MAT Submission 30

Inquiry into Microgrids and Associated Technologies in Western Australia

Horizon Power's Submission to the Economics and Industry Standing Committee

April 2018

HORIZON POWER
energy for life

Nullagine Solar Power Station

Contents

Executive Summary

Electricity systems and their regulatory frameworks in Australia have experienced mostly gradual, incremental change over the last hundred years. Electricity has flowed in one direction, from centralised generation to blissfully unaware consumers who have not given electricity a second thought. Tariffs have been uniform and reflective of the cost structures of a centralised, fossil fuel electricity system which was expected to see sturdy, year on year growth and captive customers.

Australia's electricity systems, however, are now confronting the most transformational period of change since Edison and Tesla kick started the industry in the late 1800's. Historically high retail electricity prices, the widespread adoption of distributed energy resources (DER), such as solar panels and energy storage, energy-efficiency efforts, and declining asset utilisation rates are simultaneously driving profound change.

Australia's electricity system operators are now recognising that by 2022, whole regions of our electricity system must be capable of operating securely, reliably and efficiently with 100 per cent of instantaneous demand met by DER. Located at the polar opposite end of the system from traditional centralised generation, these DER include dispersed renewable and non-renewable generation, energy storage and demand response devices located at customer premises or connected directly to the low voltage distribution network. Not only does this phenomenon present monumental technical challenges, it also places unparalleled stress on regulatory frameworks, pricing structures, and business models that were all designed for an entirely different time.

At a high level, this transformation is being driven by the combined forces of the three D's: decentralisation, digitisation, and decarbonisation. From a whole-of-system standpoint, the transformation is occurring in an increasingly ad hoc, and at times chaotic manner, disrupting traditional business models. This is because traditional incentives were never designed to encourage customer DER investments that support whole-of-system optimisation and our electricity systems are now increasingly being stretched beyond their original architectural boundaries.

These changes, also being experienced around much of the world, are driving the need for entirely new system architectures designed to harness the full potential of a high-DER future. In this context, Horizon Power is leading the development of 'advanced', microgrids[1] as a fundamental building block of low-cost, high-DER electricity systems. Advanced microgrids achieve this by maximising reliance on intermittent renewable generation, better balancing supply and demand, reducing

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1 Advanced microgrids – digitised grids integrating loads that derive the majority of their energy from DER

extreme peak demand, and increasing service reliability. Advanced microgrids are powered by integrating centralised power generation with high levels of DER (30 per cent or more), either located on customer sites or directly connected to the distribution network. They enable customer DERs to provide optimisation services to the grid in exchange for a financial benefit and support energy trading between customers.

At the heart of the advanced microgrid lies the distributed energy resources management system (DERMS), designed to manage and optimise the technical operations of thousands of grid-connected DER to dynamically manage supply and demand, maintain system stability and optimise long-term economic efficiency. Horizon Power is currently focused on developing and adapting these systems in its portfolio of microgrids.

The transition of energy systems from a centralised to decentralised model is similar to refurbishing a plane while flying it: complex and risky.

At the same time, the economics of new energy technologies are also enabling thousands of remote electricity customers to be shifted to a more economically-efficient solution. In this context, Horizon Power is focused on the development of 'micro power systems' (MPS which are off-grid, utility-scale power systems) as a new utility asset class that provides remote customers with a full electric utility service, only without requiring a 'poles and wires' network connection. Distinct from privately-owned off-grid power systems, they are fully integrated across all utility back-office systems, designed for multi-decade life cycle efficiencies and capable of being fleet-managed by utilities. The economic driver for their adoption is also triggered by a utility, mostly as part of annual network asset management and in consultation with customers who must be assured by the utility of reliability and security.

The transition of energy systems from a centralised to decentralised model is similar to refurbishing a plane while flying it: complex and risky. With decreasing utilisation and the rise of DER, the value of network businesses will inevitably continue their decline while they progressively transform at the distribution level to accommodate increasing levels of DER and microgrids.

The legislative and regulatory frameworks built for the centralised model need to adapt to the proliferation of DER. This is articulated by cultural anthropologist Gretchen Bakke, "the grid, then, is built as much from legal frameworks as from steel, it runs as much on investment strategies as on coal, it produces profits as much as free electrons"[2]. Hence, to navigate the labyrinth of legislative change is daunting without a future-focused compass.

With decreasing utilisation and the rise of DER, the value of network businesses will inevitably continue their decline while they progressively transform at the distribution level to accommodate increasing levels of DER and microgrids

The rise of connected and coordinated distributed systems, or advanced microgrids, is an opportunity to reset the regulatory framework for fair and sustainable customer and shareholder protection in a highly distributed world. Several initiatives for this purpose have started around the world and may provide a base for the transformation required in Western Australia (WA). In the National Electricity Market (NEM), the Energy Networks Association (ENA)

[2] Bakke, G. The Grid: The Fraying Wires Between Americans and Our Energy Future. New York: Bloomsbury USA, 2016, p. 13.

and the Commonwealth Scientific and Industrial Research Organisation (CSIRO) have started this thought leadership, defining different end-states (all largely distributed), a network transformation roadmap and regulatory path that can be followed , but nothing of that nature has been developed for WA. Several states in the US have also defined a roadmap for long-term network transformation. Although they share a goal to accommodate very high levels of DER, their strategies for getting there are different, in particular concerning whether the distribution system operator (DSO) should only facilitate the take-up of DER as a public service or also participate in the competitive provision of DER.

WA is well suited to a microgrid-focused approach to managing this transition. Its vast geography, dispersed population, and generally high costs to supply are conducive to energy systems that must deliver power in a variety of conditions to a range of customers, many of whom are isolated and not connected to the larger grid. WA also has two large interconnected networks where the dynamics of wholesale markets have not yet been linked to DER pricing and services.

Horizon Power owns and operates 37 microgrids, eight MPS, and a large interconnected system in the North West, with plans to develop these into high-penetration, advanced DER systems and mitigate expensive network replacement and augmentation. Similarly to Hawai'i's utilities, Horizon Power has pushed efficiency in the management of its portfolio of microgrids as far as it can and now must turn to new technologies to further decrease costs.

Horizon Power believes microgrids, and in particular high DER microgrids, present the State with further opportunities that support Government strategy of reducing State debt and creating new jobs.

With advanced microgrids, Horizon Power can reduce the cost of electricity in WA and develop new revenue streams from exporting its microgrid expertise. The energy transition underway has already proven to be a major source of job creation around the world, with renewable energy jobs in California already employing more people than the coal industry across the United States (US). A comprehensive shift to microgrids will create new jobs and facilitate the transition of the existing workforce to highly sought-after skills. Based on the experiences of California and plans from other nations, at the scale of WA, a strategic thrust into clean energy would translate to a bold goal of creating 50,000 jobs by 2030 in the industry. WA's unique circumstances means that, in addition to State debt reduction and direct job creation benefits, a coordinated policy could reduce costs to consumers and industry and add to indirect economic development, consumer spending and overall job creation.

Fitzgerald River National Park
Stand-alone Power System

In this submission, Horizon Power articulates the key points a State-led strategy on microgrids and associated technologies should consider, while maintaining the balance of our energy systems: reliability, affordability, sustainability, as in Figure 1.

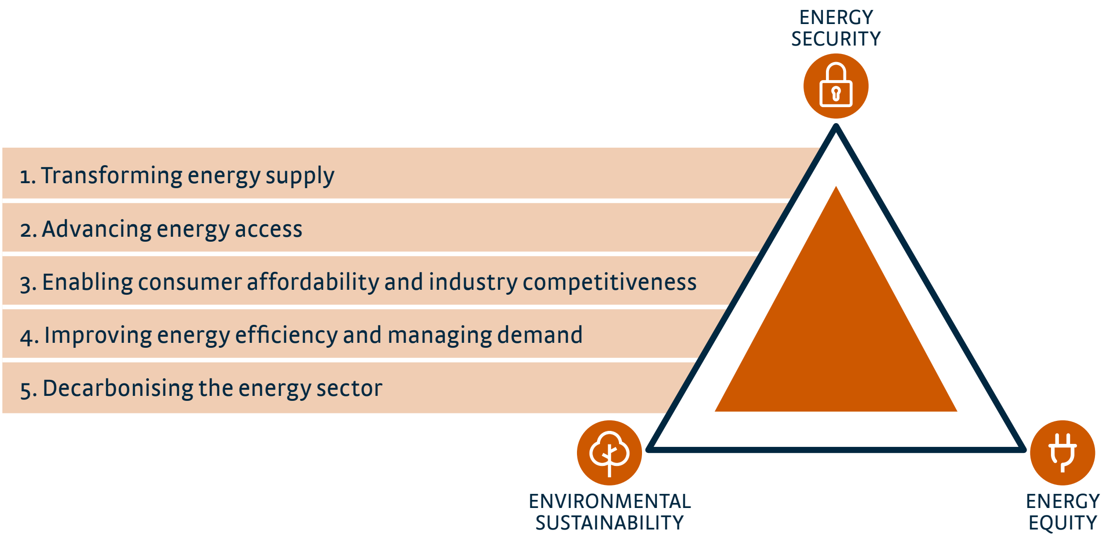


Figure 1: The energy trilemma describes competing interests in our energy systems

Horizon Power articulates the three pillars that constitute a roadmap for transforming our energy systems:

A. Strategy and Technology – ensure a common understanding of microgrids and develop a strategic roadmap for the South West Interconnected Network (SWIS) and microgrids; review and modernise regulatory frameworks

B. Jobs and State Development – accelerate microgrid development in WA and the multiplier effect from public investments; build export capability to capitalise on emerging microgrid markets in the Asia-Pacific region; establish housing standards to reduce peak energy use and create jobs

C. Customers and Pricing – include and engage the customer from the outset

In the transition to a modernised grid, the energy sector cannot avoid pain altogether. Customers' pivotal role in the development of microgrids means that ad hoc installation of DER will lead in many cases to suboptimal outcomes for the whole system and to a decline in the value of public assets. It also means that the business model of utilities in large interconnected systems should evolve away from traditional asset management toward platform providers who can encourage DER take-up where it reduces the average system costs without compromise. This 'creative destruction' was theorised long ago by political economist Joseph Schumpeter[3] and has since been observed and studied in the disruption of modern industries by Clayton Christiansen[4] in his work on the entrance of fringe innovators who come to eventually overturn and dominate the industries they infiltrate .

[3] Schumpeter, J.: *Capitalism, Socialism and Democracy*. New York, Harper Perennial, 1942.

[4] Christiansen, C. et al., 'What is disruptive innovation?'. *Harvard Business Review*, Jan-Feb. 1995

New technology, however, can provide substantial societal benefits if it is properly managed. The role of the customer must first be recast as both a consumer and an investor in our energy system. Microgrid designs must also provide solutions for vulnerable customers who cannot afford DER solutions because of financial hardship or tenancy status.

There is an opportunity for the State Government to lead the nation, and the world, in further developing and implementing a modern energy system that delivers clean power to more customers the way they want at lower cost. GTEs will play a critical role in managing the transition through their capabilities, resources, and expertise to integrate new technology in complex systems, while retaining the confidence of customers by keeping the lights on.

Through its own advanced microgrid roadmap, Horizon Power has already embraced this philosophy by lowering its cost to supply and developing innovative retail products for its diverse set of customers. Horizon Power is well placed to help the Government develop and deploy a microgrid strategy that positions the State for technical, commercial, and social success. Horizon Power continues to be at the forefront of the energy revolution. Operating remote and islanded microgrids, from retail to generation, means Horizon Power identifies emerging issues first and has no choice but to innovate and solve these challenges that will eventually impact the larger connected grids of today, which could be a federation of microgrids tomorrow.

In this submission, Horizon Power makes recommendations about developing a comprehensive microgrid strategy for WA that encompasses regulatory change, job creation, tariff reform and customer engagement. Australia, and WA have been identified by San Francisco-based research company Navigant Research as “an incubator and a laboratory where DER opportunities ranging from remote microgrids to virtual power plants” can be tested and validated for a global market[5].

Strategy and Technology	
Recommendation 1:	Develop integrated supply and network economic modelling for microgrids in the SWIS, both in metropolitan areas and at the fringe of grid.
Recommendation 2:	Review the DERMS standards from best-practice areas around the world and adopt the relevant standards for WA.
Recommendation 3:	Develop a roadmap toward the desired end-state of DSOs and ensure strategic fit to existing capabilities.
Recommendation 4:	Committee and Public Utilities Office (PUO) visit California, New York and Hawai’i network regulators to share best practices.
Recommendation 5:	Recognise remote communities as microgrids and independently benchmark existing approaches against world’s best practice to ascertain the value of a multi-utility approach.

5 Asmus, P., 2018: ‘Capitalizing on Integrated DER in Australia’. San Francisco: Navigant Research, 2018.

Jobs and State Development	
Recommendation 6:	Review, at the conclusion of Horizon Power's regulatory trial, the application of the framework to unregulated systems and at the fringe of grid.
Recommendation 7:	Immediately develop a State-sponsored communications campaign to promote each, and every, announcement on project investments.
Recommendation 8:	Upgrade energy-efficiency housing standards to support peak mitigation and regional building activities.
Recommendation 9:	Mandate an economic benefit study on local jobs and derived tax revenues during the procurement process for major GTE contracts.
Recommendation 10:	Support the PUO's investigation on deployment of standalone-power systems and micro power systems (MPS) in WA.
Recommendation 11:	Support on going efforts to secure Federal funding for RD&D efforts related to the development and commercialisation of advanced microgrid and MPS solutions.
Recommendation 12:	Create a Centre of Excellence for advanced microgrids in WA to coordinate RD&D, intellectual property commercialisation, and new skills development with universities.

Customers and Pricing	
Recommendation 13:	Create a shared database for public utilities in WA to support the research and development of fit-for-purpose products.
Recommendation 14:	Support the deployment of a demand-centric pricing structure, like MyPower, as a base tariff in Horizon Power's service area, and in the SWIS through installation of advanced meters.
Recommendation 15:	Review feed-in tariff (FiT) to create local incentives and incorporate ancillary services, so that the right DER is installed in the right place and at the right price.
Recommendation 16:	Invest in government housing (Department of Communities) energy efficiency focused on insulation, efficient air-conditioning and water heating.
Recommendation 17:	Investigate the conversion of concessions, grants, rebates and payments to vulnerable customers for energy efficiency technologies that decrease energy bills.
Recommendation 18:	Create an innovation taskforce for vulnerable customer DER product development.
Recommendation 19:	Deploy advanced meters through the fringe of grid of the SWIS and to vulnerable customers in priority.

A. Strategy and Technology

1. Transformation of the energy sector and rise of DER

The Australian renewable energy sector is seen as a market leader in many respects, but the shift from traditional, centralised to modern, clean energy systems has not been smooth, nor has it led uniformly to improved value for utilities or lower prices for customers. Indeed, the ‘perfect storm’ of Australian electricity market conditions resulted from a combination of short-term policy incentives in a regulatory framework, ill-suited to adapt to new technology or acknowledge declining consumption, followed by massive investment by customers in renewable technologies and by networks in transmission and distribution infrastructure. Higher utility costs and declining revenues have outweighed rising consumer prices, thus furthering the ‘death spiral’ of increased defection from utility- to consumer-based generation. System capacity utilisation continues to decline, as does the value of fossil-fuel generating assets. Figure 3 shows network utilisation declines in three of four of the Future Grid Forum’s scenarios to 2050, and a near net-zero effect in the most unlikely scenario, ‘Set and Forget’.[6]

NETWORK UTILISATION

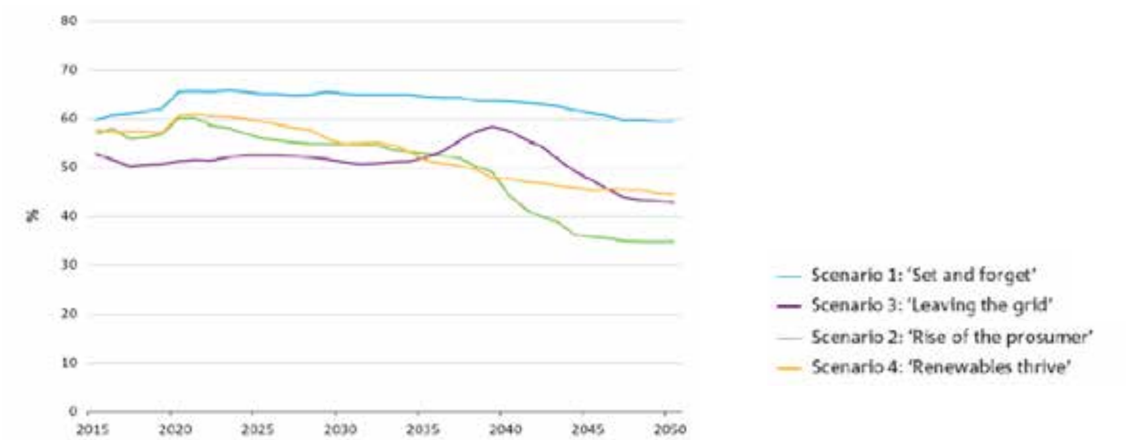


Figure 3: Network utilisation forecast from Future Grid Forum

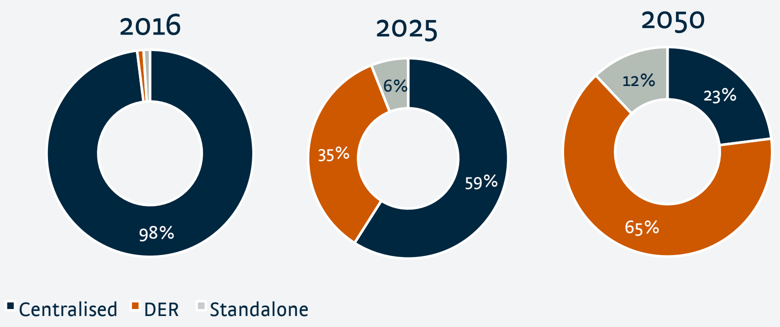
6 Graham, P., et al., ‘Change and choice: The Future Grid Forum’s analysis of Australia’s potential electricity pathways to 2050’. Newcastle: CSIRO, 2013, p. 39.

Some thought is being given to the emergence of DER at scale in large grids, but in all cases it lacks a comprehensive, long-term transformation roadmap. Beyond the financial challenges of managing a network, which has value with regulatory protection today but is declining in real terms, are the operational challenges of managing the emerging complexity at the distribution and low-voltage end of networks. In Australia, the Australian Energy Market Operator (AEMO) and ENA are pushing thought leadership on the impact of increasing levels of DER on the NEM and the SWIS. But their efforts may be frustrated by vested interests, regulatory barriers, or differential ownership as they seek to translate thought leadership into demonstration projects in a timely fashion.

As customers demand more information about their energy consumption, they learn how to limit and control it, which in turn drives the network operator (and/or retailer from which they purchase energy) to offer correspondingly more sophisticated products and services. Meanwhile, peak energy consumption is still vexingly high (and expensive), so utilities are still seeking ways to 'reduce the peak' while stemming revenue losses. Furthermore, given Australians have high expectations for grid reliability and power quality, utilities find they must invest in new control technologies and resources to better manage a less predictable power consumption curve, and a much less predictable supply portfolio that includes renewables.

The ongoing development and deployment of DER systems are unavoidable, particularly as battery costs continue to plummet. By enabling energy storage at both small and large scales, batteries will be the major disruptor of our traditional electricity system, which heretofore has required that energy produced be immediately consumed. Battery uptake will accelerate energy system distribution, causing microgrids of various sizes and technological sophistication to proliferate, although it is unlikely DER will obviate the grid altogether. Instead, networks and their operators will need to become more sophisticated, more secure, and more robust, while retailers offer incentives to customers they want to keep and migrate expensive customers to stand alone systems.

Acknowledging the need for a strategic roadmap for the eastern states, ENA, in partnership with CSIRO, developed the Electricity Network Transformation Roadmap 2017 (ENA Roadmap), highlighting the need to integrate microgrids and DER as a key component of the future energy system. Similarly, Horizon Power has conducted this exercise through its entire microgrid portfolio, resulting in a strategic roadmap and blueprints for each of its towns, modelling the best supply model and the transition to DER or standalone models for its high cost towns. Horizon Power's modelling, shown below, indicates the percentage of system supply that will come from DER, off-grid, and centralised generation. It forecasts that a timely transition, at the expiry of the different power purchase agreements, will result in an increase in levels of renewables (77 per cent of combined DER and off-grid by 2050) and decrease in cost to supply, resulting in a 46 per cent reduction in carbon emissions and a $150M reduction in net State debt.



- Will result in **over 20 per cent decrease in LCOE** in systems by 2030, resulting in a reduction in net State debt of $150M
- In the same time frame, it will also **reduce carbon** emissions by **46 per cent** from 350k to 190k tCO_2 p.a.

Figure 4: Horizon Power's system blueprints: transition to a high-DER world.[7]

CSIRO estimates nearly $1 trillion could be invested in Australia's energy systems by 2050, but that billions in expenditure could be avoided through a planned and coordinated approach.[9] All existing energy-sector players could save through lower generation costs, lower network charges, avoided network infrastructure investment, and lower end-user costs.

The transformation of our energy system is accelerating, but without careful planning, it will be more chaotic and costly than necessary.

Without a well-planned approach to navigate this transformation, Australia's energy system will be unable to efficiently and securely integrate large-scale variable renewable energy sources, customer-owned distributed energy resources, and control and communications technologies. This could result in the costly duplication and limited economic life of energy investments.[8]

If, on the other hand, the design, installation, and integration of microgrids are pursued in a planned, coordinated fashion, all members of the value chain stand to benefit. The need for information about and control of energy consumption is changing for customers, businesses, and communities; with careful consultation, these can be articulated and planned efficiently. Utilities are hoping to maintain sales and asset value while deriving revenue from new products and services, which themselves require investment in communications infrastructure and services.

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[7] In this chart, DER refers to system with over 50 per cent DER in their transition to advanced microgrids.

[8] CSIRO and Energy Networks Australia 2017, 'Electricity Network Transformation Roadmap: Final Report' (ENA Roadmap), p. i.

[9] Idem., p. iv.

Benefits should also accrue to stakeholders whose needs the traditional system has not adequately addressed. A combination of renewable generation, storage, and more efficient network infrastructure heralds a much cleaner energy system that will reduce pollution and carbon emissions. Customers with limited options in their energy choices (such as renters and low-income customers) should also be able to participate in investment in clean generation and storage by way of innovative financing, products and services.

The abilities of an advanced microgrid are balancing electrical demand with sources, dispatch scheduling, and grid reliability (adequacy and security).[10] The benefits to the operator of this enhanced manageability are cost savings and increased surety.

Recommendation 1:	Develop an integrated supply and network economic model for microgrids in the SWIS, both in metropolitan areas and at the fringe of grid.

2. Impact of DER on grids and potential for disruption

Power stations have traditionally been built for the one-way flow of energy, where power goes from the station through a bulk transmission system, on to distribution systems, and then to the customer.

