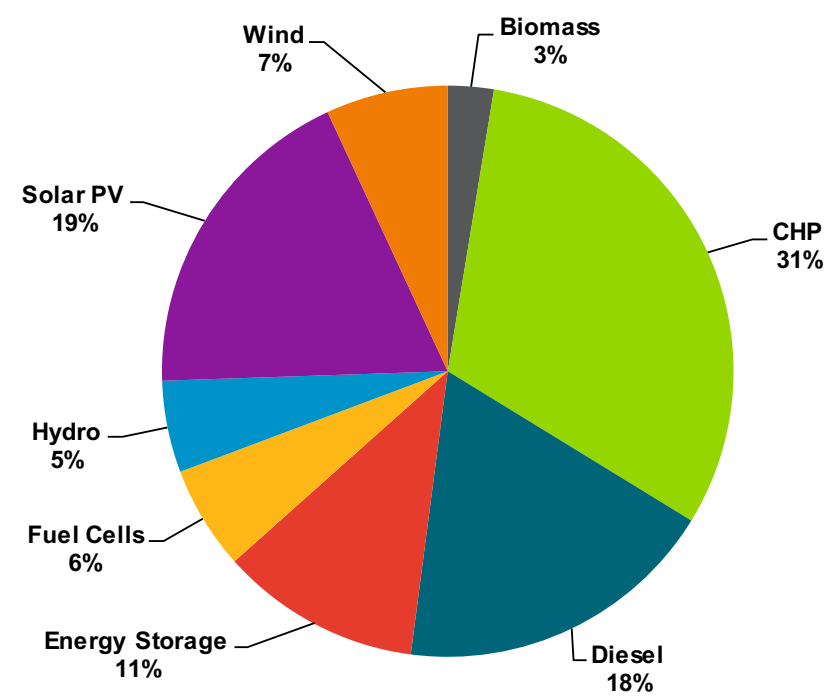
MICROGRIDS: DER GROWTH TRENDS

Selected Microgrid DER Capacity and Spending, World Markets: 2018-2027



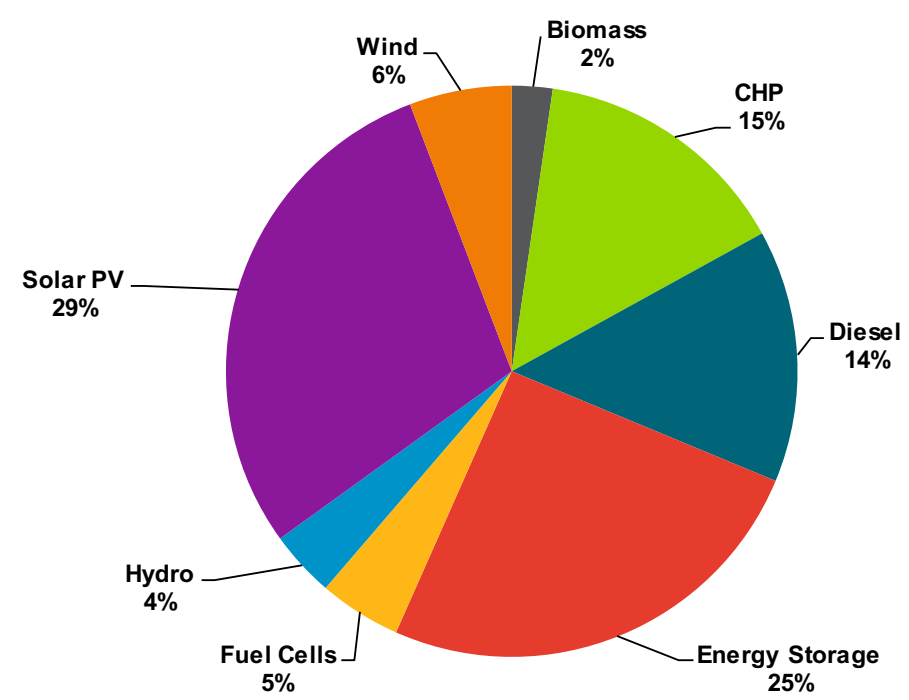
(Source: Navigant Research)