With DER, generation can be located at any point on the system. The scientific principles of system operation remain, but the actors are different.

DER offers benefits such as consumer independence, more renewable generation, and cost-effective generation, but the interactions between actors and plant become more complex.

In some respects, our distribution systems are becoming like transmission systems, but with hundreds of small generators instead of tens of large generators, and many distribution lines instead of a small number of transmission circuits.

Horizon Power and DER

Horizon Power operates regional and remote microgrids in WA comprising a wide array of power system equipment with small diesel and gas generators, hybridised thermal power stations augmented with renewable energy, large combined-cycle gas turbines, small distribution lines, large transmission lines and terminal substations, and a variety of customer-connected facilities.

Many eastern states distributors operate within the context of an 'infinite pool', where the network operator effectively sees the power system as an endless supply of energy and interconnectivity amongst loads and supply sources. Horizon Power does not have that luxury. Because the microgrids it operates are small, it encounters technical challenges long before larger grids see the same problems.

Because Horizon Power's systems are remote, the costs to operate them are high (and subsidised), so Horizon Power is always looking at ways of improving system efficiency and reducing costs. DER plays a significant role in reducing costs, but this must be balanced with pricing reform (outlined in full in Section C) and a new regulatory framework.

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107 Idem., p. 4.

Technical challenges

Power systems are a complex combination of rotating electrical machines, substation equipment such as transformers and capacitors, power lines, and consumer appliances such as motors and electronic devices. The nature of every power system is different, and each power system exhibits its own individual response to system disturbances. Some power systems are more stable than others.

The dynamic response of traditional power systems with conventional generators (rotating electric machines) is well studied and understood. On power systems with a high level of DER, and under fault conditions such as lightning and short circuits, the dynamic nature of the power system is altered. DER devices will trip off the system during system disturbances, and in such cases, they can no longer support the system during faults. This makes the power system weaker and more prone to blackouts.

Large amounts of DER introduce a number of technical challenges to the power system. In particular, unmanaged DER connected to the network quickly highlights the power system's limitations and creates operational and power quality issues, which can include excess renewable energy, sensitivity to the impact of cloud events on solar production, and additional voltage control and protection system requirements.

When there is too much solar PV output, solar generation capacity can exceed customer load. In this circumstance, excess power flows back to the power station and can trip and damage the generators.

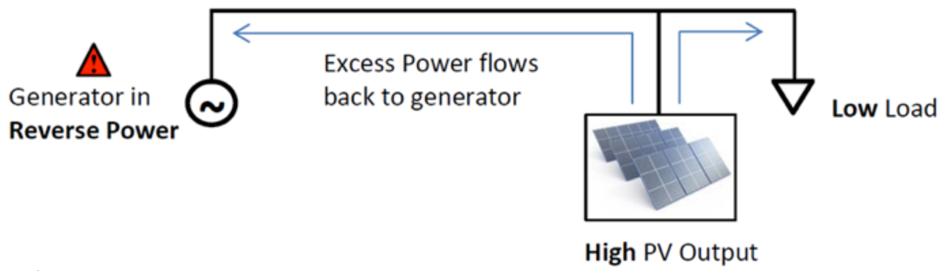

Figure 5: Excess solar can cause power station generators to trip.

Where solar PV output is high and there is suddenly large cloud cover, the power station must ramp up its output substantially. In such cases, and depending on the reserve levels being carried at the power station, the generators can become overloaded resulting in generator trips and system outages.

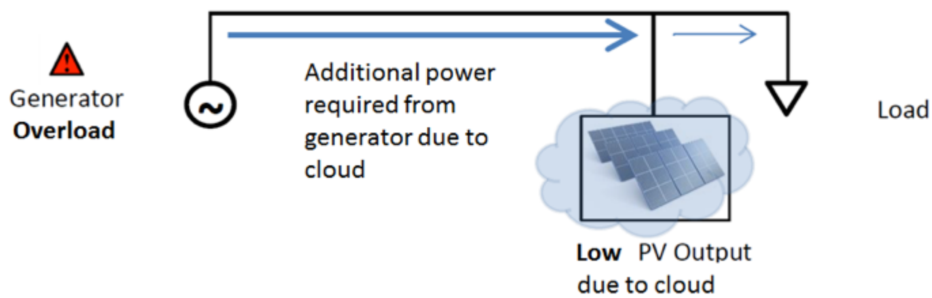

Figure 6: Generators can overload when cloud cover blocks PV output.

Another problem associated with high levels of DER generation on the network is voltage increases. As mentioned, electricity networks have been designed for power to flow in one direction, in some respects like water travelling downhill through a pipe. The height of the hill represents the voltage, and the voltage is at its highest at the source, i.e. the centralised generation plant. With DER generation, the flow is reversed. The downhill principle still applies, although now the top of the hill is where the DER generator is embedded in the distribution network, and voltage is at its highest point at this location. This makes management of voltage challenging for network operation. In addition, the range of voltage levels actually increases because the DER generation (e.g. output from solar PV panels) fluctuates. Many other technical challenges also exist (see APPENDIX 3: High DER technical challenges, Hosting Capacity and DERMS)

While challenging to integrate DER devices, their dynamic nature also means they can help the system perform. Because of the high-speed electronics embedded in many DER devices, DER can respond faster than conventional generation, but this depends on the way the DER devices are electronically programmed and configured. To date, most DER are not configured to provide such a response. For this reason, Horizon Power is working with organisations such as ENA on standards and connection guidelines to ensure DER can adequately support the system.

To ensure continued reliable operation, Horizon Power currently calculates hosting capacities for each system to ensure technical issues can be managed. The concept of hosting capacity is discussed broadly in the international literature[11]. In large power systems, hosting capacity calculations are typically based on network limitations. In Horizon Power's case, and because of the many microgrids in Horizon Power's portfolio, constraints can also relate to generation.

Few utilities globally have had to curtail the take-up of DER along the distribution network. Utilities in Hawai'i have taken a similar approach to Horizon Power and defined a strategic roadmap, which will push technical limits while improving the affordability and reliability of their microgrids (Appendix 1). New York utilities are also hoping to increase the amount of DER that can be accommodated whilst maintaining reliability (see Appendix 1: New York REV). Their work is focused on investigating the technology (storage), communications (monitoring and control), and developing approaches to increasing hosting capacity by resolving voltage, thermal and protection expectations that limit additional DER.

Horizon Power's hosting capacity methodology, which gives rise to publicly posted limits, has been endorsed by engineering consultants GHD and AECOM as a prudent approach to managing the technical challenges, and it has been adopted by other Australian utilities (see APPENDIX 3: High DER technical challenges, Hosting Capacity and DERMS for full summary).

Horizon Power also has network challenges, which it addresses individually, as new DER generators connect to the network.

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11 Covino, S., et al., "The Fully Integrated Grid: Wholesale and Retail, Transmission and Distribution". Future of Utilities, Utilities of the Future. Ed. F. Sioshansi. London: Elsevier, 2016.

The solutions

Horizon Power has considered a range of solutions to these technical challenges.

As a response to market demand for solar energy, Horizon Power in 2012 released an updated technical standard outlining the requirements for DER systems with generation management. This standard, an Australian first, enabled customers to install DER systems with batteries that perform renewable energy smoothing, to mitigate the effect of cloud events on the power system.

In the standard, Horizon Power specifies a ramp rate curve with which the customer's installation must comply, to ensure the fluctuations do not affect the power system. Horizon Power has now seen many systems connected with this functionality.

Horizon Power has also introduced feed-in management to large installations to manage the effects of reverse power flows.

These solutions are working effectively to manage the levels of DER connected to Horizon Power's systems thus far. The path to much higher levels of penetration, however, depends on the ability to monitor and control the output of all DER on the system, and to employ a range of other new technologies.

The table below outlines the range of problems encountered with higher levels of DER penetration, along with solutions Horizon Power uses now and is working on for use in the future:

Problem	Existing solutions	Solutions under trial and development
Reverse power	Feed-in management (large DER systems)	Feed-in management (small DER systems)
Cloud event management	Generation management (customer battery storage with renewable energy smoothing) Feed-in management (large DER systems)	Feed-in management (small DER systems) Solar forecasting Cloud cameras
Voltage rise	Change transformer taps Change system voltage levels	New DER standards Improved inverter power factor performance & voltage control
System stability	Existing DER standards	New frequency control strategies New voltage control strategies New DER standards Improved inverter fault ride through performance
System network loading constraints	Network reinforcement	Optimised charge coordination of energy storage
System black start and energisation	Power station operating guidelines	DER network black start control schemes
System protection sensitivity	New protection philosophies New protection relays	Advanced sensing (e.g., travelling wave) relays Utilise system monitoring (DER, advanced meters)

Table 1: Horizon Power can manage some problems associated with high levels of DER penetration and is working on solutions that will work for even higher levels

The future

Horizon Power is a microgrid company committed to solving these challenges and transitioning toward over 50 per cent of system energy produced by DER, but only where it makes commercial sense for lower system cost and equal or better reliability. The design and build of advanced microgrids in our service area are already underway and can be extended to those at the fringe of grid and beyond.

Technical barriers to be overcome to increase distributed energy targets

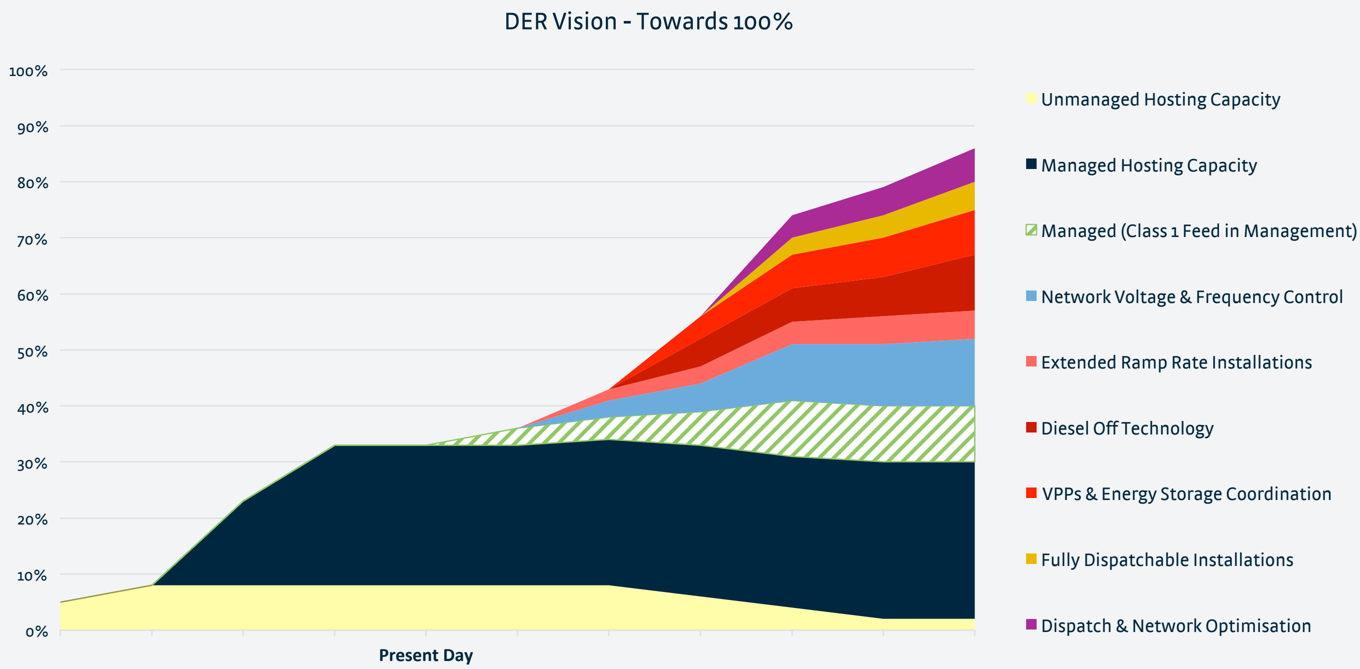

Figure 7: Technology and practices required to get to 100 per cent DER.

If the DER integration is implemented well, the resultant management system creates new benefits for the power system as a whole: through better provision of network support services; avoidance of network augmentation; diversification of funding sources for large infrastructure projects; optimisation of energy production and consumption; and minimising outages and disturbances using load prediction algorithms.

$/kWh vs. per cent Renewable Penetration (Diesel Town)

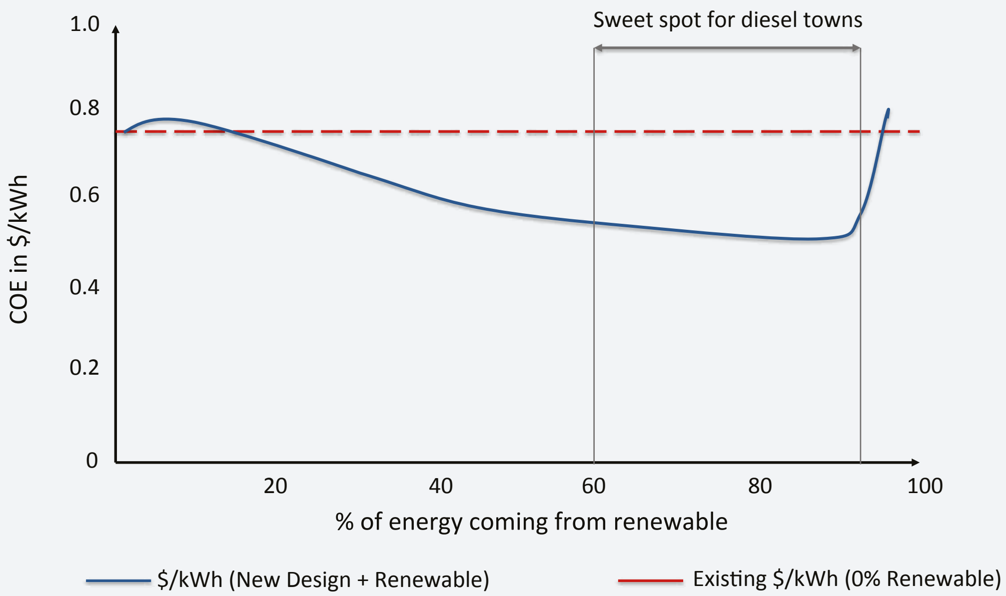

Figure 8: Optimal levels of DER to reduce system costs in a diesel town.[12]

3. Distributed Energy Resource Management Systems

Industry Trends

Historically the electric grid was managed using a combination of manual controls, supervisory control and data acquisition (SCADA), and distribution management systems (DMS), which provided basic information and control to electric utility operators.

These systems enable the management of traditional capabilities such as voltage, reactive power (VAR), and monitoring of power flow, but they were designed to support centralised generation and very limited amounts of renewable and DER. As DER penetration levels increase, utilities and power system operators must look to new control solutions.

SCADA, DMS, and remote microgrid control providers are thus adapting their systems to de-centralised assets with often unpredictable and intermittent generation profiles. Because these solutions are still based on a centralised framework, they prevent operators and owners from fully leveraging the capabilities of distributed generation. This, in turn, hinders the development of new value streams derived from DER's inherent flexibility.

[12] Based on Ardyaloon microgrid, assuming cost of a greenfield development and a diesel price of $1.1/L; only compares generation costs.

As DER systems expand and proliferate, all actors in the power system (local utilities, third-party aggregators, communities, and end-customers) want the value they contribute to it to be recognised. A platform is needed to manage as a coordinated system such diverse assets as solar, wind, energy storage, combined heat and power, and conventional generators.

With a distributed energy resource management system (DERMS), a utility can ensure power reliability with high amounts of DER, lower costs, and create new value streams for other local utilities, their customers, service providers, developers and site owners.

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The figure below shows an overview of the various DERs that a DERMS could interact with.

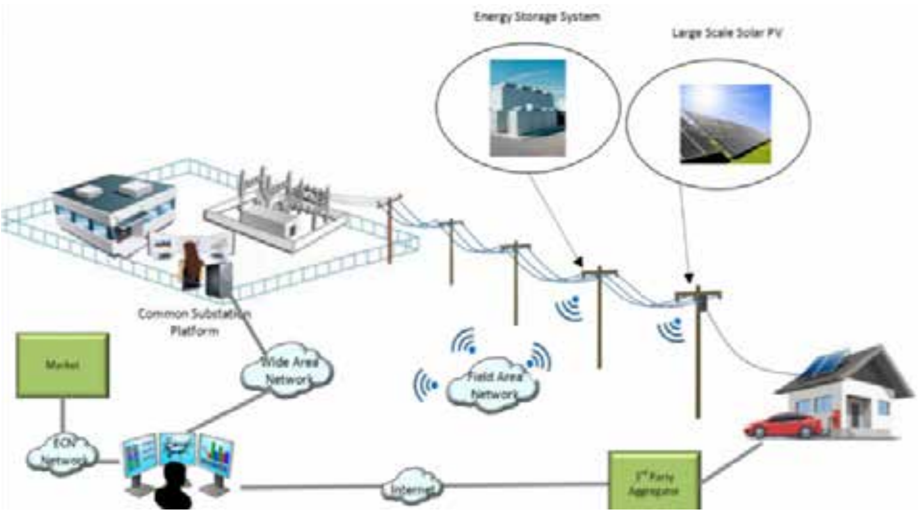


Figure 9: An ecosystem in the DERMS environment where the operations of all generation sources, supply networks, the energy market, and customer loads are coordinated.

Value of DERMS

The future will see energy markets that compensate entities (including customers) which provide valuable grid services to the power system. Where policy incentives and financing mechanisms create new opportunities, and business models spur the installation of distributed generation, DERMS solutions must adapt to ensure that DER add value, not just shift costs from one user group to another. As policies and regulation change, a DERMS must be able to extract from the same underlying architecture and DER capabilities, values that simultaneously complement different business strategies.

Horizon Power believes that a DERMS which fully integrates DER at the fringe of the grid with power systems, can unlock valuable benefits to customers, service providers and grid operators alike. To do so, the system must adapt to the order of magnitude increase in controllable and viewable assets. It must also allow DER to be grouped and controlled to adapt to new business models. One-off, customised designs will not adapt fast enough to compete.

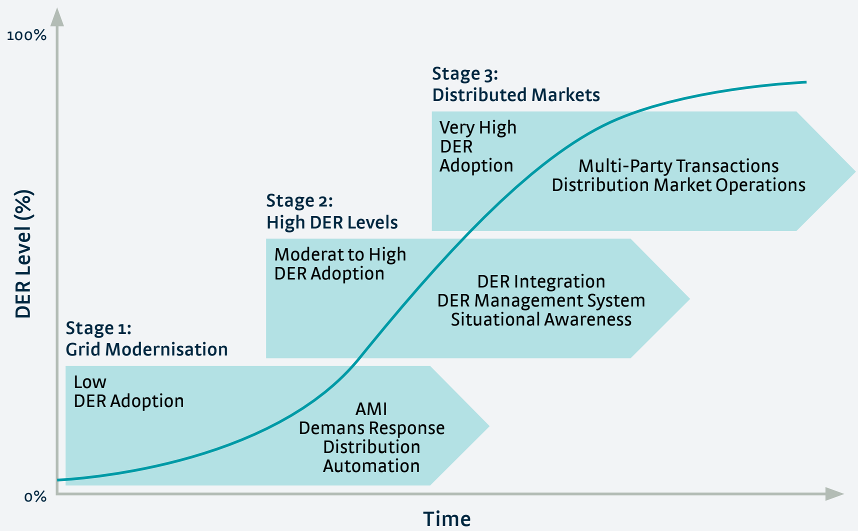
DERMS are still underdeveloped in WA, but Horizon Power is aiming to enable DER proliferation to a variety of customers and for a variety of business models through a DERMS platform by being the distribution system operator (DSO) for both utility-owned and non-utility-owned DER.

Horizon Power envisions the following roles for DERMS:

- Aggregate – take services from individual distributed energy resources and aggregate them in a manageable number
- Organise – manage DER settings and provide simple grid-related services
- Optimise – harness the multitude of DERs economically and enhance reliability
- Translate – communicate to many resources that may use different communication protocols, but interface cohesively through DERMS.

Additionally, a DERMS platform could provide the following benefits to Horizon Power and other stakeholders in Western Australia:

- New business models – encourage new product and service development and new revenue streams from these offerings
- Customer empowerment – provides customers with choice of services, through which customers can sell back to the grid
- Economic value – reduces cost of ownership while increasing reliability, efficiency and overall system utilisation. Exposes resources to a larger market at the distribution level.
- Regulatory flexibility – allows jurisdictions to implement higher penetration of DERs, while maintaining power quality within prescribed limits
- Societal value – reduces emissions with prolific deployment of DERs, and improves management of renewable intermittency and volatility.



Source: P. De Martini, L. Kristov – Distribution Systems in a High DER Future – October 2015

Figure 10: To enable and maximise DER asset utilisation at high penetration of DER, a localised DERMS microgrid is required.

Recommendation 2:	Review the DERMS standards from best-practice areas around the world and adopt the relevant standards for Western Australia

4. Transition role of distribution system operators with a target end-state in mind

As the role of the customer is recast in a DER world, so too is that of the utility. To achieve a customer-centric electric power system, in which customers and third parties invest in and derive value from DER, Distribution System Operator (DSO) roles will greatly evolve going forward. So that microgrids do not become the 'new solar' for unprepared utilities and government, a clear strategy with an end-role already mapped out for DSOs should be defined and adopted from the onset of the rise of microgrids.

The role of DSO varies greatly depending on geographies covered, with on one hand the management of a large grid and its embedded microgrids within it, and on the other hand islanded and fringe-of-grid microgrids. The States of California and New York have already acknowledged these differences and started to develop alternative regulatory models for these.

So that microgrids do not become the 'new solar' for unprepared utilities and government, a clear strategy with an end-role already mapped out for DSOs should be defined and adopted from the onset of the rise of microgrids.

In New York, the government produced a transformation roadmap supported by regulatory changes in the "Reforming the Energy Vision" (see REV case study in APPENDIX 1: Case studies from the US). In this transformation roadmap, the role of DSOs changes from asset managers to platform providers. The Distributed System Platform Provider (DSPP) provides the interface between the wholesale market and the customer. DSPPs are not allowed to provide DER products and solutions except for ancillary services: that is the role of competitive energy-service providers.

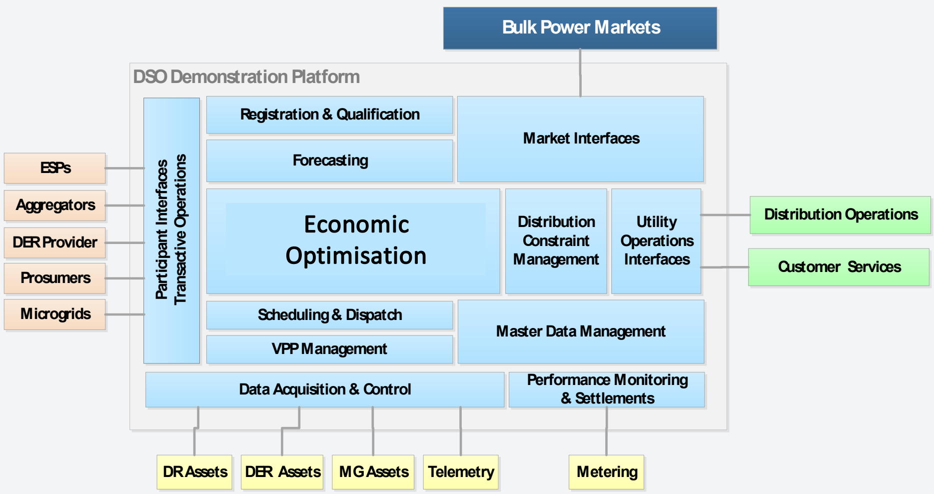


Figure 11: DSO transactive platform functionalities.

Marble Bar Solar Power Station

In California, there is a move toward stronger integration of distributors and DER retail solutions within the DSOs. Indeed, the market regulator and investor-owned utilities (IOUs) are working together toward the renewable goals and tackling the following areas in priorities for high DER:

- Measure hosting capacity at a circuit level
- Define an Optimal Location Net Benefit Methodology to identify locations at which DER deployment is a viable substitute for conventional distribution investments
- Transition operational practices toward control of DER

In remote and fringe of grid areas, the role of microgrids is first and foremost a cost management exercise. Wholesale markets usually do not exist and vertical integration provides a way to optimise overall system costs across the different roles that would exist in a disaggregated energy system. In the costly systems, DER and off-grid solutions should be a key focus, with fit for purpose centralised generation. In that sense, the Californian approach may be more relevant to remote WA and fringe of grid areas.

The role of the DSO in the customer-dense part of the South West, with a dynamic wholesale market and pockets of optimisation, is radically different. It is evolving toward a transactive platform with economic optimisation as an ultimate goal. As opposed to the remote and fringe grid systems, the greater size of the metropolitan South West grid provides for any number of possibilities and arrangements for DER, virtual power plants (VPP) and microgrid formation which, if appropriately coordinated, will all approximate an optimum value for the entire system. For the full benefits of microgrids to be realised for the electric system as a whole, however, connection standards and decisions to separate from the grid must be fully coordinated with the relevant authorities and system operators. There will always be limits on the size, scope, and number of embedded microgrids at a local level. Careful planning is required to ensure operability, stability, and resilience are not compromised as microgrids take hold.

The suite of solutions is as a result very different from a remote and fringe grid DSO, with a stronger emphasis on specific pathways and on transactional capabilities. A model similar to the New York REV in the metropolitan area should be explored for the South West grid.

Further details in Appendix 1 describe how New York and California have taken different approaches to deploying state strategy.

Recommendation 3:	Develop a roadmap toward the desired end-state of DSOs and ensure strategic fit to existing capabilities.
Recommendation 4:	Committee and PUO visit California, New York and Hawai'i network regulators to share best practices.

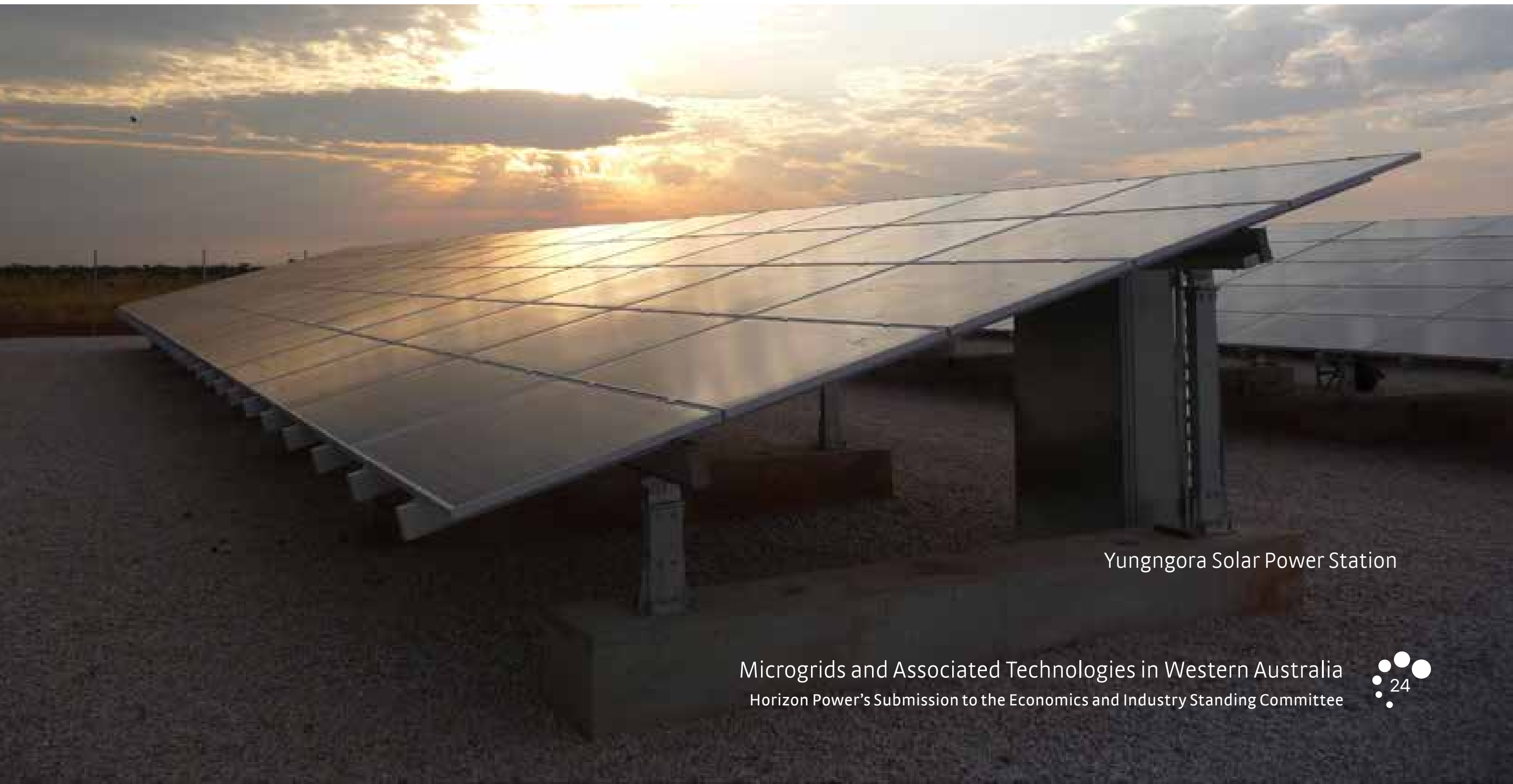
5. Regulatory considerations

Customer and shareholder protection

The premise of an energy regulatory framework is to protect both customers and shareholders in respect of safety, quality of service, and financial responsibilities. Regulating microgrids is no different, but the stakeholders are different because they are playing new and more complicated roles than in a traditional, centralised system.

To avoid cross-subsidisation, between classes of consumers	To facilitate government control requirements.	To protect the long-term interests of consumers, particularly vulnerable consumers.	To promote efficient investment in, and efficient operation and use of, utility services.
Shareholder Protection		*Consumer Protection*	
To facilitate a graceful entry and exit into the regime for assets.	To provide investors with the requisite level of certainty.	To promote competition in the supply of utility services.	To effectively manage utility monopoly power.

Figure 12: Protections afforded by an energy regulatory regime.



Yungngora Solar Power Station

There are two regulatory extremes co-existing within Australian energy systems:

- Heavily regulated systems such as the NEM and WEM, which are often prescriptive about the role that various players of the value chain can play and about ring-fencing different activities, can result in high overhead costs and discourage innovation.
- Unregulated microgrids: 300 across Australia, including about 200 in remote WA, with 91 (serving populations over 50) funded under the Remote Essential and Municipal Services (REMS) program, which is run by the WA Department of Communities. These systems are highly subsidised and characterised by ad hoc infrastructure and capital works planning and unregulated electrical safety and reliability standards.

a. Heavily regulated systems

The difficulty of redesigning a regulatory framework to suit microgrids stems from complex interfaces between generators, distributors, wholesalers, retailers and consumers.

In the SWIS, Western Power is responsible for distribution, while Synergy manages part of the generation, the wholesale and retail functions in a ring-fenced arrangement. The control, reliability and safety of consumption behind the meter are covered by the retail agreements but the retail products for coordination and orchestration of DER do not exist yet.

In an advanced microgrid, these three interfaces must work together seamlessly, such that:

- the distributor monitors the energy balance at the node and commands dispatch
- the wholesaler prices different sources of energy at any time
- the retailer creates the products and arrangements to allow customers to participate in this market.

Each of these players should be ‘rewarded’ for the service it provides, but current conditions in the WEM regulatory framework do not facilitate this in the SWIS.

As explained in the previous section, Horizon Power’s vertically integrated structure, however, minimises the frictions and costs between the different parties and simplifies the protection models, focusing on the customers and a single shareholder.

A change in the role of the DSO in the SWIS, in-line with recommendation 3, to provide a platform for transactive functions, should be considered.

b. Unregulated systems

There are 91 Aboriginal remote communities whose essential services are provided by REMS. A further 180 or so communities receive ad hoc operations and maintenance services or are fully self-sufficient. Power, water and wastewater service delivery in remote communities is characterised by:

- diffuse accountability;
- lack of clarity in respect to ownership and compliance obligations;
- a high cost to supply in remote areas;

- high subsidy requirements;
- affordability problems and ad hoc user-pay arrangements; and
- lack of regulation or application of standard regulatory framework

In 2013, the State developed an alternative standard (the Remote Service Level Guidelines), which set out high-level requirements for Australian standard electrical safety and drinking water quality but relaxed obligations for response times, services reliability and other non-critical factors. The Department of Communities is not regulated, nor is its delivery of services measured against the recommended guideline.

The State subsidises these services at around $35M per annum and is looking to invest a further $52M in the next year for upgrades to water and wastewater in only three or four communities.

The above problems are conflated by the high cost of any proposed capital works upgrades (such as the $22M to be invested in Tjuntjuntjara Community, east of Kalgoorlie) and limited funding.

Horizon Power suggests a different approach to these communities:

Recommendation 5:	Recognise remote communities as microgrids and independently benchmark existing approaches against world's best practice to ascertain the value of a multi-utility approach.

c. Horizon Power regulatory trial

Horizon Power has been designing a regulatory model for microgrids that encourages it to drive the lowest sustainable costs across its systems. Drawing on elements of conventional regulation, the model features new incentives for shifting to DER, including microgrids, while enabling it to recover past investments so that the state's net debt position is not adversely affected.

The model differs from traditional regulation in that it covers the whole system, compassing all owners of microgrids – generators, distributors, and retailers. It also uses actual costs as the basis for forecasting future costs to address the inconsistencies in information that exist between Horizon Power and the Government.

The objective of the trial of the regulatory model for microgrids is to test whether it:

- facilitates lower investment across the electricity supply system, which leads to lower costs and a reduction in subsidies over time if tariffs are reformed
- facilitates customer participation to deliver more efficient outcomes, which increases competition in the supply of services
- appropriately balances the interests of the Government (as subsidy payer), Horizon Power and consumers
- appropriately balances the costs of administering the regulatory model with the risks

- provides the flexibility to adapt to changes in circumstances, such as a different mix of generation, and to changes over time, including technological changes, environmental changes and changes in consumer preferences
- avoids cross-subsidies, between classes of customers and between customers in the trial towns and other customers.

Recommendation 6:	Review at the conclusion of Horizon Power's regulatory trial the application of the framework to unregulated systems and at the fringe of grid.

Cybersecurity

The rise of advanced microgrids is underpinned by advanced meters and connected technologies within the home. As the system moves from centralised to decentralised, from analogue to digital, it increases the attack surface where cyberattacks could happen. After the power grid attacks in Ukraine in December 2015 resulting in 225,000 customers losing power, and on a nuclear plant in the US last year, energy cybersecurity has been named the number-one risk to grid security by global utilities. Cybersecurity experts at ECU consider it is not a matter of "if" but "when" an attack would occur, requiring a two-pronged approach for risk mitigation:

- Preventive measures which allow early detection of abnormal behaviours, multiple layers of security
- Reactive measures which allow immediate isolation and containment of threats.

Horizon Power takes the security of its systems, data, and people seriously. Its information security management system (ISMS), which uses elements of the Australian Government's Information Security Manual (ISM) and ISO 27001, is the framework that specifies the controls, processes, and policies for protecting its IT systems. Not all elements apply to the operation and management of microgrids, so Horizon Power has investigated alternatives it can use to ensure the same level of security in Horizon Power's corporate environment works in the microgrids space.

To this end, Horizon Power works with ENA and the Critical Infrastructure Centre in the Australian Department of Home Affairs on ways to implement and manage of cybersecurity practices associated with the operation and use of Operational Technology assets (OT). Horizon Power has already completed a gap analysis using the Cybersecurity Capability Maturity Model (C2M2) Program that has been specifically designed to look at improving the electricity sub-sector cybersecurity capability. The output of the gap analysis will be used to determine the controls/processes Horizon Power needs to put in place to:

- mature and improve our cybersecurity capability in the microgrid space
- provide effective and continuous benchmarking of our cybersecurity capability
- collaborate with other utilities and industry to improve best practice and foster knowledge sharing
- ensure informed investment of cybersecurity controls aligns with Horizon Power's risk profile
- move towards adoption of the National Institute of Standards and Technology (NIST) Cybersecurity Framework for the OT environment.

Given the changing nature and increase in targeted attacks on energy utilities, Horizon Power will continue to invest in not only the right technical controls, but also the skilled resources for building more resilient and secure microgrid infrastructure. Horizon Power is committed to and offers cybersecurity leadership in control and protection of microgrids and associated technologies.

6. Lessons learned from overseas

Three states in the United States are advancing clean energy through comprehensive reform programs. Appendix 1 features these three case studies in detail, showing different approaches to adapting to regulatory frameworks that can drive DER and microgrids.

a) New York REV (case study in appendix 1)

New York's microgrid and renewable strategy for higher resilience, affordability and renewable penetration, details the regulatory decisions to support the mutation of distribution system operators into distributed system platform providers and leverage the private sector to drive new services.

b) California Strategy toward renewables (case study in appendix 1)

How California is working with the incumbent utilities to repurpose their operations as plug and play distribution platforms.

c) Hawaii's policies and trials toward more managed DER (case study in appendix 1) and 100 per cent renewables have presented similar technical and customer challenges to Western Australia's islanded systems (hosting capacity, tariffs and incentives).

Credit: Aeonsolar LLC
http://www.aeonsolar.com

B. Jobs and State Development

1. Potential for jobs in green technology and microgrids in Western Australia

Countries taking a strategic approach to modernising their energy infrastructure have predicted and are experiencing job growth in the electricity sector.

The 2017 International Renewable Energy Agency's annual review on renewable energy jobs revealed the global renewable energy sector employed 9.8 million people in 2016 – a 1.1 million increase over 2015:[13] "The investment in low-carbon energy sources and energy efficiency is a major source of job creation," according to IRENA.[14]

We can estimate the State could create between 40,000 and 70,000 jobs to effectively transform our energy systems.

In California, where a major program of energy reforms has been under way since 2007, over 600,000 jobs have been created.[15] In South Korea, the addition of 1.5 million jobs in the clean energy sector is predicted by 2030.[16]

If scaled to the population of Western Australia, we can estimate the State could create between 40,000 and 70,000 jobs to effectively transform our energy systems.

To maximise the multiplier effect on its public investments ($300m estimated annual capital investment in advanced microgrid infrastructure and technologies), Western Australia would need to make strategic choices about areas of focus for job creation. The figure below shows the value chain applicable to strategic job creation in WA's energy sector; the four sub-sectors on the right constitute appropriate areas of focus:

[13] International Renewable Energy Agency, "Renewable Energy and Jobs – Annual Review 2017". Abu Dhabi: IRENA, 2017.

[14] Idem.

[15] Burger, M., 'Solar jobs: progress and challenges in diversity'. *PV Magazine USA*, Sept. 2017.

[16] Kim, H., et al., "Green Growth and Green Jobs in Korea: Potentials and Perspectives". Bonn: Energy & Climate Policy Institute, Friedrich Ebert Stiftung, 2012, p. 18.

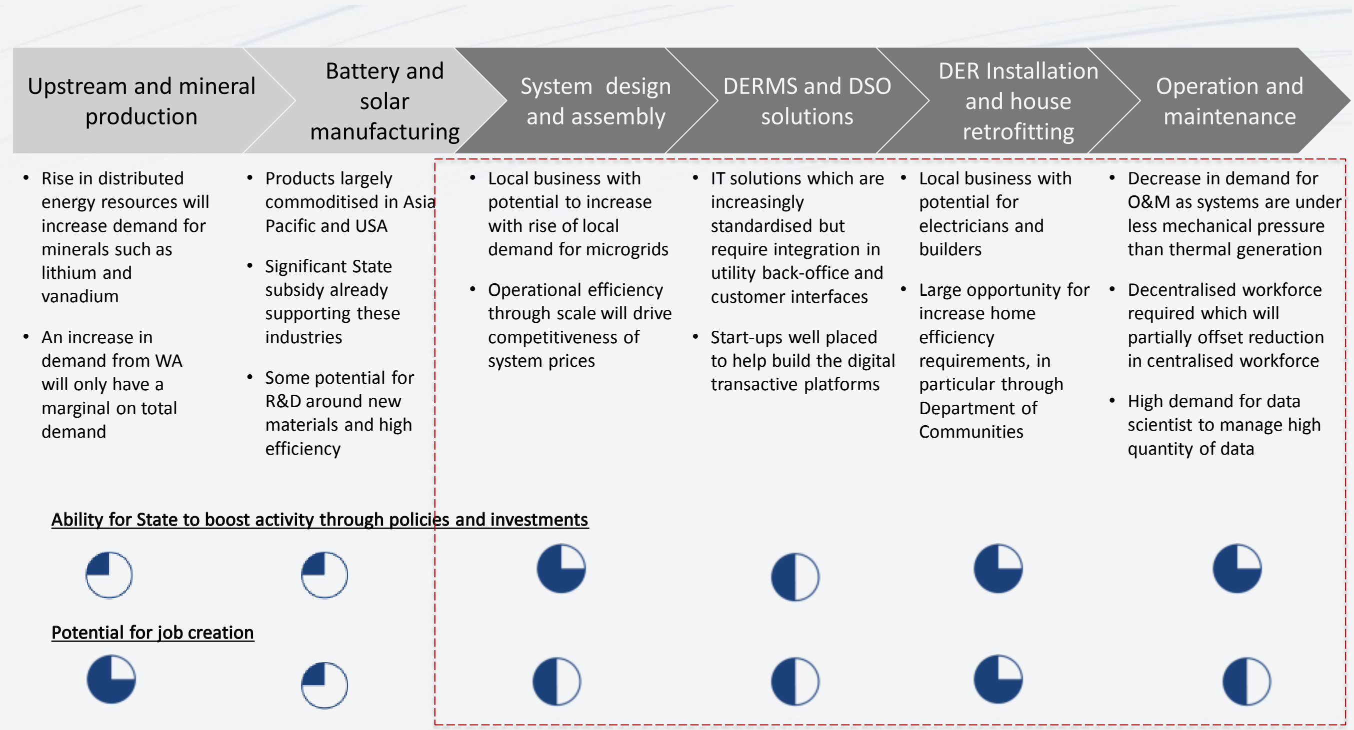


Figure 13: Simplified value chain for DER in Western Australia and potential for job creation.

Upstream and mineral production

With the third largest reserves of lithium and the largest production output worldwide, Australia has been following the development of storage technologies and electric vehicles with great interest. More than half of the world's lithium is produced in Western Australia, with the potential for thousands of jobs to be created as mines begin or expand their operations.

This is of course a strategic opportunity for Western Australia to build on its already world-class mining capabilities. Nevertheless, it is a global, commoditised market, driven by macro-economic trends. Electric vehicle legislation in China, as well as European and American policies on renewables, will drive the level of activity in Western Australia. An increase in domestic sales of batteries and electric vehicles would have only a marginal impact on the output of Western Australian's mines due to the small size of Western Australian's population.

In WA, research and development of new materials to improve the efficiency of DER technologies would be a better strategy with more global impact than would efforts to stimulate demand through domestic growth. Western Australia has excellent research institutes, as well as reserves in other metals such as vanadium that could prove to be alternatives to lithium in certain cases.

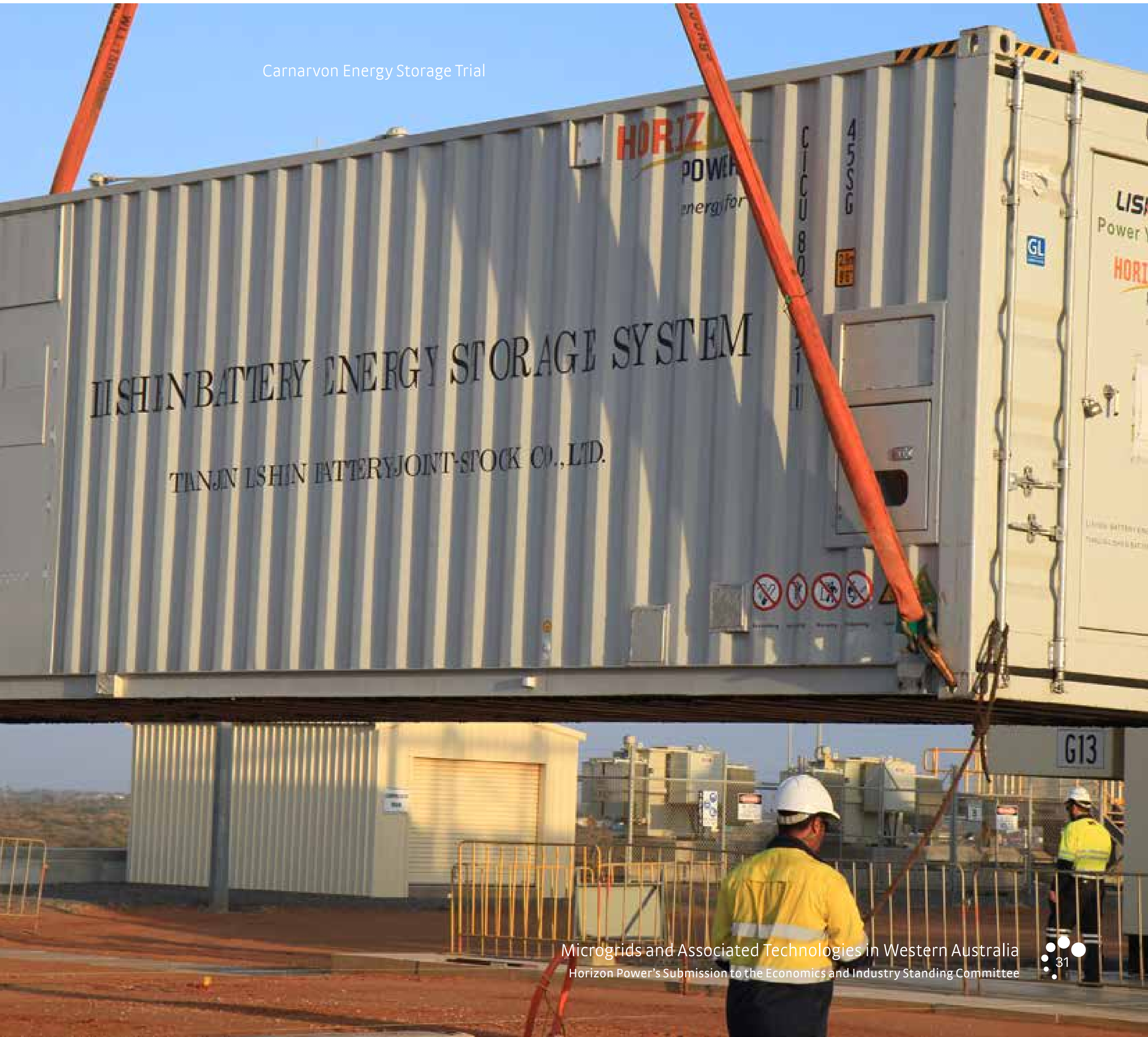
Battery and solar manufacturing

Solar and battery cell manufacturing businesses are highly competitive industries. They are subsidised in some countries that have determined these capabilities as strategic national assets.