DER Technologies in Microgrids, World Markets: 2017



(Source: Navigant Research)

DER Technologies in Microgrids, World Markets: 2027



(Source: Navigant Research)

NOTABLE DER MICROGRID TECHNOLOGY TRENDS

- Microgrids incorporate a rich diversity of DER on the generation side, but can also incorporate DR, EVs, and various loads
- CHP was the leading DER choice in 2017 (655 MW), followed by solar PV (392 MW) and diesel (385 MW)
 - All eight DER categories represented \$4 billion in asset value in 2017
- By 2026, the DER landscape shifts away from fossil fuels
 - Solar PV jumps to lead with 3,786 MW annually
 - Energy storage is next with 3,292 MW annually
- Solar PV ranks as the top DER investment target for microgrids, with annual spending reaching virtually half of all DER microgrid investment by 2026 at \$6.7 billion
 - Energy storage spending follows at \$4.5 billion
- By that same date, annual spending on all DER increases to nearly \$23.6 billion
 - That growth represents a 21.7% compounded annual growth rate (CAGR)
- DER assets wrapped into microgrids worldwide represent \$112 billion in cumulative spending over the next decade



SPOTLIGHT ON AUSTRALIA

WHY AUSTRALIA?

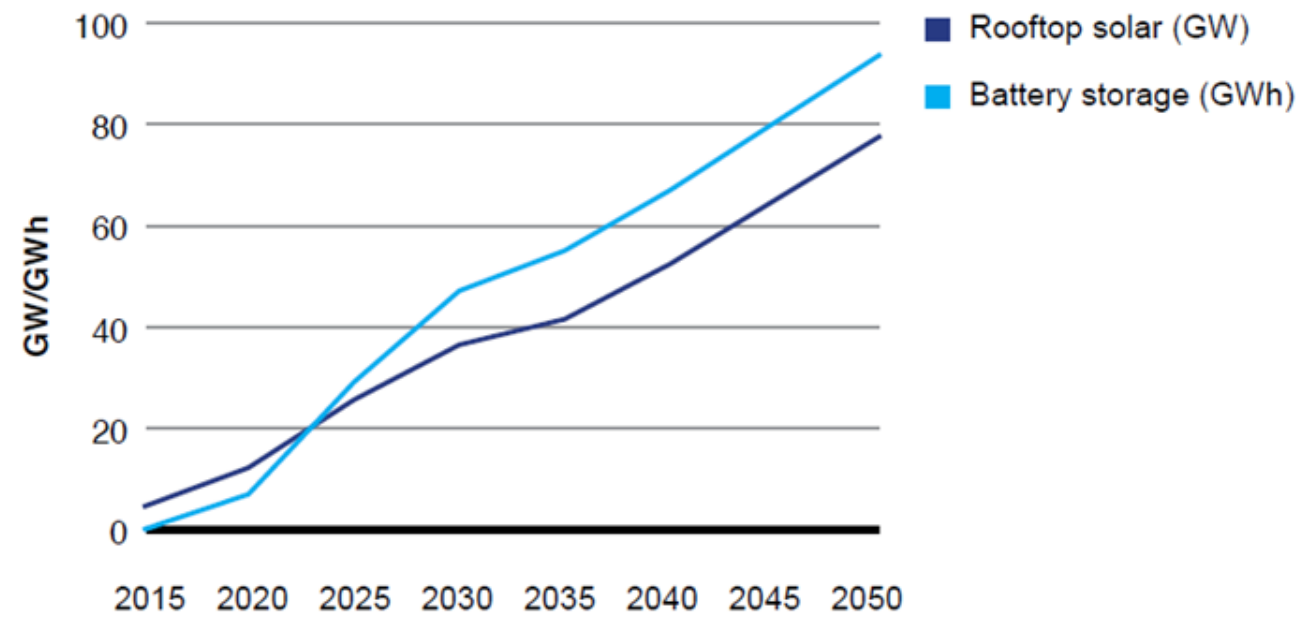
- Australia's consumers boast one of the highest per capita consumption rates of electricity in the world (even greater than the US)
- Despite a modern industrialized economy, Australia also features a high reliance upon remote, off-grid microgrids for basic electricity service
 - Many of these microgrids are relatively large in size and feature advanced automation and control technologies
- Horizon Power, a nationalized utility serving western Australia, boasts the largest utility service territory in the world—the size of five California's!
 - It also features the lowest customer ratio per square kilometer to be found in any utility service territory (1 for every 53.5 km²)
- Australia features the highest percentage (+15%) of households with rooftop solar PV, 85% of which are smaller than 10 kW in size
 - Small-scale solar plus energy storage systems doubled between 2016 (1,566 systems) and 2017 (3,763 systems)
- All told, 1.25 GW of solar PV was installed in Australia in 2017, a capacity record for the country