Seven of the ten largest solar module producers in the world are Chinese, with only one South Korean and two American companies in the top ten.

The battery cell market in China is not as concentrated as solar, as the technologies are still evolving, with competing lithium technologies.

Similar to the recommendation for the upstream market, research on high-efficiency materials and value-addition on industry standards could be better suited to Western Australian capabilities.



Carnarvon Energy Storage Trial

Horizon Power predicts three areas of focus for job creation through microgrid development:

a. System design and assembly

The activities required in the design of microgrids are very utility-centric, heavy in engineering and tailored to each system.

Advanced microgrids have customers at the centre of the design and thus require a more diverse skill set than just engineering for optimal outcomes. The rapid development of microgrids is also leading to standardised design and lower costs.

Advanced microgrids have customers at the centre of the design and thus require a more diverse skill set than just engineering for optimal outcomes.

Horizon Power's approach to microgrid design, known as System Blueprints, governs the design of the microgrid for each system by considering the conditions, supply and demand, and customer base in each community so that costs are minimised while service and power quality are maximised. Timing the migration towards microgrids depends on current contractual arrangements, costs of labour and materials, and prospective costs of operations and maintenance. Horizon Power has three distinct steps to the design of an optimal low cost reliable microgrid.

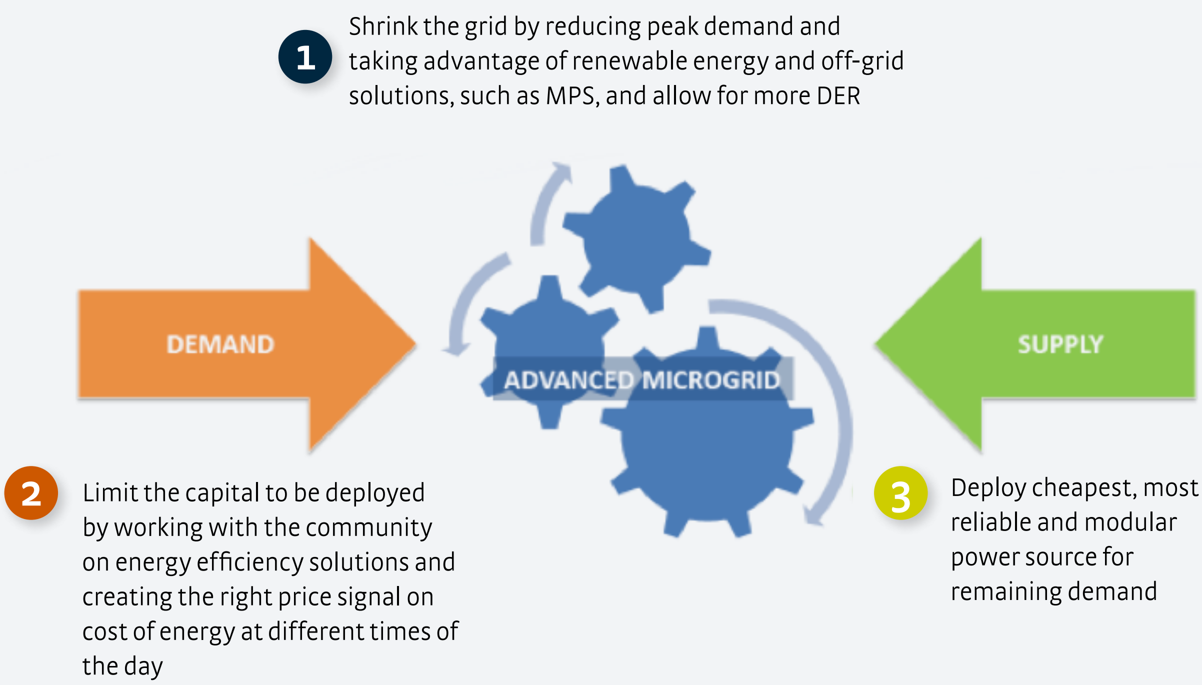


Figure 14: Horizon Power's System Blueprint approach to designing micrograms.

Where Horizon Power's microgrids follow a model of either DER, hybrid-centralised, or off-grid; each system will still have elements of tailoring to the community it serves, however we are seeing the emergence of clusters with similar demographic profiles and energy needs across the microgrids. Each microgrid design is validated with the community where the system is installed. Then, construction engages a local workforce as much as possible, and ongoing operations and maintenance aims to support regional employment.

To achieve these outcomes, Horizon Power has invested in its own design, engineering, information technology, and stakeholder management capabilities. Most utilities will similarly start to diversify their workforce to include behavioural specialists and reinforce their regional stakeholder management footprint.

Beyond microgrid development, Western Australia has an opportunity to take a leadership role in the design and assembly of utility-grade off-grid power systems, or micropower systems (MPS). MPS are the sum of commoditised products like battery and solar cells, along with layers of communication and software, combined to offer a seamless vertically integrated utility experience for off-grid customers.

b. DERMS and DSO solutions

With the increase in microgrid integration across all energy systems, utilities will firstly need to develop DERMS and build them into their asset management platforms. Some off-the-shelf DERMS solutions already exist in the market, but their applications and operationalisation needs to be investigated and demonstrated. Horizon Power is focused on doing this in Carnarvon and Onslow.

The development, integration and commercialisation of these applications to DSOs and customers will require a combination of power system engineers, IT specialists and commercial experts.

Secondly, these DERMS will need to be supported by a robust and modern telecommunications network, in particular in regional WA and at the fringe of grid in the SWIS. By coordinating their efforts with Telstra, NBN Co, and other telecommunications providers to upgrade the infrastructure needed to accommodate more DER, Horizon Power and Western Power could assess the prospects for new jobs and training in these functions.

c. DER installation and house retrofitting

Buildings are a major source of carbon emissions globally. Retrofitting houses to improve their energy efficiency and improve energy affordability, particularly for vulnerable customers, is an emerging growth area all over the world.

In the US, the Low-Income Home Energy Assistance Program provides federally funded assistance in managing costs associated with home energy bills, energy crises and energy-related home repairs.

In WA, a huge opportunity exists in this space. The energy efficiency of much of the State's existing housing stock – both public and private – is low, meaning residents must spend more on heating and cooling than would be necessary in more efficient buildings. This affects vulnerable residents disproportionately, but there are few options or incentives for improvement. The State's Hardship Utility Grant Scheme, for example, does not address any underlying causes of debt that many vulnerable customers face, including poor energy efficiency of public and private housing.

Three of the Remote apprenticeships program's first graduates, Clinton 'Minty' Sahanna, Robert Hassett and Brendan 'Koomi' Walters

Horizon Power has direct experience in residential energy-efficiency retrofits. Residents of Aboriginal communities where Horizon Power undertook energy-efficiency retrofit work in 2009-10 enjoyed an immediate reduction in energy costs in the order of 20 per cent which would flow to a reduction in Horizon Power's fuel costs. Recommendation 16 and 17 provides a solution for vulnerable customers to access DER solutions and for the State to reduce its net debt by deploying DER and solar in housing across the State.

Horizon Power has also worked with the State's Government Regional Officer Housing office to ensure energy efficiency is incorporated into the design of new government-funded housing. Horizon Power would like to continue discussions on this topic and see the retrofit program reignited. This work could be expanded throughout the state, not just in regional WA.

Importantly, retrofit work is not easily outsourced, which means it is a source of jobs for the local community – which are much needed in many parts of regional WA.

d. Operation and maintenance

Operating and maintaining microgrid systems represent further job opportunities in WA. The skills required to manage and maintain solar, batteries, communications, and other IT/OT assets exist to some extent in Western Australia, but not in sufficient quantities to support the quantum of DER projected to be installed by 2030.

Energy sector O&M jobs in WA are still mostly concentrated in Collie and Perth. These will become more dispersed as microgrids proliferate throughout the State. In Horizon Power's service area, there is a significant demand for qualified labour to run and maintain our existing microgrids, especially in remote communities; the cost of flying experienced staff to remote areas is prohibitive, and local, trained labour is short on the ground. Horizon Power recognised this in 2008 and developed an Australia-first trade qualification with two aims: to improve response times and reliability by providing maintenance capability for electricity (and in the future, water) on the ground, and to provide careers in Aboriginal communities that any utility in Australia can adopt. There is an opportunity to expand this program and also relocate and retrain existing energy workers.

There is also a growth area in data science, which delivers operation and maintenance insights from large quantities of data produced by sensors on assets in several sectors, including mining, oil and gas, and other energy-intensive manufacturing operations. The market is also short on experienced data scientists, and Western Australia is competing with worldwide demand for these skills.

Given the scalable nature of the work and the ability to work from anywhere on datasets, several countries, starting with India, are positioning themselves to be the home of international data science hubs. Horizon Power believes the hands-on operational experience on offer at world-class operating sites in WA could make for an attractive value proposition for an international O&M data science service hub in our state.

Horizon Power recognised this in 2008 and developed an Australia-first trade qualification with two aims: to improve response times and reliability by providing maintenance capability for electricity (and in the future, water) on the ground, and to provide careers in Aboriginal communities that any utility in Australia can adopt.

A microgrid ecosystem of both public and private companies already exists in Western Australia. Targeted support in certain areas of the value chain could create low- and high-qualification jobs. While the highly-qualified jobs will continue to grow with demand, it is unlikely that the jobs in the building industry will take off without some form of economic stimulus or legislative change to building codes from the government.

NON EXHAUSTIVE

Figure 15: Western Australian microgrid ecosystem.

The opportunities across the value chain identified above will translate into job creation only if supported by sales both in domestic and international markets.

In the next financial year, Western Power and Horizon Power will invest $300M in microgrid and advanced grid capital. This level of investment is commensurate with that in previous years and has helped suppliers, many of whom do not have a footprint in WA, develop important skills and credentials in the microgrid space. In line with the Australian Jobs Act 2013, we recommend taking into account the economic benefits associated with local industry development analysis at allocation of major contracts, and strategic support to local industry. This should be done over time based on alternative development scenarios that look to aggregate scale and scope across the state, and with a view to maximising the likelihood of domestic industry development and success, irrespective of whether jobs are public or private.

Recommendation 7:	Immediately develop a state-sponsored communications campaign to promote each and every announcement on project investments.
Recommendation 8:	Upgrade energy efficiency housing standards to support peak mitigation and regional building activities.
Recommendation 9:	Mandate an economic benefit study on local jobs and derived tax revenues during the procurement process for major GTE contracts.

2. Opportunity for utility off-grid solutions in Western Australia and beyond

With only one customer per $58km^2$, Horizon Power serves the world's largest and most sparsely populated utility service territory. Historically the only feasible way to electrify at scale such large regional areas involved traditional 'poles and wires' network.

Over the coming decades thousands of Horizon Power customers, and tens of thousands of Australia's regional electricity customers, will be transitioned from a traditional grid connection to more cost-effective new energy alternative provided and managed by their utility.

New energy technologies such as energy storage and solar photovoltaics, however, now promise reduced dependence on expensive fringe-of-grid networks because they are safer and more cost efficient. In this context, Horizon Power and several other utilities have recognised that Utility Off-grid solutions will constitute an entirely new utility asset class. Over the coming decades thousands of Horizon Power customers, and tens of thousands of Australia's regional electricity customers, will be transitioned from a traditional grid connection to more cost-effective new energy alternative provided and managed by their utility.

Transitioning customers to a non-network alternative is more feasible for Horizon Power than any other Australian network business because it is vertically integrated, has an enormous geographic footprint, and operates under a light-handed regulatory framework. In an Australian first, Horizon Power in 2016 adapted vendor-supplied off-grid systems to avoid rebuilding network infrastructure destroyed by bushfire near Esperance.

After upgrades of these systems to utility-grade safety and engineering standards, five units have now been operating successfully for almost two years. Further trials have been deployed at the Exmouth Golf Club and the Fitzgerald River National Park ranger station, which were moved off-grid in 2017.

While this emerging market has enormous scale potential, Horizon Power's trials demonstrated that the established supply chain for traditional off-grid systems lacks depth and maturity. Only now emerging from cottage industry status, the supply chain has largely focused on consumer-grade units sold to and maintained by individual customers. While several market actors are producing elements of a larger solution, no utility or commercial vendor – public or private – has commercialised a full utility-grade offering that is ready to deploy at scale. Unsurprisingly, therefore, the scale efficiencies and cost reductions – without compromise to safety and system longevity – are also yet to be realised.

Most importantly, customers whose utility moved them off-grid, and removed poles and wires, for wider societal benefit do not expect to find themselves responsible for managing and maintaining their power supply or experiencing sub-standard service quality.

As such, this fundamental lack of market maturity and scalability poses a significant issue for utilities wanting to derive the economic benefits of off-grid alternatives. By definition, utilities operate at scale in almost everything, managing and optimising extremely large fleets of assets to serve whole populations. Therefore, beyond pilot projects, even the most promising technology can be considered 'utility-grade' only where it is:

- fully integrated, 'end-to-end', across all utility back-office systems
- designed for multi-decade life cycle efficiencies
- fully scalable for fleet management
- organised to have a regional presence that engenders customer trust.

As noted earlier, Horizon Power and several other utilities have recognised that utility off-grid solutions will constitute an entirely new utility asset class. This is a materially different and far more complex undertaking with more barriers to entry than supplying traditional off-grid units to individual private owners.

It is a serious miscalculation, therefore, to underestimate the difficulty of bringing together all the core elements to implement such a whole-of-system and fully scalable solution. Indeed, the deep involvement of a utility business, ideally a vertically-integrated utility, is an irreducible ingredient in achieving a compelling solution offering. Horizon Power is partnering to help mature the value chain for utility off-grid power solutions in Western Australia and potentially beyond.

Recommendations 7 and 9 apply to the procurement decisions of both Western Power and Horizon Power for utility off-grid solutions.

Recommendation 10: Support the PUO's investigation on deployment of standalone power systems in Western Australia.

3. Promote WA as a research, development & demonstration sandbox to attract innovative companies

With the scale of DER-driven transformation in Australia's electricity systems, key industry funding and regulatory institutions such as ARENA and AEMO are recognising that the nation needs new models for research, development and demonstration (RD&D).

With 37 microgrids and two large interconnected systems, Horizon Power is now recognised as an ideal 'sandbox' for RD&D of technologies and business models for a high-DER future. This is because Horizon Power is:

- Australia's only fully vertically-integrated utility whose employees live and work in the regional communities they serve
- Able to demonstrate 'whole-of-system' benefits of a deep-DER future
- Is subject to a light-handed regulatory framework enabling technology, business model, and DER orchestration demonstrations that are difficult to implement elsewhere
- Highly motivated to collaborate and share knowledge to accelerate Australia's electricity transformation in a systematic manner.

With these unique advantages, Horizon Power is engaging with ARENA, AEMO and a number of other leading Australian utilities on how its portfolio of microgrids may function as a collaborative RD&D platform of benefit to the nation. In collaboration with other industry partners, this is likely to attract federal grant funds for nationally relevant RD&D that is systematic, accelerated and globally-connected. Horizon Power:

- Addresses diverse but interrelated technical, economic and regulatory challenges in a whole-of-system way that is transferable to the NEM.
- Accelerates RD&D that is strategically aligned with transitioning the nation's electricity system and deployed in a collaborative environment that reduces transaction costs and maximises shared learning.
- Is globally connected, aware of major international developments, and can ensure that Australia is positioned to 'leap-frog' unnecessary steps.

Recommendation 11:	Support on-going efforts to secure federal funding for RD&D efforts related to the development and commercialisation of advanced microgrid and micro-power system solutions.

4. Establish a globally-relevant Centre of Excellence for advanced microgrids in WA

To lead the state's microgrid strategy across industry, research, commercialisation of intellectual property, and capabilities in new markets, Horizon Power recommends the establishment of an Advanced Microgrid Centre of Excellence.

A Centre of Excellence (CoE) is a collaborative industry initiative that harnesses the technology, expertise, capability, and thought leadership of recognised energy and microgrid leaders to advance the state of the art in advanced microgrids. It fosters collaborative, cutting-edge research to develop world-class workforce training and education products, and to facilitate commercialisation of creative solutions, intellectual property, and microgrid technologies. This CoE would develop WA, Perth, and Technology Park in Bentley as a world-leading destination for advanced microgrid industry, conferences, study tours, international students, and professional skills training.

A CoE provides benefits to all stakeholders:

INDUSTRY AND RESEARCH	STATE GOVERNMENT	CUSTOMERS	HORIZON POWER & GTEs
o Direct access to ecosystem of portfolio of microgrids across Australia and SE Asia o Located within regulated, developed economy, with ability to standardise process o Access to engaged end-use customers with strong appetite for renewables o Strong research expertise and funding support o Opportunity to test and showcase interoperability of microgrid components o Accelerates commercialisation	o New jobs, enterprise and growth in emerging technology industries o Promotes State and Federal innovation policies o Development of export opportunities that exploit WA's unique context o Diversified non-mining growth in value added industries o Develop WA as leading destination for hosting global conferences, events, tours and awards o Foreign and federal investment potential into the state	o Enhances customer choice by accommodating increasing penetration of decentralised renewables o Provides access to leading vendors and technology o Increases renewable energy penetration & products o Improves reliability and stability of electricity supply o Incentivises lower overall cost of service	o Supports development of advanced microgrids o Give access to cutting edge research and innovation o Contributes to Horizon Power's vision of being the world's best micro-grid company. o Cements local brands as global leaders in their fields.

Figure 16: Stakeholder benefits of a Centre of Excellence.

While microgrids are still an emerging space, a number of microgrid and renewable energy industry collaborations have emerged in recent years, many based in the US:

1. Lawrence Berkeley National Lab – Living Lab for Smart Grids, California
2. New York State's REV Connect Portal – New York
3. MaRS – Energy & Environment, Toronto
4. NREL – Energy Systems Integration Facility, Colorado
5. General Microgrids – Global Microgrid Center, New Mexico
6. San Diego Gas & Electricity - San Diego Energy Innovation Center, San Diego

Figure 17: North American microgrid collaboration hubs.

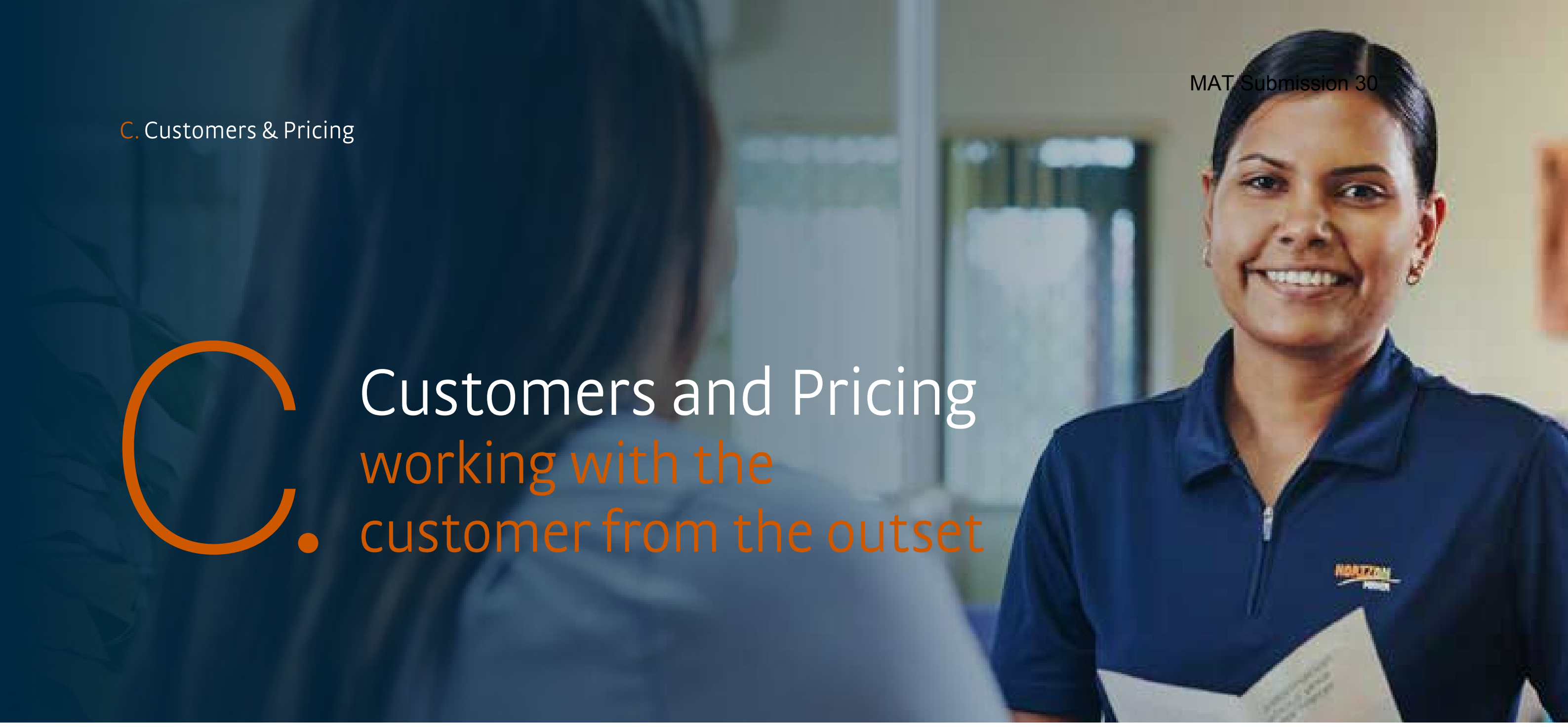
The following high-level process to establish a CoE is outlined below:

- gain commitment of founding industry and research members, including financial investment
- establish CoE governance, management, constitution and agreements on intellectual property development
- secure and fit out microgrid showroom and demonstration site
- establish a granting organisation and secure funding for research and education sponsorships
- installation of live advanced microgrid for demonstration and observation
- develop research agenda, themes and selection criteria
- develop educational and workforce training curricula with university and training partners
- develop incubation pathways and start-up acceleration support program
- design and establish Industry Hub for wider industry promotion, dissemination of knowledge and activation

Horizon Power has already embarked on developing relationships and arrangements consistent with the above for the purposes of accelerating the development of its own microgrids. This can be built on and enhanced from a broader state perspective to increase the multiplier effect.

Recommendation 12: Create a Centre of Excellence for advanced microgrids in WA to coordinate RD&D, intellectual property commercialisation, and new skills development with universities.

Fitzgerald River National Park Stand-alone Power Station



C. Customers and Pricing working with the customer from the outset

1. A changing role for customers in the energy transition

The massive uptake of rooftop solar and other energy technologies is shifting decision-making power towards the customer: Ultimately, it is customers who are exercising growing energy choice – and not the technologies themselves – and driving this transformation.[17] It is clear that microgrids need to be designed with the customer in mind from the outset.

Customers, or their agents, are no longer just consumers but also producers of energy, or 'prosumers'. Their expectations of the future energy supply network will be central to the energy system of the future.

Horizon Power's vision for a successful and fair energy system is to develop, with the community, an energy system that is more affordable for all, reliable at all times, and with sustainable commercial returns that reflect the true contribution to the system and risks carried by all participants.

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At the moment, it is questionable whether Western Australian energy systems are meeting these criteria. For example:

- Tariff structures are inequitable and favour individuals who can afford solar, pushing the large fixed component of the cost of network and generation toward those who cannot
- A substantial reduction in system cost must be driven by a reduction in peak demand, and today, the right behaviours are not signalled or rewarded
- Several customers are left out of the DER revolutions, because of high costs or tenancy status.

Working with the customer on a microgrid transformation points to the need for common understanding and dialogue at the community level.

[17] CSIRO and Energy Networks Australia, 'Electricity Network Transformation Roadmap: Interim Program Report".Report'. CSIRO and ENA, 2015, p. 7.

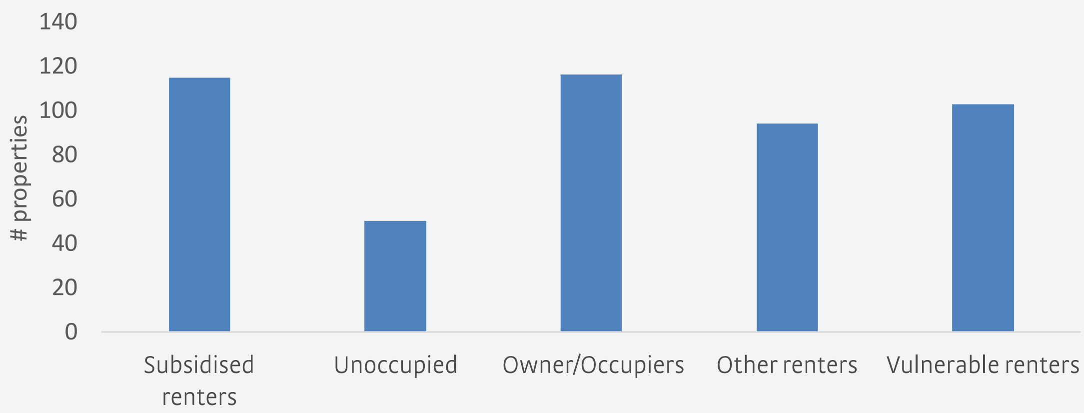
Relevant solutions must be developed to manage the risks inherent in this transition, including general economic conditions and the potential for technology obsolescence. Enabling platforms, such as advanced meters, should also be deployed to enable more local and two-way communication between utilities and customers.

2. Understanding the customer

The first step to working with customers on our energy system transformation is to understand them. When defining customer profiles, Horizon Power considers two distinct dimensions:

- The load profile, which is generally driven by the type of appliance available (air-conditioning, pool pump, hot-water heating, PV), and the number and age of residents
- The motivation profile, which describes tenancy status, disposable income, attitude toward technology, and other demographic and behavioural factors.

Horizon Power's customer base has different motivations from that in the SWIS, mostly because it has a high predominance of renters: those subsidised by employers (mining companies and shires) and others, of whom a high percentage are identified as vulnerable. Onslow's customer base is typical of Horizon Power's footprint:



Low Inertia	Empowered/Incentivised	Service Dependant
I rent and have my Power 100% subsidised.	Resident/Business - I own my property and want to reduce my bills.	I rent my property, I do not have the ability to lower my bills
I would like the potential to Lower my impact on the environment	Resident /Business Lessee - I lease my property and would like to lower my bills	I rent my property and I would like to participate

Figure 18: Distribution of Onslow customers.

a. Understanding the motivations of customers

There is a wealth of empirical evidence from the field of behavioural economics showing human decision-making often diverges from the rational. For example, when customers say they want choice and control, the behavioural research says what they actually want is to save money with simplicity and little bother:

- Most Australians, along with most customers worldwide, have paid for electricity only based on their consumption. Rooftop PV is therefore seen as the means to reducing their electricity bill.
- Customers say they want more control, which is understood to mean control of their bills. Many believe that their power bills are "out of control".[18]
- Until recently, information to assist customers to understand the appliances that drive their energy usage wasn't available. With an AMI network and customer tools such as phone apps, this information is now available to those with an interest in managing their usage costs. In Australia, Horizon Power was the first vertically integrated utility to implement an AMI platform and the first to provide an app with real-time energy usage information to customers.
- Behavioural economic research shows that above all else, people seek simplicity and ease of use. People have a strong, inertial attachment to the status quo (like flat-rate tariffs), and to what's familiar (electricity pricing according to usage, not demand). For this reason, customers tend to stick with the default option even if is patently unsatisfactory and the alternatives offer the prospect of real material gains.

Therefore a change in pricing model to one that reflects the true cost to supply will need to be effectively mandated or, at the very least, constructed as an 'opt-out' model, and implemented to ensure benefits flow to government and customers. This transition will not be without some pain. We know that customers prefer the status quo and are used to paying for the energy they use. The focus for government, through its GTEs, should be to communicate to customers why changes are necessary, how they stand to benefit, and options they have for making changes.

Horizon Power is of the view that the much talked about prosumer, who is expected to be deeply engaged in energy, prepared to invest in DER, and has a propensity to trade energy on a peer-to-peer basis will not materialise in significant numbers. Our research[18], supported by CSIRO, suggests that tomorrow's customers are already here – they are today's customers, and they have neither the time nor inclination, to spend time on energy matters. In fact, tomorrow's customer are here today, and long for the experience of yesterday's customers – in their preference to see energy as 'boring', as an underlying and enabling necessity in life that can simply work in the background, is affordable, and managed by others so that they can focus on all other aspects of their lives.

> "Tomorrow's customers are the customers of today, and long for the experience of yesterday's customers"

[18] Stenner, K and Fischle, M. "Review of MyPower Marketing – Behavioural Economics Perspective". Paddington, Australia: Concentric, 2018.

b. Shining a light on vulnerable customers

Approximately 10 per cent of Horizon Power's customers receive some form of concession, including Energy Assistance Payments. In the last 12 months, 15 per cent of concession cardholders have failed to meet a payment plan or payment extension and are receiving a hardship grant or concession.

Vulnerable customers therefore need consideration and consultation in the transition to a new electricity pricing model and tariff structures. In the implementation of a new pricing option, Horizon Power had face to face meetings with vulnerable customers, members of the Bloodwood Association, who could benefit from the product, with savings of up to $300 a year (Pictured below. See Appendix 2).

MyPower pricing pilot

The ENA/CSIRO describes vulnerable customers as those experiencing energy hardship and households that cannot adopt new electricity solutions given rental property constraints or insufficient capital to invest in energy-efficient appliances or technologies to reduce their bill.[19]

Horizon Power has many such customers who rent and thus do not install efficient, reverse-cycle air-conditioners because the appliances are not transportable—leaving a rental house means leaving that air conditioner behind. Instead, these customers purchase inefficient box air conditioners installed in window spaces, often with poor sealing. Their electricity bills are higher and their quality of living is lower than would be the case with more efficient appliances.

Customers who are vulnerable or in hardship will have similar challenges covering the costs of water, gas, fuel, health care, and so on. There is an opportunity for government agencies and GTEs to improve their understanding of, and provide more effective support for, vulnerable customers by sharing information and working on more comprehensive solutions together. With this information, investments can be directed where most value can be gained.

Recommendation 13:	Create a shared database for public utilities in WA to support the research and development of fit-for-purpose products.

[19] CSIRO and Energy Networks Australia, 'Electricity Network Transformation Roadmap: Interim Program Report'. CSIRO and ENA, 2015, p.8.

Chevron Australia, Onslow Power Project

3. Tariffs and incentives for sustainable and fair microgrids

Utilities can no longer dictate the way their customers purchase products and services. Instead, they must embrace and adapt to the change to remain relevant by working with their customers during this period of energy sector transformation.

a. Tariff structures need to be re-balanced

Under WA's existing uniform tariff system, customers pay for electricity based on a small daily supply charge (the fixed component) and a much larger energy consumption (the variable component).

However, this structure does not reflect the cost of the system, and DER is exacerbating the distortion.

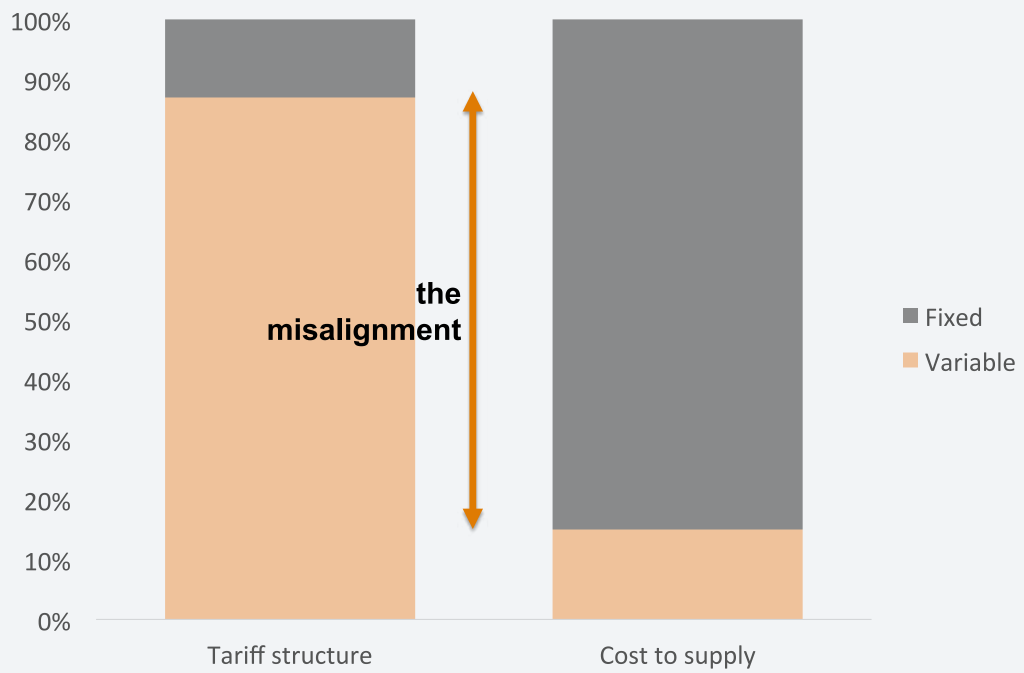


Figure 19: the fixed and variable components of the uniform tariff do not match Horizon Power's fixed and variable costs.

One of the key platforms for reform is to ensure pricing reflects the real cost of electricity (the cost of peak demand) to ensure customers are appropriately incentivised to use electricity efficiently.

The ENA Roadmap recognises customers need to be engaged in taking up products that reduce peak usage and helps them make savings, identifying that this opt-out approach to demand based pricing will result in $17 billion savings across Australia. The key findings of the ENA Roadmap for pricing includes:

- Fairer, more efficient electricity network prices could provide significant benefits, preventing cross-subsidies (in the short and long term) and lowering electricity bills in the long term. They will also function to incentivise investment in both networks infrastructure and DER.
- Tariff reform could save Australian customers up to $17.7 billion by 2034 from more efficient investment in networks and distributed generation capacity.

Horizon Power has been developing a program of price reform since 2013. The conclusions from this work align entirely with the ENA Roadmap.

Building the network to meet peak demand is a major driver of network costs. Around 25 per cent of the NEM, for example, is required to meet only 40 hours of peak demand each year.[20] Most network tariffs are not cost-reflective because they are based on total consumption and not when that consumption occurs.

In its exploration of different tariff structures, Horizon Power found a contract maximum demand (CMD) approach to pricing was the most fair and equitable, as well as the most efficient, for customers and the industry. This is because customer pricing moves to align with industry costs, the fixed costs of poles and wires and generation plant are reflected by the peak demand fixed charge, and variable fuel costs are reflected as a variable consumption charge.

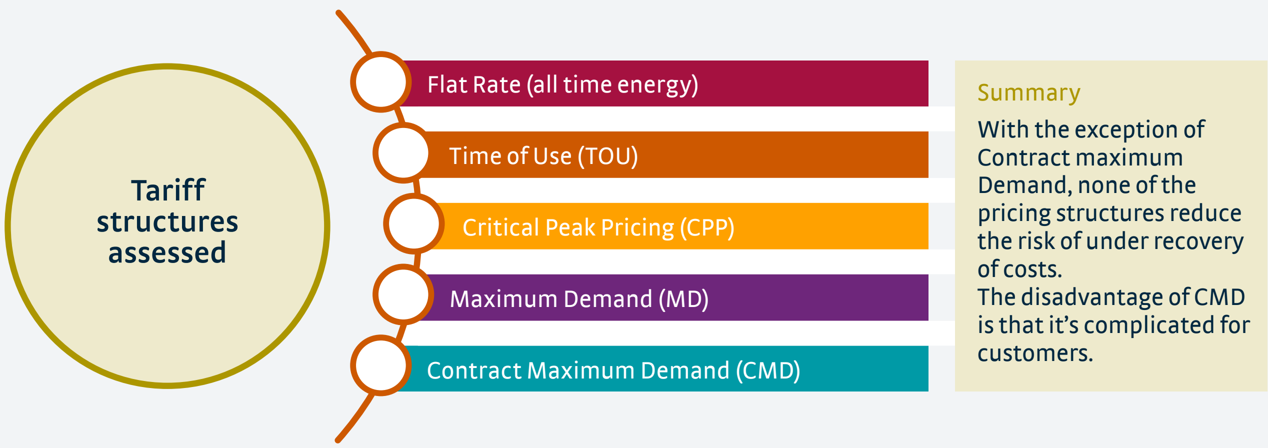


Figure 20: Tariff structures assessed by Horizon Power

CMD is the only pricing structure that aligns revenues to Horizon Power's cost structure, taking into account the effects of disruptive technologies like rooftop solar and, in future, electric vehicle charging. Furthermore, this structure is most easily adapted to future changes in cost structure.

CMD has traditionally been used for larger customers. The challenge of implementing a CMD price for retail customers is that it is more difficult to understand, primarily because the data that drives their bills needs to be followed in real-time. CMD pricing also requires customers to have a smart meter that can capture and present this information.

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20 Energy Security Board, "The Health of the National Electricity Market". 2017, p. 47.

Through its MyPower product, Horizon Power has adapted CMD for small-use customers (mass market) such that pricing resembles that of a mobile phone plan: the fixed charge is higher, and the variable rate is lower. Customers have a peak allowance and are alerted if they exceed it; a smartphone app gives them visibility of their peak energy use.

By aligning customers' usage of system with the cost to supply, My Power provides appropriate price signals to inform DER investment, and it improves Horizon Power's bottom line. Insodoing, it provides a chance to reduce the subsidy Horizon Power receives through the Tariff Equalisation Contribution (TEC).

If the existing uniform tariff policy is maintained, the TEC paid to Horizon Power will increase by 20 per cent by 2030. If pricing structures are reformed, as proposed in MyPower and the ENA Roadmap, the TEC paid to Horizon Power will decrease by nearly 40 per cent by 2030.

b. Incentivise the right DER at the right place

In the spirit of facilitating customer-owned DER from the onset of a microgrid, it is important to properly incentivise DER according to the needs of the community. Incentives for DER should deliver fair value for both energy and ancillary services.

Excess solar energy fed into a grid at noon often does not provide an essential service to the community. This energy would instead be very valuable at 7 pm, when peak demand surges in a larger grid, or in a high-cost town powered by diesel.

COST TO SUPPLY BY FUNCTION

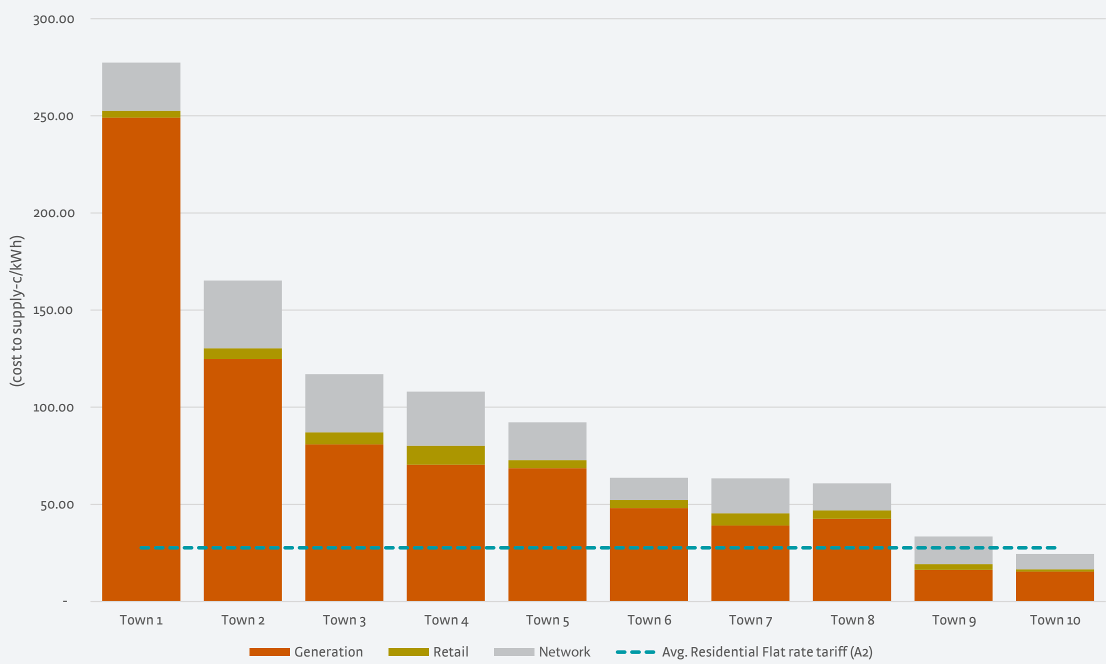

Figure 21: The cost of supply varies in Horizon Power towns; DER may compete with traditional generation in some.

Similarly, the provision of ancillary services through batteries is not yet price-competitive in the Pilbara. But in Carnarvon, battery systems do compete with the cost of diesel, and the utility-scale battery (2MW, 2MWh) Horizon Power has installed there has helped reduce the total cost of system by five per cent, representing savings of $1.4M p.a.

Horizon Power has had incentives in place for DER in its high-cost towns through its renewable energy buyback pricing scheme (REBS). REBS alone is not sufficient to drive significant adoption of DER by residential customers, largely because of the economic capacity of residents, high tenancy rates, and the high rate of government or company ownership of residences.

Recommendation 14:	Support the deployment of a demand-centric pricing structure, like MyPower, as a base tariff in Horizon Power's service area, and throughout the SWIS through installation of advanced meters.
Recommendation 15:	Review feed-in tariff to create local incentives and incorporate ancillary services, so that the right DER is installed in the right place and at the right price.

4. Democratisation of DER solutions

While customer investment in DER is correctly described as the 'democratisation' of the electricity system, this does not mean that everyone in society is equally able to participate or necessarily pay up front to drive the benefit of DER, which may be offered as a service. Neither does it mean that individual customer investments – which over the coming decades may constitute 30 per cent of all electricity system investments – will be capable of delivering optimal outcomes either for the customer or the electricity system.[21]

While a democratised, high-DER future may be inherently exciting, the potential for both social inequities and technical and economic drawbacks is significant. Helping customers successfully navigate this inherently complex area will be critical if positive end-user, infrastructure, and societal outcomes are to be achieved. In this context, the ENA Roadmap highlights the need to consider customer protections and incentives in a holistic manner. For example:

- Introducing a universal national energy services framework and improving information for customer choices on new technologies and services would make a material contribution to supporting active, confident participation in new energy service markets. This in turn fosters innovation and competition to serve the interests of customers with more tailored services and products.

While a democratised, high-DER future may be inherently exciting, the potential for both social inequities and technical and economic drawbacks is significant. Helping customers successfully navigate this inherently complex area will be critical if positive end-user, infrastructure, and societal outcomes are to be achieved.

[21] CSIRO and Energy Networks Australia, 'Electricity Network Transformation Roadmap: Final Report'. CSIRO and ENA, 2017.

- Similarly, clarifying future rights and responsibilities related to reconnection is important to avoid unforeseen consequences in cost allocation or inequity emerging between customers. Supporting a predictable regulatory framework allows for the optimisation of customer and grid investments.

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In regional Western Australia, the greatest challenges communities face in taking up DER are:

- The inability for customers in financial hardship to pay an upfront cost for DER solutions should they have access to them.

- The comparatively high cost of supply and installation of DER products. Where a typical 5kW system in the greater Perth metro area retails for about $4,500, in regional centres such as Karratha, an equivalent system costs about $10,500.

- Tenancy arrangements – 68 per cent of all Horizon Power customers rent their homes. Tenancy introduces split incentives, which erect barriers to the uptake of DER. Split incentives occur when those responsible for paying energy bills (the tenant) are not the same entity as those making the capital investment decisions (the landlord or building owner). In these circumstances, the landlord may not be inclined to make the necessary upgrades to building services or appliances when the benefits associated with the resulting energy savings accrue to the tenant.

Within and across government agencies, particularly those involved in housing, an opportunity exists to reduce electricity costs by facilitating DER uptake at reduced or no cost to the end-consumer. South Australia[22] and the Northern Territory[23] have embarked on such programs.