WHY NOW?

- Australia is emerging as one of the top markets for DER aggregation and optimization platforms
 - In the past, and today, the country is a leader in remote microgrids
 - Wind-diesel systems dominated the past
 - Solar-battery systems are the current focus
- Growth in DER, changes in regulations, and a need for trading platforms have transformed Australia into a hot market for virtual power plants (VPPs)
 - Sunverge moving forward with 5 MW VPP (solar plus battery storage) with 1,000 homes
 - Tesla announced in February 2018 the world's largest VPP with 50,000 homes
 - GreenSync trading platform used in control areas throughout the country
 - Audrey Zibelman, formerly of PJM, Viridity Energy, and New York PSC, is heading up the Australian Energy Market Operator
- Australia has opportunity to showcase how the diversity of DER management platforms can address both physical grid and market transactional aspects of the Energy Cloud
 - Global vendors are seeking opportunity in Australia (ABB, Siemens, etc.)
 - Australian vendors are also seeking opportunity elsewhere (Power Ledger and GreenSync)

SOLAR AND STORAGE GROWTH TRENDS IN AUSTRALIA

Rooftop Solar PV and Battery Storage Adoption: 2015-2050



(Source: Energy Network Australia-Commonwealth Scientific and Industrial Research Organization)

MICROGRID CASE STUDY: HORIZON POWER

- Horizon Power is the only utility in the world to commit to being “the world’s best microgrid company”
 - This is noteworthy since its focus is on remote microgrids not interconnected to traditional utility distribution networks
 - It views DER integration as vital to its goal to reduce government subsidies for the provision of electricity
 - It met its target of a \$100 million reduction in government subsidy in the current 2017-2018 budget cycle
- Australia’s only vertically integrated utility, Horizon Power, is looking to incentivize solar deployment in areas of greatest benefit to its disaggregated utility system
 - It has also implemented variable solar generation buyback arrangements to encourage solar deployment in areas with higher electricity prices with rates varying between 10 c/kWh and 50 c/kWh
- The utility thinks big; if approved, Horizon Power’s proposed merger with NTPWC would result into roughly 200 remote microgrids all managed by a single entity
 - The utility is focused on O&M fleet optimization, seeking to explore market opportunities in other countries, starting with Indonesia