Similarly, products that offer DER as a service and can spread the benefits of DER between the owner and tenant, need to be developed. In the 'rent-a-roof' concept, the landlord installs rooftop solar on building, with all energy fully exported to the grid; tenants pay for their energy in a fixed amount per period at a rate that reflects the low cost of solar power. The building owner may benefit from a higher building value and happier tenants, and/or any subsidies or grants awarded to offset the capital cost of the solar system.

Recommendation 16:	Invest in government housing (Department of Communities) energy efficiency focused on insulation, efficient air-conditioning and water heating.
Recommendation 17:	Investigate the conversion of concessions, grants, rebates and payments to vulnerable customers for energy-efficiency technologies that decrease energy bills.
Recommendation 18:	Create an innovation taskforce for vulnerable customer DER product development.

[22] Government of South Australia, 2017: "South Australia's Virtual Power Plant", Our Energy Plan. http://ourenergyplan.sa.gov.au/virtual-power-plant

[23] Australian Renewable Energy Agency, 2017: "Northern Territory Solar Energy Transformation Program". https://arena.gov.au/projects/northern-territory-solar-energy-transformation-program/

5. Enabling platforms

Advanced metering infrastructure (AMI) is the enabler of the 21st century electricity system with microgrids at its heart. Over the past three years, Horizon Power has developed experience in deploying and managing AMI across our entire network, as well as advanced pre-payment metering solutions for Aboriginal communities. Common capability provisioned through the AMI program includes remote meter-reading, remote de-energisation and re-energisation, and fault diagnostics. Horizon Power and the State have witnessed tangible and intangible benefits from AMI that have contributed to Horizon Power's $100M subsidy reduction and provided value to customers by reducing safety risks and giving them more choice.

The customer benefits from AMI include accurate invoices (no longer estimated), on-time invoicing, and reconnection of power following either a disconnection for non-payment or moving in within three hours of the request. Previously customers could wait up to six days in remote areas to have power restored. Horizon Power has improved safety monitoring and developed new services and products, which combined are not available anywhere else in Australia. Some benefits that could also be made available to fringe-of-grid customers include:

- Safety: neutral integrity reporting and management

Using AMI voltage and current data, Horizon Power has developed an algorithm that identifies customer premises that may have a neutral fault in their premise. Local crews are automatically sent to investigate and de-energise properties if unsafe.

- Customers informed to make choice

Horizon Power deployed online self-service via My Account in 2014. This web-based service, which contains secure customer account information, can perform limited transactions online.

The Horizon Power App (HAPP), launched in 2017, provides a breakdown of customers' usage so they can better understand how they are consuming power. The HAPP also estimates current expenditure and projects a bill, reducing customer bill shock. Real-time payments are also available, which speeds-up the time to reconnect customers.

Figure 22: Horizon Power App screens

INFORMED TO SEE HOW THEY ARE USING ELECTRICITY

Figure 23: Horizon Power App information

- Efficient and understandable pricing (For more details on MyPower, see Appendix 2.)

MyPower: Interval reading from the AMI network gives MyPower customers current energy usage data, importantly during the peak, so they can monitor their progress against hourly targets.

- Pre-payment

The AMI system underpins the pre-payment system by reading meters regularly reads to determine current account balances and executing commands to re-energise / de-energise in real time.

Recommendation 19:	Deploy advanced meters through the fringe-of-grid of the SWIS and to vulnerable customers as a priority.

RevoluSun Hawaii revolusun.com

Three States in the United States are advancing clean energy through comprehensive reform programs. The following case studies by California consultancy Strategen outline each state's goals and the strategies for achieving them.

New York

New York State's "Reforming the Energy Vision" (REV) is an initiative to utilise the clean energy transformation as an opportunity to build a stronger economy, foster a healthier environment and create a cleaner, more resilient, and affordable energy system. REV is focused on modernising America's electricity infrastructure and is motivated by the observation that the electricity industry has remained fundamentally unchanged for nearly a century, while other industries and sectors have embraced revolutionary technological advances. New York identified three key ways that transformational technology can assist the power system:

1) **Financial Cost:** Electricity bills have risen 32 per cent for the average New York ratepayer since 2004. The existing planning and operation of the distribution system can be inefficient and is also often underutilised.

2) **Environmental Cost:** Electricity generation is a leading cause of greenhouse gas emissions in New York State.

3) **Network Resilienc**e: Superstorm Sandy and tropical storms Lee and Irene left millions of New Yorkers without electricity. A more resilient energy system will be better able to power homes, businesses, and the economy in the face of these increasingly common extreme weather events.

Figure 24: New York Rev Clean Energy Goals

REV has three core pillars that support and guide the approach to achieving the goals seen in Figure 9. These are:

1. **Regulatory Reform to support technological advancement and grid modernisation.** Reformed price signals and compensation structures will reward investments that improve overall system efficiency (e.g., by managing loads to reduce peak demand), engage the private sector to invest in clean energy opportunities, and place clean and distributed energy at the core of the utility business model. By aligning the regulatory system to catalyse and leverage innovation, technology advancement, and private investment, New York is creating increased choice and value for consumers while also protecting the environment.
2. **Market Activation to encourage third parties and achieve optimal outcomes through market mechanisms.** For clean energy to become fully integrated into the energy system, New York must address a diverse set of market barriers and gaps. The goal is to remove barriers and unleash the power of the private sector to lead New York's energy transformation in a meaningful and scalable way, rather than one-off grants and subsidies.
3. **Leading by Example through leveraging its significant public assets, piloting innovative technologies, demonstrating what is possible with customers, providing expertise and showcasing opportunities to invest in grid innovation that will drive cost savings.**

These pillars guide investment in seven separate streams, which all aim to achieve the REV clean energy goals. Each stream has a number of demonstration projects to verify, advance, stimulate, establish and inform the path towards New York's clean energy goals.

1. Renewable Energy
2. Buildings and Energy Efficiency
3. Clean Energy Financing
4. Sustainable and Resilient Communities
5. Energy Infrastructure Modernisation
6. Innovation and R&D
7. Transportation

The important aspects of the REV project are identifying challenges, setting goals that are tailored to New York (e.g. storm resiliency and targeting building energy efficiency), and providing streams to stimulate innovation and new markets in relevant areas. Most importantly, while demonstrations are being done to inform progress, REV is trying to address fundamental aspects such as financing, regulation, markets and underlying frameworks that pose limitations to achieving their goals to create an environment that is sustainable, scalable and conducive to achieving the desired outcomes.

California

In California, energy and environmental policy initiatives are driving significant electric grid changes. Key initiatives are:

- 50 per cent of retail electricity from renewable power by 2030;
- greenhouse gas emissions reduction goal to 1990 levels;
- regulations in the next 4-9 years requiring power plants that use coastal water for cooling to either repower, retrofit or retire;
- policies to increase distributed generation; and
- an executive order for 1.5 million zero emission vehicles by 2025.
- Energy storage mandate of 1,325 megawatts by 2020 (recently increased to 1,825 MW), with installations required no later than the end of 2024

At the distribution level, the California Public Utilities Commission (CPUC) has mandated all investor-owned utilities (IOUs) undertake efforts to integrate DER effectively into their system, called the distribution resource plans (DRP) proceeding. This aligns with California's overall clean energy goals but specifically plans to modernise the grid in order to:

1) Support California's policy of significantly reducing greenhouse gas (GHG) emissions.
2) Modernise the electric distribution system to accommodate two-way flows of energy and energy services throughout the IOUs' networks.
3) Enable customer choice of new technologies and services that reduce emissions and improve reliability in a cost-efficient manner.
4) Animate opportunities for DERs to realize benefits through the provision of grid services.

The DRP outlines a holistic approach to grid modernisation in order to yield the optimum deployment of DERs. The DRP aims to progress the IOUs from traditional utilities to become 'network platforms' that offer a plug and play distribution system (within reason) for DERs to connect, operate and contribute to a low emission, cost-effective, safe and reliable energy system. To achieve the desired outcomes the CPUC offered guidance on the aspects that should be investigated. These are:

1) Demonstration and Deployment
2) Data Access
3) Tariffs and Contracts
4) Safety Considerations

5) Barriers to Deployment

6) DRP Coordination with Utility General Rate Cases

7) DRP Coordination with Utility and CEC Load Forecasting

8) Phasing of Next Steps

The DRP proceeding currently has two key areas, each with its own working group and demonstration project. These are the Integrated Capacity Analysis (ICA), which is a DER hosting capacity tool, and a local net benefits analysis (LNBA), that aims to appropriately value DER. The ICA will direct DER to optimal locations within the distribution network and assist with the interconnection process. The LNBA will value DER for the services it can provide at its embedded location within the distribution network and incentivise its use in valuable areas. Each IOU has a demonstration project to inform, refine and verify the ICA and LNBA. The ICA was comprehensively discussed in the technical report while the LNBA will be discussed in this report.

Hawaiʻi policies and trials toward more managed DER

The State of Hawaiʻi aims to generate 100 percent clean energy by 2045.[24] In 2016 the level of energy provided by renewables ranged by island from 19 per cent to 54 per cent with Hawaiian Electric Companies (HEC) stating that they are on track to reach 100 per cent renewable energy five years ahead of target.[25] In parallel, the HEC are committed to tripling the amount of rooftop solar by 2030.[26]

To achieve Hawaiʻi's ambitious renewable energy goals and satisfying an increasingly involved consumer base, Hawaiʻi is developing an effective technical and market framework and no-regrets roadmap to ensure the transition is in the most reliable, safe, and cost-effective way, while enabling maximum consumer choice and control.

On October 12, 2015, the public utilities commission (PUC) issued reforms to the state's DER programs and rules, mainly through the closing of the NEM program at existing levels with two interim programs for customers seeking DER: customer grid-supply (CGS), and customer self-supply (CSS). The latter effectively blocks exports to the grid. On October 3, 2016, the PUC stated that "all major issues raised in Phase I of this proceeding has been resolved," and Phase II would divide between a "technical" and a "market" track to address medium and long-term solutions for DER. These tracks will include further review of Hosting Capacity Analysis; further revisions to applicable interconnection standards; improvements to existing DER tariffs, which include NEM, CSS, CGS, TOU, and electric vehicle tariffs; and a successor tariff(s) for CGS, CSS, and the Interim TOU Program.[27]

24 https://www.electric.com/clean-energy-hawaii/clean-energy-facts/about-our-fuel-mix

25 https://www.hawaiianelectric.com/about-us/our-vision/triple-distributed-solar

26 https://energy.hawaii.gov/wp-content/uploads/2011/08/FF_Nov2016.pdf

27 https://www.hawaiianelectric.com/Documents/about_us/investing_in_the_future/final_august_2017_grid_modernization_strategy.pdf

Hawai'i has made substantial progress to achieve its 100 per cent clean energy goal as cost effectively, safely, and reliably as possible with the work completed to date. However, much more needs to be done to reach its goal. The relevant State regulatory proceeding's technical and market tracks provide a forum to prioritise the development of agreed upon goals and customer outcomes The Hawai'ian PUC has also procured a detailed roadmap for the near, medium, and long term, to guide progress in both the technical and market tracks. With respect to grid modernisation specifically, Hawai'i has the guiding principles seen in Figure 25.

Hawaiian Electric Companies Guiding Principles to Inform Grid Modernisation
• Enable greater customer engagement, empowerment, and options for utilising and providing energy services;
• Maintain and enhance safety, security, reliability, and resiliency of the electric grid, at fair and reasonable costs, consistent with the state's energy policy goals;
• Facilitate comprehensive, coordinated, transparent, and integrated grid planning across distribution, transmission, and resource planning.
• Move toward the creation of efficient, cost-effective, accessible grid platforms for new products, new services, and opportunities for adaption of new distributed technologies;
• Ensure optimised utilisation of resources and electricity grid assets to minimize total system costs for all customers' benefit;
• Determine fair cost allocation and fair compensation for electric grid services and benefits provided to and by customers and other non-utility service providers

Figure 25: Hawai'i's grid modernisation goals.[28]

[28] https://www.hawaiianelectric.com/Documents/about_us/investing_in_the_future/final_august_2017_grid_modernisation_strategy.pdf

Appendix 2:
Case studies on vulnerable customer energy solutions and MyPower

The ecosystem encompassing DER and microgrids requires a diverse and comprehensive toolkit for addressing inequity and delivering benefits to all players. Fortunately, technology can provide the solutions for inequities between customer groups, as well as in cost and price.

The following three case studies provide examples of Horizon Power's approach to solving technical and social problems by engaging its customers.

Case study: MyPower - restructuring tariffs

During its 2013 strategic review, Horizon Power determined that price reform is imperative if consumer behaviour was to be incentivised to reduce peak consumption, pricing inequalities amongst consumers were to be addressed, and customers were to be given the price signals to drive economically efficient DER decisions.

In parallel with the introduction of advanced meters, and with knowledge of their capabilities, Horizon Power researched alternative pricing models. The research and industry engagement conducted over four years resulted in MyPower, a product whose pricing structure is based on contract maximum demand, rather than the traditional daily fee plus volumetric charge. Using MyPower, customers can control their energy consumption (ideally by avoiding peak periods) and reduce costs. The product was trialled in the summer of 2016/17, with successful broad-scale customer engagement and subsequent peer review, by CSIRO, ENA and the Grattan Institute. From the summer of 2017/18, over 800 customers from Broome and Port Hedland have opted into using MyPower as a demonstration.

To address the opportunities and risks created by the increasing uptake of new customer technologies, MyPower will:

- enable customers to reduce their electricity bill by shifting energy use outside peak times or by investing in technologies such as PV and battery;
- provide information to customers that enables them to understand what appliances and behaviours drive their electricity bill;
- support customers through making bills more predictable and reducing bill shock; and
- better align with the cost drivers of electricity service provision.

The MyPower product is packaged more in the style of a mobile phone plan, leveraging customers' mobile phone plan literacy rather than attempting to develop their electricity literacy.

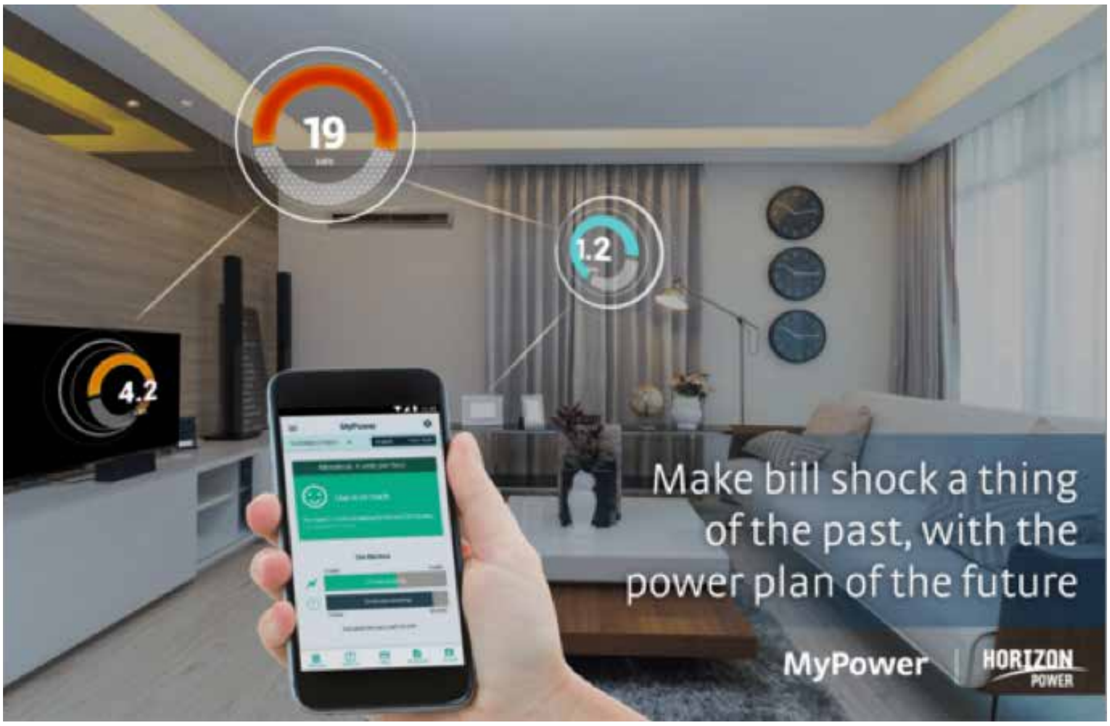


Figure 26: Advertising campaign featuring MyPower.

Customers purchase a plan sized to their historical rate of electricity use during peak times (1pm to 8pm) and pay for each unit of electricity used at a much-reduced rate. The peak period of 1pm to 8pm is only applicable for five months of the year. This means that plan charges are reflective of the fixed costs incurred by Horizon Power to meet energy usage peaks. For example, if a customer contributes a small amount to the peak they pay a small proportion of those fixed costs and those that contribute a large amount to the peak contribute a large amount through the fixed component of the plans. The variable charges reflect variable costs of Horizon Power, largely the fuel costs for electricity.

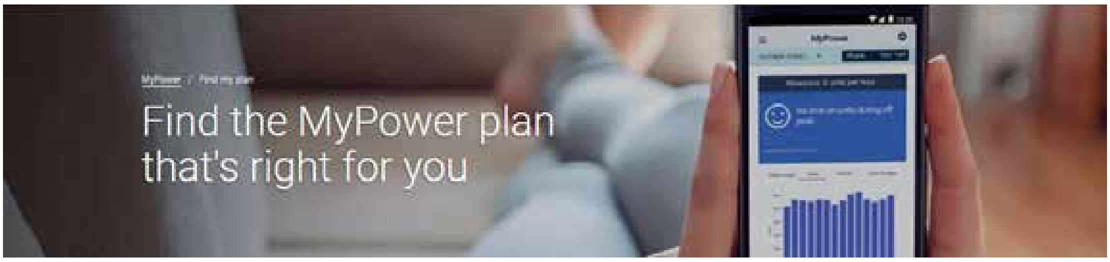


Figure 27: Online MyPower advertising.

In this way customers pay a bill that is proportional to the cost they impose on the electricity system. Customers are also rewarded with discounts to stay on plan and are alerted through a mobile app if they are predicted to go over plan. However, if a customer goes over their plan four times within a year, they will lose all of their rebates and be moved onto a higher plan. Customers can make behavioural changes as they will have near real time visibility of their energy use and can see how turning on and off equipment and appliances affects electricity use.

Horizon Power's learnings from its MyPower product can be leveraged in the SWIS by Synergy and Western Power as advanced meters are installed by Western Power as part of its fourth access arrangement. Advanced meters are essential to the role out of MyPower as they allow the identification of the right plan for customers based on historical individual consumption data and feed usage data automatically to the app and this data is used to alert customers of their peak usage.

Horizon Power customers want options to reduce their electricity costs as well as provide greater bill predictability. Horizon Power has been working with customers to develop solutions that meet these expectations sustainably.

MyPower is more equitable for all customers as the pricing structure more closely aligns with the cost drivers of supply. Customers who use electricity more efficiently (spreading their load rather than turning everything on at once) will be better off on MyPower, whilst inefficient customers with a low demand and a high peak use would not be better off.

There are a number of unique benefits from MyPower for all customers (the product is currently only offered in Port Hedland and Broome during this demonstration phase).

- The product allows customers more choice and control over their bill as they can see their electricity use in near real time and reduce their bill with behaviour change in a way that reduces overall electricity system costs.
- Customers are offered monthly or bi-monthly billing and a much more even bill every month providing a 'bill smoothing' effect. This is a particular benefit for many customers, particularly those on low incomes and those who get large bills over the summer months.
- Customers have the information to understand what is driving their energy use, allowing them to reduce their bill whilst consuming the same amount of energy. (Instead they will use more energy in off peak and less energy in peak).

All these features are highly valued in towns in Horizon Power's service area, particularly in the north of the State where electricity bills can double or triple in summer.

An online calculator allows customers to work out, in a simple way, if they will potentially be better off on a MyPower product as well as allowing for online signup. Horizon Power engages with all customers to assist them to understand the new plans, including the importance of behaviour change.

MyPower rewards customers who can shift load from peak times and may penalise customers who do not. The product removes much of the cross-subsidisation that exists so that smaller customers who contribute little to system peak are better off. Modelling indicates that around 65 per cent of vulnerable customers (e.g. low-income households) will be better off on MyPower.

The product provides the right economic signals in line with the emerging distributed energy market, so will encourage further take-up as battery prices continue to fall, allowing customers to drop down a plan and make significant savings.

The CSIRO have reviewed the MyPower product and provided insight based on behavioural economics. Their conclusions indicate that MyPower will meet its stated objectives and that MyPower provides more fair and equitable pricing for customers with an effective and equitable economic signal. Customer perceptions of this will need to be managed as with any significant change.

The CSIRO also concluded that customers will accept the new product although there will be issues in the short term, again based on customer perceptions and individuals that will not be advantaged.

Case study: vulnerable customers

In modernising our energy systems and regulating them in the context of DER, all customers should be afforded the opportunity to take advantage of changing technology, lower prices, and more consumer-centric services.

In particular, the concerns of vulnerable customers should be taken into account.

To this end, Horizon Power has been working with members of the Bloodwood Tree Association, a not-for-profit charitable organisation in Port Hedland that provides services for the homeless, unemployed, those affected by alcohol and other drug use, to help with electricity bill debt and determine whether they could benefit from Horizon Power's MyPower product.

At monthly morning teas with Bloodwood Tree members who are Horizon Power customers, Horizon Power staff help with energy-saving advice, payment plans, budget cards, rebates, and using MyPower.

Figure 28: Morning tea Bloodwood Tree Association members and Horizon Power.

Member June Tullock says she appreciates the face-to-face information sessions and help she got signing up to and using MyPower. Many members do not use the internet, she said, and often missed information on websites as well as related advertising and promotion.

Horizon Power has learned that vulnerable customers need tailored support, like in-person meetings, to use its products and services. Horizon Power may also have to amend its standard help information, like SMS alerts, which will not work for customers who do not have a smart phone.

Case study: pre-payment options

In the past, some social services groups viewed pre-payment metering as a mechanism that unfairly discriminated against vulnerable customers, particularly in Aboriginal communities. The chief reason for this was a poor understanding of how disconnections applied (frequency and timing), along with the inability of vulnerable customers to access payment extensions and appropriate concessions.

In 2010, Western Australia's Code of Conduct for the Supply of Electricity for Small Use Customers was revamped to provide a system that would provide concessions more equitably, give regulatory bodies better visibility of pre-payment activity, and improve the safety net for vulnerable customers. Of the more than 1000 residences with pre-payment meters (PPMs), more than 95 per cent of customers choose PPMs over a credit bill.

The new pre-payment system enables customers to pre-purchase electricity from local stores (recharge operators), and within minutes of this purchase, the credit is added to the meter. If the meter is de-energised, then the meter is armed for the customer to press a button on the meter to reconnect power. PPM customers are also provided with low credit warning via SMS and granted $20 emergency credit before 9am and after 2pm weekdays and on weekends, public holidays when recharge operators are unavailable to purchase electricity. This system provides customers the ability to appropriately manage and prioritise the availability of electricity. Direct feedback from customers in particular communities have appreciated the smaller, more frequent payments rather than receiving a significant invoice over two months that they have no ability to repay. Customers have also appreciated the fact their family members can make payments to their account. This was a problem with post-paid (or credit) accounts, where visiting family members created significant bills, leaving the account holder with a bill at the end of the period that was unaffordable.

Recently, Horizon Power, Western Power and Synergy collaborated to provide this service to the customers of Ninga Mia, a community near Kalgoorlie operated by Synergy and Western Power in the SWIS.

The pre-payment system has been incredibly successful in providing vulnerable customers with choice and debt management support. Since deployment, there have been numerous enhancements to the product to further provide more assistance to our customers. Such items include: direct credits from Centrelink to their meter. Via Centrelink, customers can elect to have their payments sent directly to their meter which reduces the need to regularly visit recharge operators and top up their balance. As per the Centrelink credits, Government rebates are directly credited to customer accounts based on the concession cards they have. The next enhancement which will be available in quarter two of 2018 to pre-payment customers is real-time payment and visibility of the account status via the Horizon Power App (HAPP). The following screen shots provide an overview of the next enhancements to the HAPP.

Figure 29: New payment feature set.

Customers and non-customers (other family members) can make a payment directly to the pre and post-payment accounts. Payments to pre-payment accounts will go directly to the customer's meter and if de-energised will be automatically armed to enable electricity supply to be returned.

Figure 30: Pre-payment features.

Figure 12 provides a snapshot of what a registered pre-payment customer will see. They have full visibility of their balance, usage and estimated time remaining until they need to purchase more credit. The extension of the Horizon Power APP incorporating pre-payment provides customers the ability to top up whenever they want, without having to wait for a local store to be opened or to travel long distances to purchase power. Additionally, the new app provides scalability and allows vulnerable customers outside of current pre-payment communities to use pre-payment. Once tested and proven, Horizon Power is looking to provide this choice to vulnerable customers.

Horizon Power is looking to further expand and offer the choice of pre-payment to other customers segments. There are options to also provide pre-payment to other customers that are experiencing payment difficulties.

Appendix 3: High DER technical challenges, Hosting Capacity and DERMS

Technical challenges of increased DER on small electrical systems

Excessive unmanaged DER connected to a network quickly highlights the power systems limitations and creates operational and power quality issues, which can include:

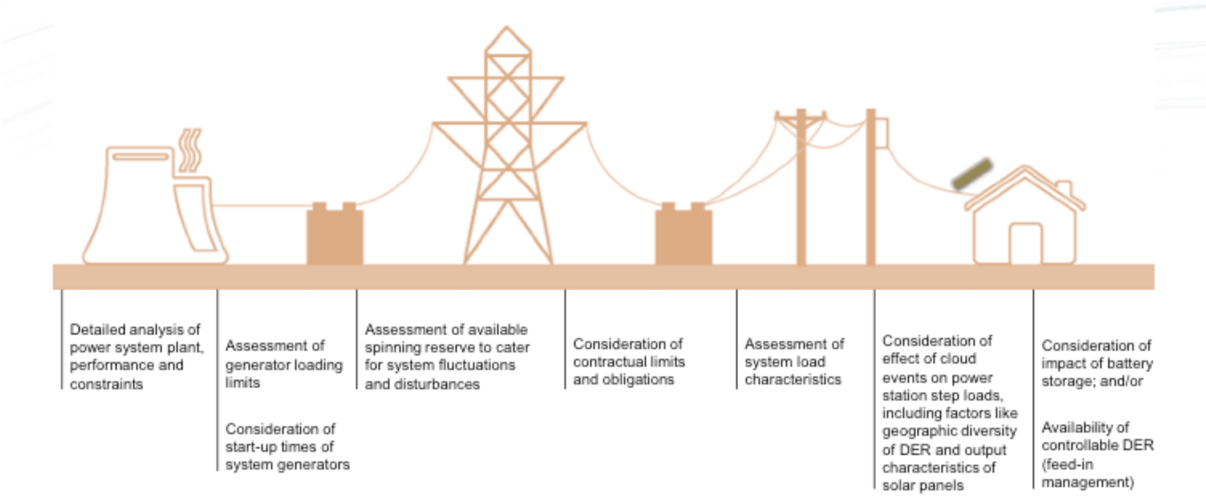
1 Planning	• More complex system planning
2 Protection	• Reduced protection sensitivity because of lower system fault levels • Increased voltage flicker because of changes in system fault levels • More complexity in managing system voltage, and requirement for additional voltage support from DER
3 Power Flow	• Reduced ability to start large motors or energise feeders with a high degree of motor load • Increased system harmonics because of higher inverter-based generation • More complexity in managing system frequency and requirement for additional frequency support from DER devices • Higher network loadings because of reverse power and battery charging

Figure 31: Technical Challenges from high DER.

Hosting Capacity Methodology

Horizon Power is committed to using and promoting renewable energy. To safeguard the quality of electricity to each community, we have set a Hosting Capacity (also known as Distributed Energy Target) in all the towns supplied. This target means how much rooftop solar Horizon Power's electricity system can accommodate without disrupting supply to its customers.

To calculate hosting capacity limits, Horizon Power uses a comprehensive methodology that features the following considerations across the electricity system:



DERMS conceptual architecture

The figure below presents a high-level concept for the DERMS solution that Horizon Power plans to deploy. The DERMS is expected to provide an interface between Horizon Power's systems operations centre and its 37 remote microgrids by the end of 2020. Some of these microgrids could be operated by other utilities, third-party aggregators or other customer-owned DERs.

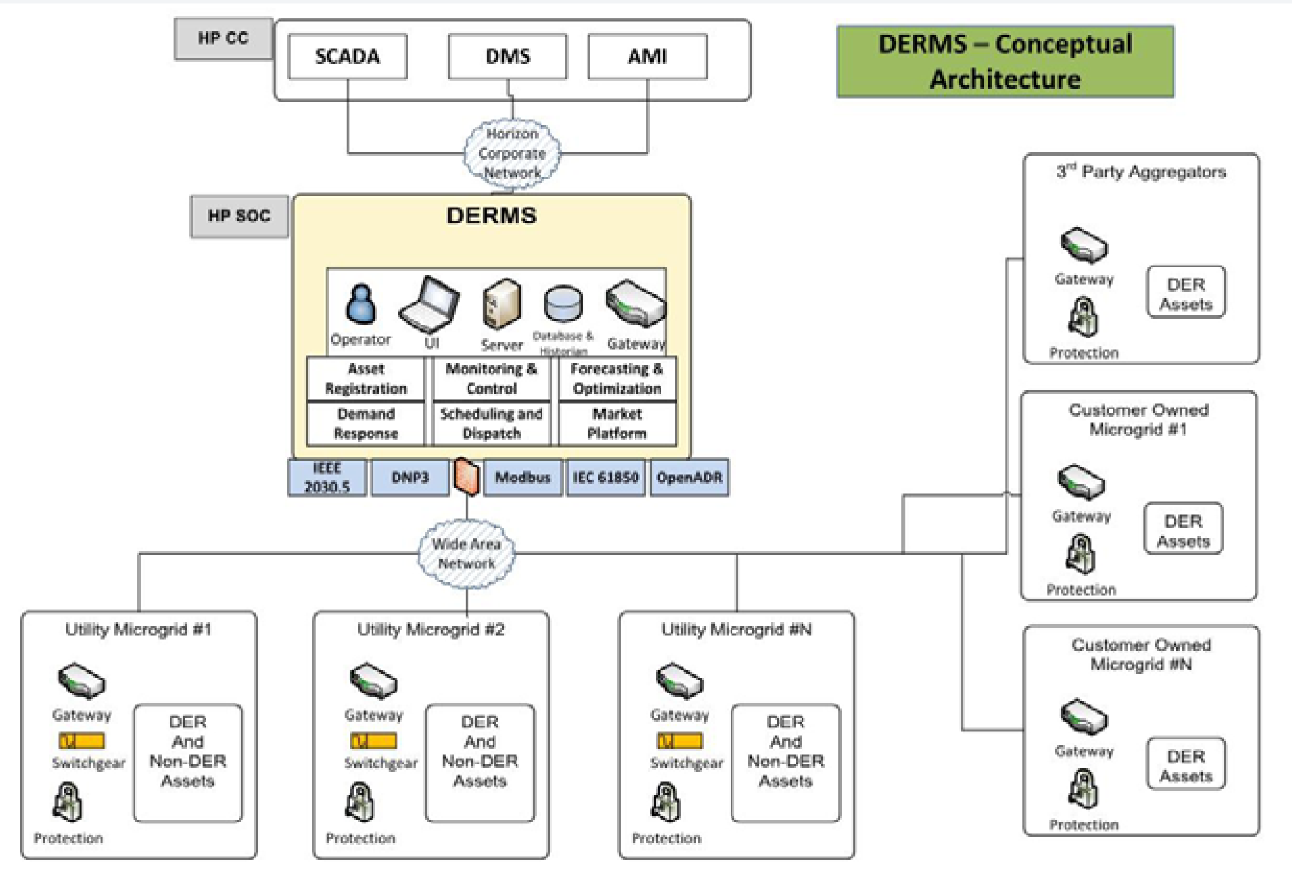


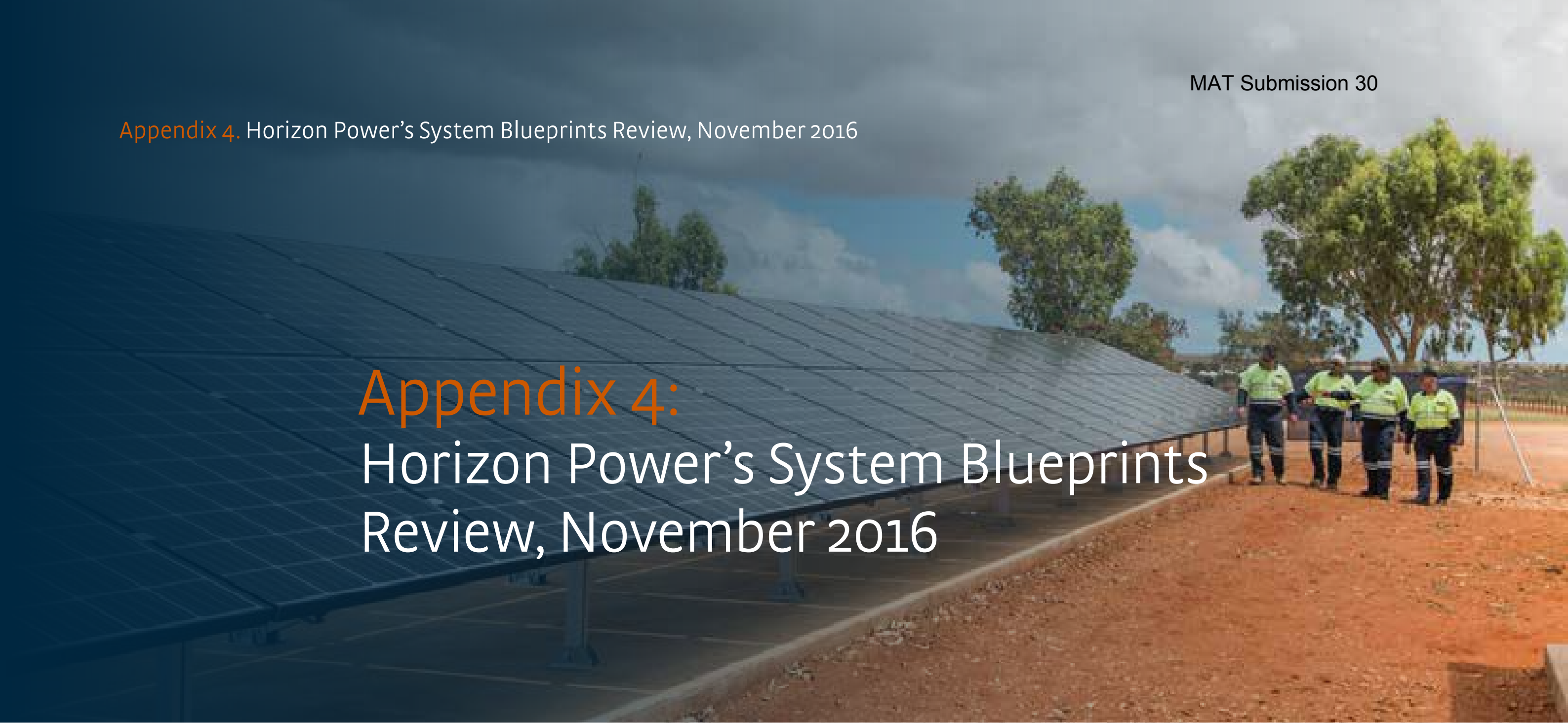
Figure 32: Horizon Power DERMS conceptual architecture.

Given the potential for DERMS to meet emerging needs in Western Australia, Horizon Power is focussing on using DERMS to deliver a series of benefits across its systems. The coordinated management of distributed and renewable generation, energy storage, and demand response can deliver significant value to the host utility, including:

- Distribution Services Management – i.e. enhancing system resiliency and reliability via peak shaving, managing voltage profiles, voltage/frequency regulation and support of renewable smoothing
- DER Device Management, Monitoring and Control – e.g. shifting load away from high price periods and providing situational grid awareness
- DER Optimisation, Scheduling and Dispatch – e.g. improving load factor through load shaping, providing economic and environmental dispatch, and customer load priorities
- Minimising system losses through phase balancing and improved power factor
- Managing congestion and circuit overloads, which defers capital expenditures
- Market Operation - supplying ancillary and other Grid Services to bulk power and electricity markets, transactive energy platforms, and facilitating load and price-driven demand management

Following are the key functions or features that a DERMS solution shall support to meet the objectives of the above use cases:

- Systems Operations Centre – Enables operation of the DER through a control centre.
- Data Acquisition – Acquires and maintains power system topology and parametric data for network connected DER under active management of DERMS.
- Field Equipment Integration – Enables integration of devices in the field that connect the DER to the DERMS. Allows creation of protection schemes for the DERs to effectively participate in the DERMS area of operation.
- DER Management – Provides access and enables oversight and management of various DERs under its area of control.
- Change Management – Allows expansion of DERMS control area through modular change and expansion.
- Enterprise Integration – Enables integration with backend systems and other systems in Horizon Power's operations centre.
- Application Management – Enables incremental extension of capability with modular applications for selective installation or uninstallation.
- User Access and Management – Enables secure access to authorised users and stakeholders.
- Security – Implements high-level security functions that enable safe modes of operation for the DERs and protects the data from these resources.



Appendix 4:
Horizon Power's System Blueprints Review, November 2016

Recognising the challenges facing Australia's electricity networks, the CSIRO in 2012 convened the Future Grid Forum (FGF) to explore what the sector might look like in 2050 and how it might best plan for its future. In December 2013, the Forum published its findings, which envisioned four scenarios that it used for extensive modelling, analysis, and social research.

Building on the FGF, the CSIRO in 2013 partnered with the Energy Networks Association (ENA) to develop the Electricity Network Transformation Roadmap (the Roadmap), focussing on the next decade of industry transformation. Aims of the Roadmap process were to identify new services and technologies that future customers would value, along with the best and most economically efficient options for regulation, business models and pricing to support delivery of those services.[29]

In October 2015, the CSIRO published its Australian National Outlook, its landmark attempt to scientifically model the relationships between energy, water and food in Australia's economy. In exploring the nation's economic activity, resource use, and environmental performance and living standards between 1970 and 2050, the Outlook also presents scenarios for future planning that it hopes will inspire conversations about resource planning and economic investment amongst decision-makers and the wider community.

Following Horizon Power's 2013 strategic review, the System Blueprint project was established to help determine the most economical way to deliver energy to each of Horizon Power's service areas. The System Blueprints methodology forecasts the levelised cost of energy (LCOE) over time for three different 'business futures' – centralised generation, distributed energy resources (DER), and standalone systems – modelled against business as usual. For each of its 38 systems, Horizon Power now has a System Blueprint designed to guide new investment decisions like contract renewal, asset management, and network expenditure.

Familiar with the CSIRO's work with scenarios, Horizon Power in mid-2016 engaged the CSIRO's Energy Research unit to analyse the Systems Blueprint methodology, with a view to more accurately assessing the plausibility of the business futures and to incorporating scenarios into Horizon Power's regular strategic planning.

[29] CSIRO and Energy Networks Australia, 'Electricity Network Transformation Roadmap: Interim Program Report'. CSIRO and ENA, 2015.

The aims of the collaboration between CSIRO and the Strategy team were to:

- construct a set of Horizon Power-specific scenarios
- identify, quantify and test key drivers, and develop narratives for the resulting scenarios
- define characteristics of each scenario to allow for sensitivity analysis of business futures in relation to Horizon Power systems and projects.

The CSIRO gave a presentation to the board in August 2016 laying out the case for scenarios, its history in developing and using them (including work in the electricity sector), the process the CSIRO uses to develop scenarios, and their applicability to Horizon Power.

The collaboration between Horizon Power and the CSIRO is now complete, resulting in:

- a set of scenarios closely aligned to those of the FGF, but with factors specific to Horizon Power
- a set of drivers, also specific to Horizon Power's business and operating environment
- a dataset encompassing 12 variables over 25 years and the four scenarios.

In addition, the CSIRO has delivered to Horizon Power a report comprising:

- its analysis of the System Blueprints methodology
- recommendations for improvements on the methodology.

This report summarises the CSIRO's work on scenarios, the outcomes of the collaboration between Horizon Power and the CSIRO, the CSIRO's analysis and support of Horizon Power's use of Strategic Blueprints, and the case for applying scenarios to Horizon Power's strategic planning.

Outcomes from the Future Grid Forum

The FGF also took the form of a collaboration, between the CSIRO and members of the Australian energy sector, including large consumers and producers of electricity, peak bodies, consumer groups, governments, and academia and think tanks. CSIRO describes the result of project as 'the first extensive whole-of-system evaluation encompassing the entire energy chain – from generation through to consumption.'[30]

In its report, Change and choice: the Future Grid Forum's analysis of Australia's potential electricity pathways to 2050, the forum considered drivers for change facing Australian utilities and other electricity sector stakeholders:

- electricity costs and bills are rising
- peak demand and consumption are falling
- there is an oversupply in generation capacity
- residential prices are not aligned with costs

[30] CSIRO, "Change and choice: the Future Grid Forum's analysis of Australia's potential electricity pathways to 2050". Newcastle: CSIRO, 2013.

- decarbonising the sector has begun but has a long way to go
- carbon policy remains uncertain
- attitudes about reliability and costs are changing.

FGF cited three categories of uncertainty it needed to capture in developing scenarios: general uncertainty around fuel prices, technology costs, and policy; major sectoral shifts including cheap energy storage, declining demand for traditional, centrally supplied power, and the need to reduce emissions; and finally, a spectrum of consumer participation in energy provision and consumption.

FGF then presented four scenarios that represent conceivable future states of Australian electricity networks:

1. set and forget – where consumers rely on utilities
2. rise of the prosumer – where consumers actively design or customise solutions
3. leaving the grid – where consumers disconnect from the grid
4. renewables thrive – where storage plays a large part in the entire electricity system[31]

Four 2050 scenarios

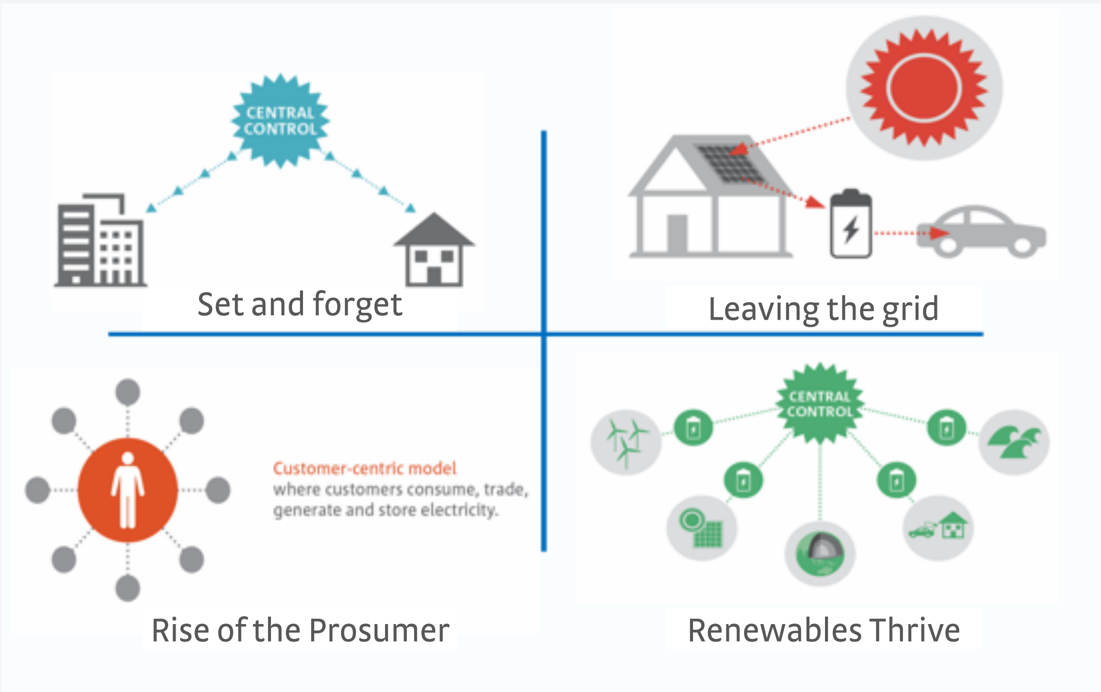


Figure 33: Future Grid Forum scenarios.

[31] CSIRO, 2013: Change and choice: the Future Grid Forum's analysis of Australia's potential electricity pathways to 2050. Newcastle: CSIRO, pp.14-15.

Finally, FGF explored the complex interactions of aspects of the scenarios with aspects of the electricity value chain: consumers, costs, reliability, emissions, climate change, policy uncertainty, and so on. These four scenarios were also mapped to Horizon Power's footprint and associated challenges, with the likehood that they would be appropriate for the SWIS as well.

Outcomes from the Electricity Network Transformation Roadmap

The first stage of the Roadmap project concluded in December 2015, when the collaboration, in which industry members and over 200 customer representatives participated, published its interim report. Drawing on the same scenarios in the FGF, the report emphasised the shift – in all four scenarios – of investment decision-making from utilities to end-users.