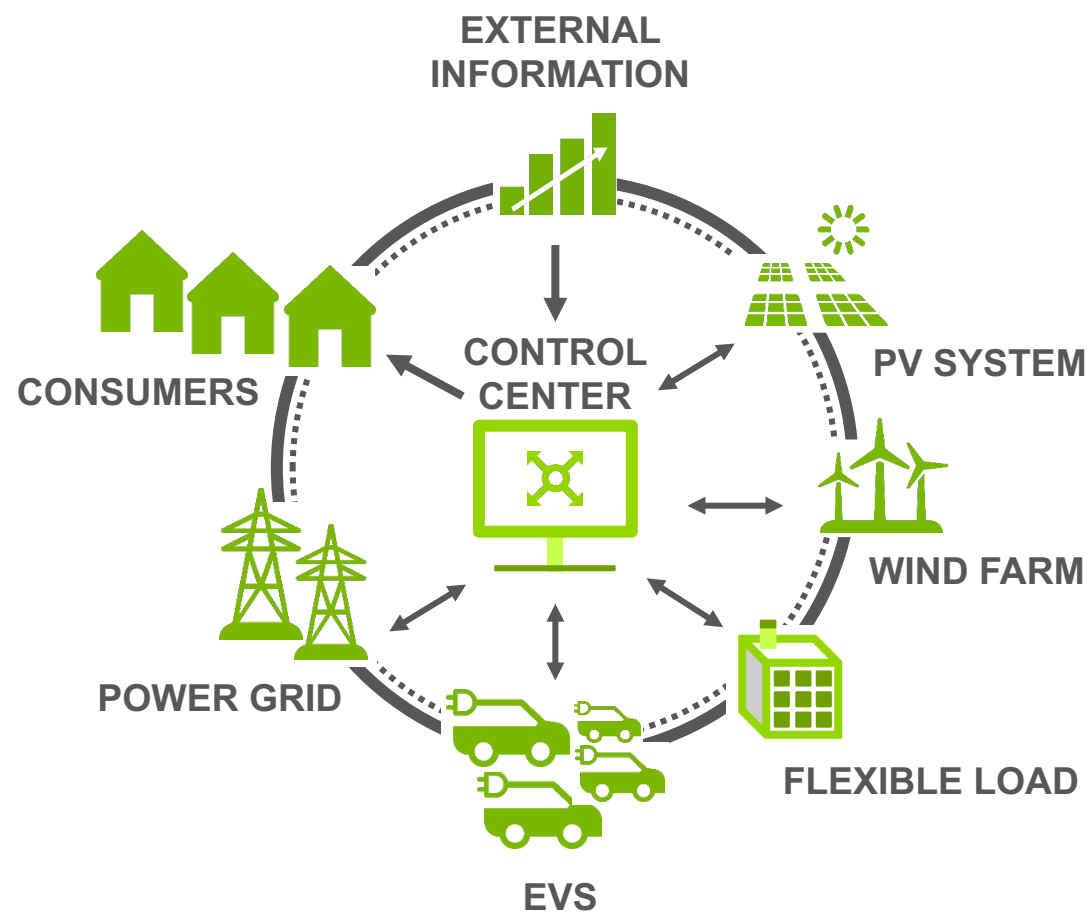


VIRTUAL POWER PLANTS

WHAT IS A VIRTUAL POWER PLANT?

- There is no official government definition of a VPP, Navigant Research therefore came up with its own definition:
“A system that relies upon software and a smart grid to remotely and automatically dispatch retail DER services to a distribution or wholesale market via an aggregation and optimization platform.”
- Navigant Research divides the VPP market into three segments:
 - **DR VPPs:** Peaks in demand can be met by ramping down loads in real-time instead of firing up peaking power plants; this is the largest commercial segment in the US
 - **Supply-side VPPs:** Largely pioneered in Europe, a portfolio of diverse renewable generation mimics services provided by a conventional, 24/7 coal or nuclear plant
 - **Mixed-asset VPPs:** This segment represents the epitome of a VPP—it is a platform where any node on the grid represents a potential solution to both grid pool supply and reliability challenges
- The mixed-asset VPP is quickly emerging as the market leader due to major advances in software functionality and control of DER

VPP: CENTRALIZED CONTROL OF DIVERSE DER



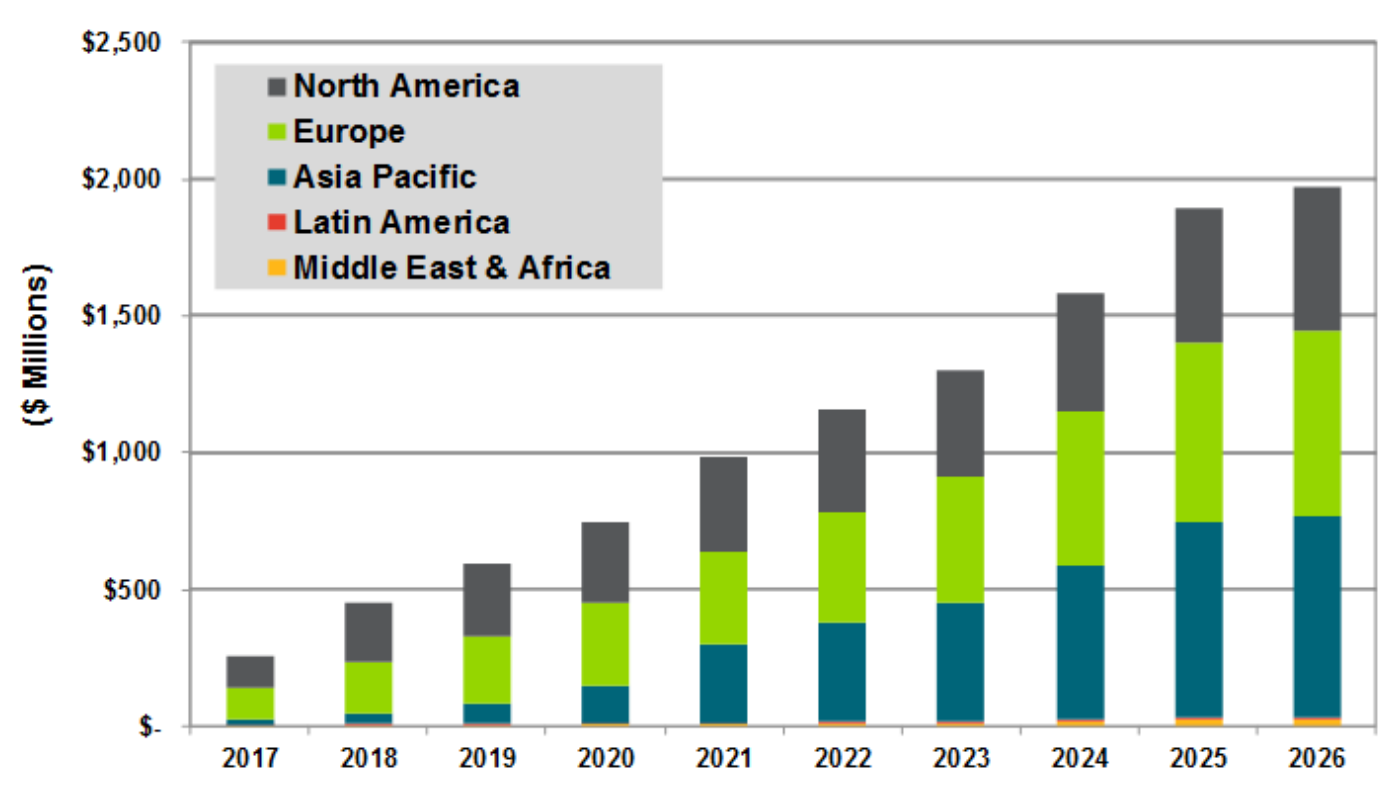
(Source: Navigant Research)

WHAT IS THE VPP VALUE PROPOSITION?

- The virtualization of energy services reduces capital costs, boosts efficiency, and harnesses advances in software to create a more flexible and resilient power grid
- Among the benefits attached to a VPP are the following:
 - Load diversity as a flexible resource pool
 - Fast-acting ramp rates for a diversity of DER to address physical grid challenges
 - No more not-in-my-backyard issues
 - Low capital costs, but high value grid services
- VPP value linked to Metcalfe's Law and the so-called "network effect"
 - The greater the number of assets aggregated into a VPP, the greater the value that VPP can deliver to the connected users individually and to the grid as a whole
 - The larger the pool of available assets that can be scheduled and controlled for any particular grid service, the closer one can get to capturing the maximum potential value from a network of assets
- As fleets of diverse DER grow over time, it is the basic principles of Metcalfe's Law that underscores the value of mixed-asset VPPs
 - And one could argue microgrids that integrate diverse DER also benefit from this basic principle

ADVANCED SOFTWARE IS THE KEY DRIVER FOR VPPS

VPP Software Revenue Streams, World Markets: 2017-2026



(Source: Navigant Research)



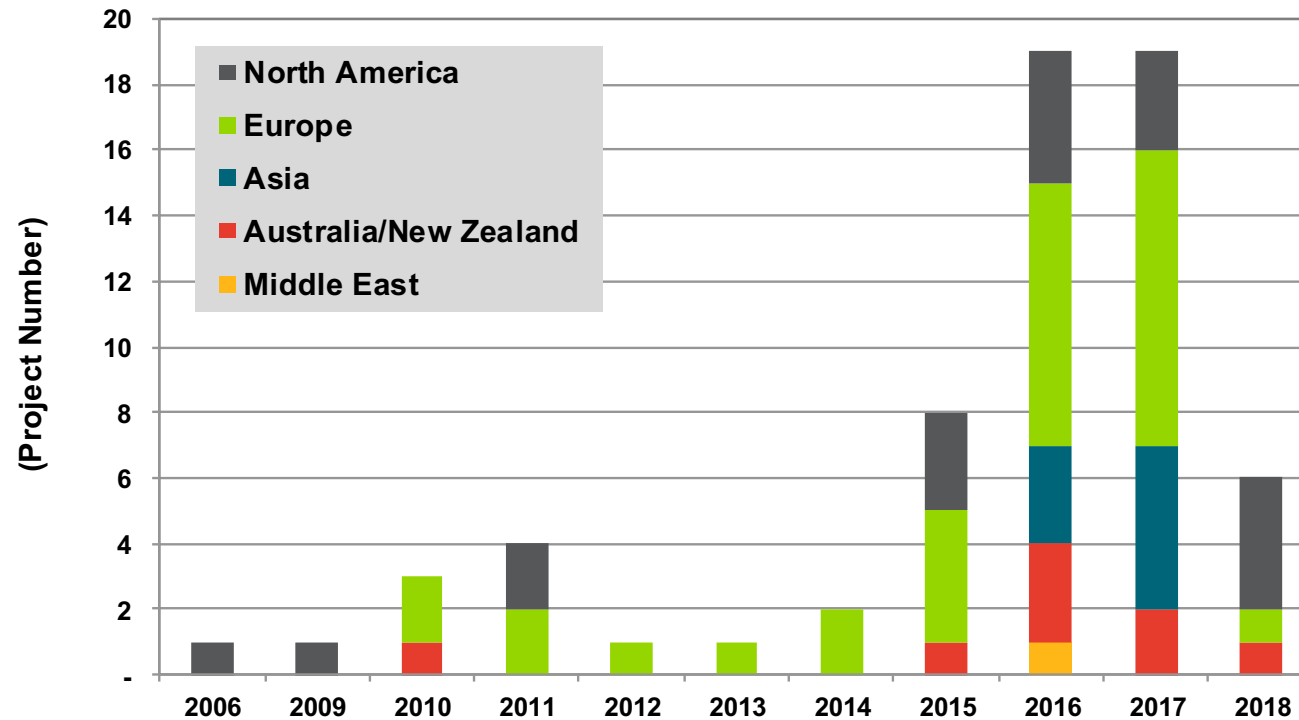
TRANSACTIVE ENERGY

WHAT ABOUT TRANSACTIVE ENERGY?

- While there is no official government definition of a VPP, the concept of transactive energy (TE) is clouded by even more uncertainty
- TE essentially enables DER owners to trade electricity on the open market
 - While TE is at an early stage, initial trials have focused on small-scale solar PV installations
- TE is a way of economically rewarding solar and other DER owners for their excess energy, which negates the need for feed-in tariffs or other incentive schemes
 - As a result, TE more accurately reflects the output of power onto networks and does not rely on cash generated by green levies on every electricity customer's bill (note that these basic goals align with the goals of VPPs)
- TE requires the free communication of information among parties, allowing them to exchange energy services, no matter where they are on the energy supply/demand value chain
 - The notion of peer-to-peer transactions is where some conflict arises in the definition of TE itself and with VPPs
 - Navigant Research believes TE will integrate with VPPs over time and as market rules evolve

A GLOBAL TRANSACTIVE ENERGY TIMELINE

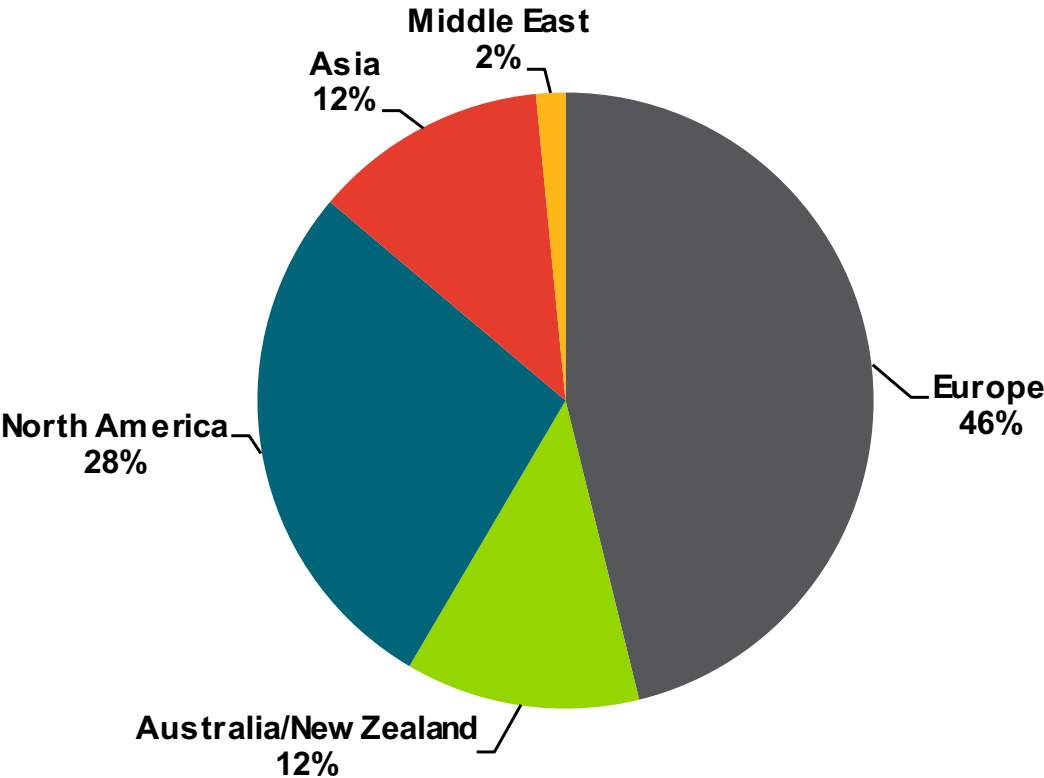
Annual Tally of Global TE Pilots by Region and Country: 2006-2018



(Source: Navigant Research)

12% OF PILOTS TO DATE IN AUSTRALIA-NEW ZEALAND

Market Shares of TE Pilots by Region, World Markets: 2018



(Source: Navigant Research)

TE PLATFORMS: AT THE HEART OF A MICROGRID UTILITY?

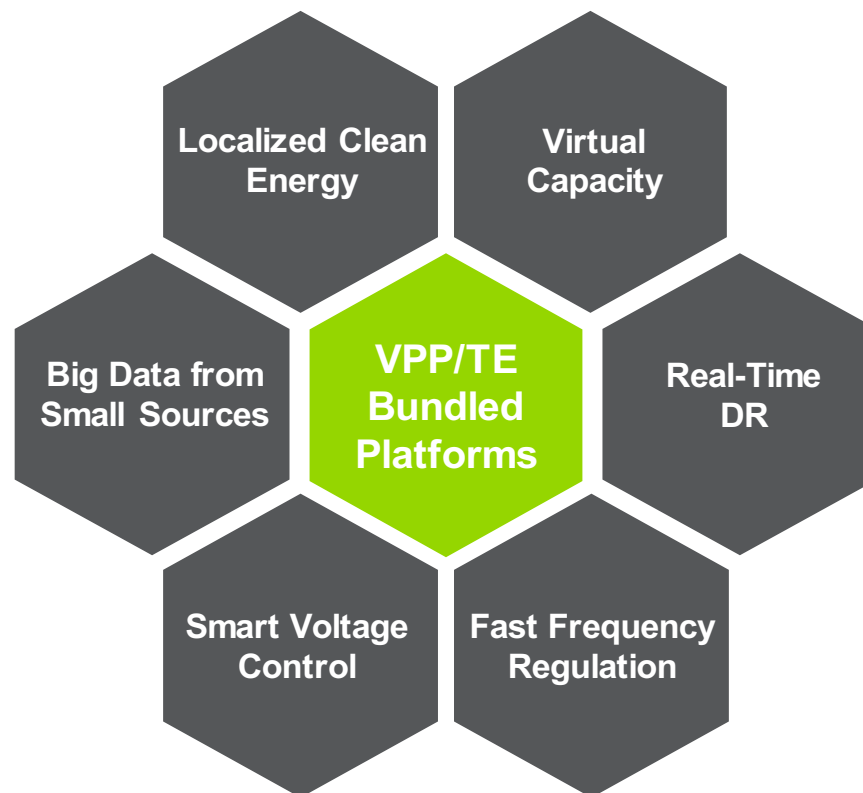
- Horizon Power's goal of creating a for-profit (but customer-centric) utility that maximizes local renewable generation translates well to TE
 - In this case, note that TE would be integrated to stimulate solar PV adoption in remote microgrids originally powered by centralized diesel generators
- A TE platform will help maximize the use of new and existing customer-owned or hosted generation, storage, and DR resources
- With the right regulatory framework—customers must be permitted to buy and sell electricity at intraday market rates—it will become an important driver for the adoption of subsidy-free solar
- A TE platform will enable rural communities to:
 - Shift more quickly from all diesel systems to renewable hybrid systems while reducing the overall cost of ongoing operations
 - Catalyze the adoption of solar plus storage technologies
 - If coupled with a smart network, a TE platform could create an environment more amenable to DR
 - Create a more customer-centric electricity system to generate local economic development, setting the stage for additional services that help build the resilience of communities

HOW DO THESE POTENTIAL TE SERVICES IMPACT VPPS?

- TE could turn the utility business model on its head, placing the customer at the heart of the energy market and disrupting traditional generation/grid relationships
- TE projects are all early stage, but interest in the subject is growing
 - Regulatory hurdles remain significant in the near term
- Regulators, solar and storage vendors, utilities, and new entrants are starting to look at how TE can maximize residential customers' investments into solar PV and electricity storage technologies
- A TE market that allows prosumers to sell their power into a market at spot prices could lead to compelling, subsidy-free residential energy services, garnering the support of utilities and other incumbents
 - TE may also call into question utility demand charges, exit fees, etc.
- Piggybacking on VPP deployments already taking hold in North America, Europe, and Asia Pacific, TE will only accelerate the shift to a mixed-asset VPP model
- An integrated VPP/TE offering may be the most compelling way to accelerate movement to the aggressive Energy Cloud scenario, with the tipping point for success likely occurring between 2026 and 2030

VPP + TE = AGGRESSIVE ENERGY CLOUD ADOPTION

Six Revenue Streams from Bundled VPP/TE Platforms



(Source: Navigant Research)



CONCLUSIONS

AUSTRALIA'S MESSAGE: STAY CONNECTED IF YOU CAN

- According to the Commonwealth Scientific and Industrial Research Organization, Australia has more than 140 remote community microgrids operating independently of the major national grids
 - Horizon Power is the global market leader among utilities exploring new business models in the remote microgrid space
 - ABB is the leading vendor in Australia in terms of larger-scale remote microgrids
 - Optimal Power Solutions is also a global leader in this space, having deployed 1,900 microgrids in Australia, Indonesia, Malaysia, India, Japan, and China
- A study looking out to 2050 by the Energy Network of Australia found the following benefits to energy ecosystem stakeholders with rapid uptake of DER, but prosumers remaining connected to the grid network:
 - A reduction in cumulative total expenditures for electricity services of over \$100 billion
 - Network grid operators pay customers with DER \$2.5 billion annually for grid support services by 2050
 - A medium-sized family without onsite DER pays \$600 less per year for electricity due to removal of cross-subsidies



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