Other major findings included:

- solar and battery costs fell since the project commenced in 2013, with the trend to continue
- implementing DER will help overcome many network challenges but will require changes to regulation, standards, and technology
- significant expenditure (in the order of $300 billion each) will be required by both networks and consumers for all scenarios by 2050
- the electricity sector could make a meaningful contribution to Australian greenhouse gas emissions reductions
- overall network expenditure will be in the order of $1 trillion
- the long-term outlook for customer bills has improved since the project began in 2013.[32]

The Roadmap process stressed the role of customers in energy transformation, noting that tariff reform would be instrumental in managing transitions. In May 2016, the ENA published the Electricity Network Tariff Reform Handbook to help utilities and policy-makers plan and implement the changes needed to bring prices in line with costs and to offer the right incentives to consumers.[33]

In October 2016, the Roadmap published its second major report, *Unlocking value for customers: enabling new services, better incentives, fairer rewards*. For *Unlocking value*, six scenarios were analysed, with an emphasis on how pricing reform could influence changes to networks. Among the conclusions of this analysis:

- earlier transition to demand-based tariffs will provide economic benefits
- customers should be encouraged to shift to new tariffs
- smart meters are essential to demand-based tariffs
- demand-based tariffs will need to be adapted to new technologies as costs come down

32 CSIRO and Energy Networks Australia, 'Electricity Network Transformation Roadmap: Interim Program Report'. CSIRO and ENA, 2015.

33 Energy Networks Association: *Electricity Network Tariff Reform Handbook*. Kingston, ACT: ENA, 2016.

- implementing DER could obviate over $16 billion in network investment, prevent cross-subsidies, and reduce network bills
- new pricing structures could accommodate customers with standalone power.[34]

Work on the Roadmap continues, with more reports on regulatory and technological enablers due later this year.

Outcomes from the *Australian National Outlook 2015*

The Roadmap explore scenarios for the country's electricity sector, the *Australian National Outlook 2015* projects a series of futures for the nation itself. Like the FGF, the Outlook aims to encourage discussions between policy-makers, analysts, and the wider community when considering decisions that could determine the nation's future, with particular regard for the use of and interaction between its most important resources: water, energy, and food:

> *National Outlook* is a unique tool to help us navigate to prosperity through an uncertain future, by providing a scientific assessment of the complex connections and interactions between economy activity, resource use and the environment.[35]

Many scenario-building processes explore a number of factors driving the uncertainty with which decision-makers must grapple. The Outlook looked at six:

- global economic demand
- global climate, greenhouse gas abatement effort
- Australian resource efficiency
- Australian working hours and consumption mix
- Australian land sector mix
- Australian agricultural productivity

Adding levels of sensitivity to these global and national drivers made for a combination of over 850 possible combinations, each representing a potential scenario. To make its analysis 'tractable', the Outlook team then supplemented its modelling of 20 core scenarios with sensitivity analysis; this distilled the combinations down to four 'touchstone' scenarios, which it named:

1. Stretch: strong actions to reduce emissions lead to lowest resource utility and emissions intensity
2. Mixed: emissions abatement improves, along with land sector markets; working hours and consumption do not change
3. Existing trends: energy and water efficiency improve, working hours decline, land sector markets emerge, emissions reductions improve modestly

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34 Energy Networks Association, 2016: "Unlocking value for customers: enabling new services, better incentives, fairer rewards." Kingston ACT: ENA.

35 Hatfield-Dodds, S., et al., 2015: *Australian National Outlook 2015: Economic activity, resource use, environmental performance and living standards, 1970–2050.* Canberra: CSIRO.

4. Material-intensive: assumes no progress in emissions reductions, and no changes to trends in working hours, consumption or land use.[36]

The *Outlook* then posits that Australia can look forward to a bright future without having to pit economic prosperity against sustainable resource use and environmental health – provided it pursues the right policy decisions and institutional settings.

CSIRO and Horizon Power collaboration

Horizon Power's work on System Blueprints has highlighted the rapid changes under way in the electricity sector and the degree of uncertainty these pose to the organisation. Aware of the CSIRO's work on scenarios, in particular the Outlook, Horizon Power asked the agency for an independent view of the System Blueprints.

On Horizon Power's approach to the System Blueprints, the CSIRO was largely positive, noting the methodology:

- provides a rational, quantitative basis for comparing costs of three plausible alternatives for meeting projected customer electricity demands
- provides a repeatable, transparent indication of when a planner might switch to an alternative system design, and
- is sensitive to all major factors likely to have a significant impact on those relative costs.[37]

The CSIRO then made some useful recommendations for enhancing the System Blueprints method:

1. perform sensitivity analysis on key uncertain assumptions to improve understanding of the circumstances under which the least-cost system design varies among the three business futures
2. analyse more generation options, more customer preferences and behaviour, and a comprehensive range of costs
3. use the cost analysis as a starting point for designing economically efficient transitions from existing centralised networks towards more distributed configurations
4. develop business models and network designs that are economically efficient, while balancing customer choices against the community advantages of shared infrastructure. [38]

Confident that its method for assessing when and how to move to a new supply model was sensible and robust, Horizon Power could then build on it to incorporate future pathways into its strategic planning. The collaboration with the CSIRO thus proposed customising scenarios for Horizon Power as a way of optimising the System Blueprints.

[36] Idem, pp.6-7.

[37] Brinsmead, T., 2016. "Review: System Blueprints Method". Newcastle: CSIRO Energy, p. 7.

[38] Idem, pp. 8-9.

Generating the drivers and scenarios

CSIRO and Horizon Power employed the following steps when developing scenarios:

- Identify key drivers influencing Horizon Power's (and the Australian electricity industry's) future
  - Identify broad range of qualitative drivers
  - Prioritise drivers in terms of significance of impact
  - Identify key uncertainties in drivers
- Group driver outcomes within qualitative scenario narratives
  - Identify likely correlated drivers
  - Cluster driver outcomes into groups
  - Develop a handful of brief scenario descriptions
  - Prioritise a small number of scenarios and extend description
  - Refine set of prioritised drivers
- Identify quantitative indicators corresponding to drivers
  - Identify broad range of quantitative indicators corresponding to drivers
  - Identify potential data sources corresponding to driver outcomes for distinct scenarios
  - Refine extended scenario descriptions and set of prioritised drivers.

As can be seen in the task outline above, developing and refining the drivers entailed the bulk of the work, and with good reason. According to the CSIRO, "the purpose of driver identification is to prioritise the key influences on the future of interest, in this case, the outlook for Horizon Power's business future."[39]

The drivers identified in the collaboration were derived from a combination of CSIRO published research on global "megatrends" and CSIRO's scenario work in the FGF, Outlook, and Roadmap.

Because scenarios had already been developed for the electricity industry in the FGF and the Roadmap, the four FGF scenarios in Figure 33 provided a natural starting point for the development of Horizon Power's scenarios.

Driver qualitative outcomes were matched with scenario names, as a means of starting to refine the scenarios in detail. Other techniques, including quadrant analysis, trajectory grouping, and performance trade-off analysis, were then employed to ensure the scenarios would capture a broad range of distinct and different factors.

[39] IBrinsmead T. and Graham P., "Scenario Data Pack – accompanying notes". Prepared for Horizon Power", 2016, p. 2.

A table of the four FGF scenarios, along with two additional scenarios (Microgrid Revolution and Resources Resurrection), and 13 Horizon Power-specific drivers, was then used to refine the scenarios:

	Set and Forget	Rise of the Prosumer	Leaving the Grid	Renewables Thrive	Microgrid revolution?	Resource resurrection? / Tourism / Other?
Regulatory Environment	Slow regulatory reform	High contestability	High contestability	Slow regulatory reform	Moderate regulatory reform	Slow regulatory reform
Cost of PV and Batteries	Moderate cost	Moderate cost	Low cost	Low cost pv and other renewables	Low cost	Moderate cost
Fossil fuel accessibility	Low oil price	Moderate oil price	Moderate oil price	Low cost, accessible gas	Moderate oil price	High oil price
Customer engagement	Low engagement	High engagement	High engagement	Low-moderate engagement	High engagement	Low-moderate engagement
Native Demand profiles	Moderate peak to average ratio	High peak to average ratio	Moderate peak to average ratio, high EV uptake	Moderate peak to average ratio	Moderate peak to average ratio	Moderate peak to average ratio
System Scale	All representative scales required	All representative scales required	All representative scales required	All representative scales required	All representative scales required	All representative scales required
customer Diversity	Low diversity	High diversity	High diversity	Low diversity	High diversity	Low diversity
Demand Growth	Moderate demand growth	Moderate demand growth	Low demand growth	Moderate demand growth	Moderate demand growth	High demand growth
Cost focus	Strong cost and reliability focus	High customer autonomy focus	High customer autonomy focus	Strong cost and reliability focus	High community focus	Strong cost and reliability focus
GHG emissions focus	Low decarbonisation	Moderate decarbonisation	Strong decarbonisation	Strong decarbonisation	Moderate decarbonisation	Moderate decarbonisation
Economic and population change	Moderate change	Moderate change	Moderate change	Moderate change	Moderate change in population distribution	Large change in population and economic structure
Novel Tariffs / energy services	Moderate change	Many new services	Moderate change	Moderate change	Many new service offerings	Moderate change

Table 2: Preliminary Horizon Power-specific scenarios and drivers.

To keep the total number manageable, the proposed scenarios Set and Forget and Resources Resurrection were combined into a single hybrid scenario named Strong Growth, while elements of Microgrid Revolution were rolled into Rise of the Prosumer and Leaving the Grid, yielding the following set of Horizon Power-specific scenarios and drivers:

36 Idem, pp.6-7.

37 Brinsmead, T., 2016. "Review: System Blueprints Method". Newcastle: CSIRO Energy, p. 7.

38 Idem, pp. 8-9.

Driver	Strong Growth	Renewables Thrive	Rise of the Prosumer and Microgrids	Leaving the Grid
Economic and population change	Large change in economic structure and population	Limited change	Moderate change in population distribution	Limited change
Centralisation	High centralisation	Moderate centralisation	Decentralisation	Decentralised renewables
Demand Growth	Strong demand growth	Moderate demand growth	Moderate demand growth	Low demand growth
Fossil fuel accessibility	High oil price	Low cost, accessible gas	Moderate oil price	Moderate oil price
GHG emissions focus	Low decarbonisation	Strong decarbonisation	Moderate decarbonisation	Strong decarbonisation
Cost of PV	High cost	Moderate cost PV	Moderate cost	Low cost PV
Cost Battery storage	High cost	High cost batteries	Moderate cost	Low cost batteries
Centralised Renewables costs	High cost	Low cost	Moderate cost	Moderate cost
Network capital costs	Moderate costs	Low costs	Moderate costs	High network costs
Minigrid costs	High costs	Moderate costs	Low costs	Low costs
Regulatory Environment	Slow regulatory reform	Slow regulatory reform	High contestability	Moderate regulatory reform
Novel Tariffs/ energy services	Limited change	Moderate change	Many new services	Moderate change
Cost focus	Strong cost and reliability focus	Strong cost and reliability focus	High customer autonomy and community focus	High customer autonomy focus
Gross Demand profiles	High load factor	Moderate load factor	Low load factor	Moderate load factor
Net Demand Profiles	Moderate load factor	Moderate load factor	High load factor	Low load factor
Customer engagement	Low engagement	Low-moderate engagement	High engagement	High engagement
Customer behaviour	Insensitive to price	Will invest in tech if more economic or reliable	Enthusiastic uptake of new technologies and products	Preference for autonomy
Customer Diversity	Low diversity	Moderate diversity	High diversity	High diversity
EV uptake	High EV uptake	Moderate to high EV uptake	High EV uptake	Low EV uptake

Table 2: Final Horizon Power-specific scenarios and drivers.

Figure 34: Horizon Power-specific scenarios.

The next step in the process was to identify relevant quantitative indicators that characterise each of the drivers and can be used in Horizon Power's strategic planning processes. The CSIRO noted that it will be important for Horizon Power to include in its planning process parameters such as the likely preferred generation scale and mix, required investment in network infrastructure, range and equitability of tariffs available to customers, and electricity prices. Hence, quantitative drivers that affect these planning parameters, and that vary significantly across the selected scenarios, should be identified in subsequent work.

Future Grid Forum's use of scenarios

For its part, the FGF proposed a framework of key performance indicators for evaluating the electricity sector scenarios, noting the value of each KPI would depend on a stakeholder's circumstances. The forum then identified ways the sector could best plan for and respond to the drivers and other issues explored in the modelling, such as carbon uncertainty, rising customer costs, and an increase in on-site generation.

Important in this stage of the FGF's work was managing the transition to conceivable futures – the concrete steps stakeholders (governments, regulators, industry, and consumers) could take to minimise disruption to their part in the sector as it changed. Some such steps are:

- Reviewing market structures, tariff structures to ensure they reflect market conditions and/or can achieve desired policy outcomes
- Moving to greater retail deregulation
- Investing in energy efficiency and management of peak demand and consumption
- Investing in R&D for low-emissions technology.

FGF suggests that successful management of the sector in the face of major, known challenges, is an attainable outcome of scenario development. In this vein, FGF recommends four approaches for tackling challenges where work is not already underway:

1. Implement a sustained, long-term program to increase consumer awareness of the benefits and mechanisms of cost-reflective pricing and demand management
2. Develop bipartisan agreement on the long-term (2050) greenhouse gas emission target and implementation mechanism for Australia
3. Review Australia's electricity consumer social safety net
4. Establish processes to identify the changes, if any, that might be required to market frameworks in light of the megashifts examined.[40]

Electricity Network Transformation Roadmap and scenarios

Like the FGF process, "it is also expected that Roadmap collaborators will be exposed to a range of new perspectives and stakeholder relationships." Each phase of the Roadmap incorporates scenarios, or future worlds, into analysis commissioned specifically for that phase. For example, the technology report Grid Design, Operation, Platform & Telecoms, a number of functional use cases was considered for each world. Then the project:

> ...mapped the use cases against the future worlds to determine the applicability and the functions observed and this then informed the detailed consideration of the scenarios. For each scenario, we have mapped the worlds against the Smart Grid Architecture Model (SGAM) framework which describes the various 'layers' of the grid that will need to exist to facilitate the worlds under consideration.[42]

The wealth of information emerging from the Roadmap will enable industry members who collaborated in the project to consider many options for enhancing their own strategic planning, including the use of the FGF scenarios.[43]

The Australian National Outlook and scenarios

The Outlook is largely positive about Australia's ability to make the right combination of choices about policy and institutional settings that will help it negotiate the challenges "involved in achieving sustainable prosperity".[44] Where gaps in capacity and expertise now exist, investments in innovation and technology will be required.

Like the FGF, the Outlook emphasises the trade-offs that must be considered when considering how best to manage transitions into the future. If policies and institutional settings are pursued without a comprehensive consideration of the factors that influence long-term resource use versus prosperity, the implications are that the challenges will become more difficult to manage and negative consequences will manifest sooner and more dramatically.

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40 *Change and choice*, pp. 66-67.

41 Energy Networks Association, *Roadmap Overview*. Kingston, ACT: ENA, 2015.

42 Butler, T. and Sprawson. M., *NTR: Grid Design, Operation, Platform & Telecoms*. Report prepared for Energy Networks Association.

43 T. Brinsmead, CSIRO Energy Research unit, pers comm, 9 November 2016.

44 CSIRO, *Australian National Outlook 2015*. Newcastle: CSIRO, 2015, p. 4.

Scenarios and Horizon Power's strategic planning

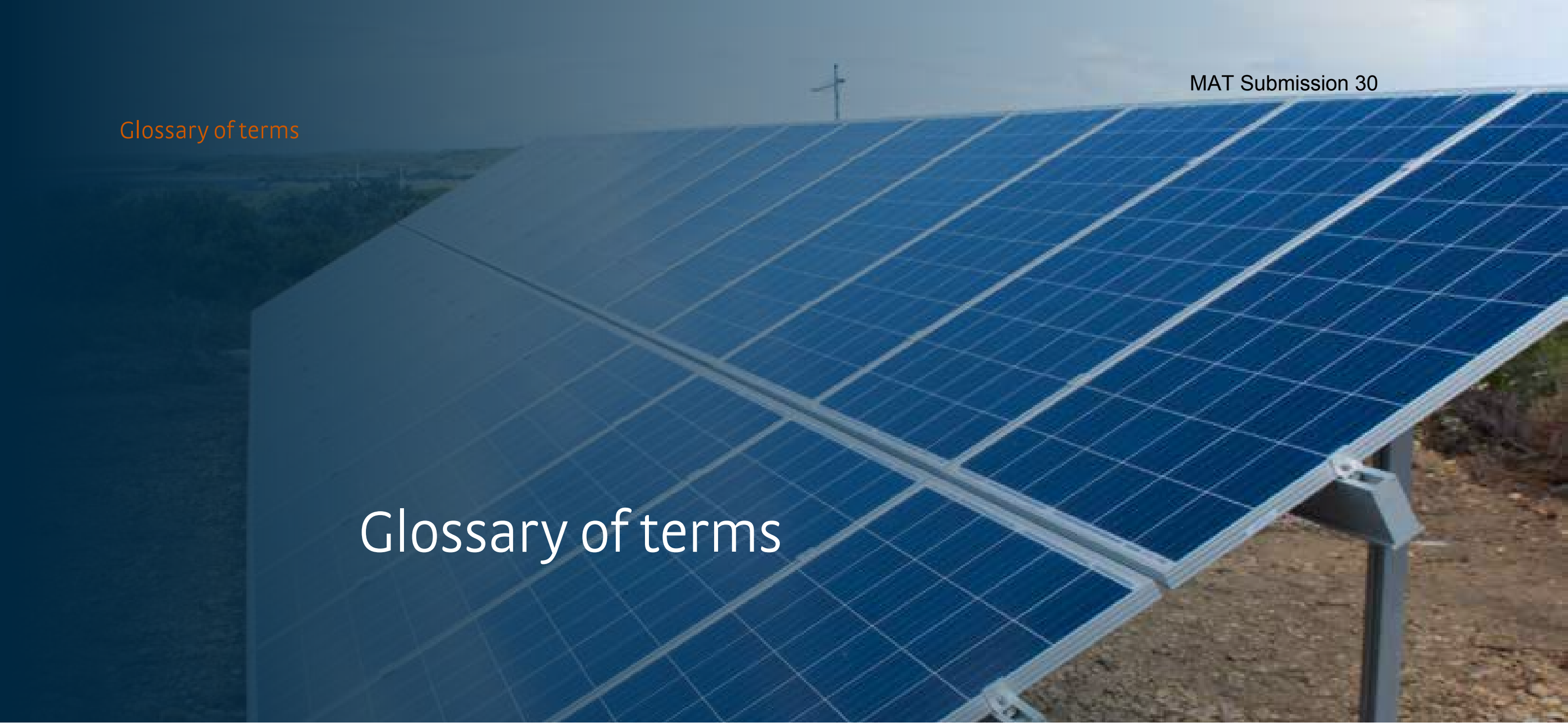
Following its collaboration with the CSIRO, Horizon Power is now in a position to enhance its own strategic planning through scenarios. With the set of bespoke scenarios and drivers now complete, Horizon Power can add a richer layer of analysis to its System Blueprints methodology, starting with CSIRO's first recommendation to perform sensitivity analysis to refine the underlying assumptions that drive least-cost system design.

Subsequent refinement could also involve analysis of more generation options, more customer preferences and behaviour, and a comprehensive range of costs, however these adjustments will all add additional complexity that will need to be balanced.

Conclusion

Horizon Power's work on System Blueprints has brought about a comprehensive understanding of the rapid changes now taking place in the electricity sector. That the organisation will move to a DER business future is an important recognition; when significant changes will manifest in the marketplace, and how Horizon Power can best capitalise on those, is still to be worked through.

By taking planners through processes that consider possible futures, along with the factors that influence those futures, scenarios are an excellent tool for managing uncertainty. Horizon Power's links to industry research can enhance the organisation's approach to strategic planning and help ensure we achieve our vision, reducing risk along the way.



Glossary of terms

ADMS advanced distribution management system	The software platform that supports the distribution management and optimisation of a network
advanced meter	An advanced meter, or smart meter, is a device that measures the amount of electricity used in real time and sends this information back to an energy retailer. Advanced meters collect large amounts of data that can be interpreted to provide customers with tailored energy-efficiency advice and alternative ways of paying for electricity, enable energy trading, and improve network security and safety. Advanced meters can be read remotely and allow electricity supply to be remotely switched on or off.
advanced microgrids	Advanced microgrids are powered by integrating centralised power generation with very significant levels of DER located on customer sites and connected to the distribution network. They enable customer DERs to provide services to the network in exchange for a financial benefit and support the trading of power between customers. Advanced Microgrids will be a key building block of High-DER electricity systems as they maximise reliance on intermittent renewable generation, better balance supply and demand, reduce extreme peak demand and increase energy efficiency and service reliability.
AMI advanced metering infrastructure	Horizon Power's Advanced Metering Infrastructure project installed 47,000 advanced meters across its service area, providing Horizon Power with extensive data analytics capability.
API application program interface	A set of routines, protocols, and tools for building software applications. An API specifies how software components should interact.
centralised / traditional generation	Large-scale electricity generation produced at centralised facilities and typically fuelled by gas or diesel.

centralised system architecture	Electricity system designs characterised by one-directional supply of electricity through 'poles and wires' infrastructure to largely passive consumers and almost entirely produced by centralised generation. These system designs have remained largely unchanged for decades and have only limited ability to integrate DERs.
CoE Centre of Excellence	A research and business hub designed to facilitate opportunities for knowledge-sharing between researchers and industry and accelerate the commercialisation of solutions.
connected trading platform	A digital platform that employs Transactive Energy architectures to enable customer DERs such as solar PV, energy storage and demand management to provide optimisation services to the electricity system, when and where they are most needed, in exchange for a financial benefit.
cost-reflective pricing	A pricing model which the price of energy varies with location and/or time of energy consumption.
DM demand management	An automated process that enables customer loads to rapidly decrease or increase their electricity use in response to changes in the condition of the grid and/or changes in energy price or other information. Demand Management is most suitable for significant customer loads such as air conditioning, electric water heating, water pumping and the charging of energy storage or electric vehicles. In a High-DER environment it can be used to both reduce the intensity of peak demand periods and better match appliance runtimes with times where there is an oversupply of renewable energy.
DER distributed energy resources	Dispersed power generation, energy storage and demand management located at customer premises or connected directly to the distribution network. While DER is often used to refer to renewable generation sources, it also includes dispersed non-renewable generation sources.
DERMS distributed energy resources management system	A system designed to manage and optimise the technical operation of thousands of grid-connected DER to dynamically balance supply and demand, maintain system stability and optimise long-run economic efficiency.
distributed solar	Smaller, modular solar generation connected to the electricity grid.
DSO distribution system operator	Entity responsible for operating, maintaining, and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands.

energy storage	A means of storing energy within an electricity system, either directly or indirectly. Storage may be either centralised or distributed throughout a network. Examples include batteries, power capacitors, flywheels, pumped hydro systems.
FIM feed-in-management	A type of generation management in which participating customers allow Horizon Power to manage the output of their solar generation to better match supply with demand and help prevent system instability.
FoG fringe of grid	Network infrastructure at the remote edge of the grid. Electricity transmitted over long distances typically experiences significant losses along the way and can be less reliable.
GTE government-trading enterprise	A government body that derives its prime source of revenue from the sale of goods and services in a commercial environment.
GM generation management	Used to monitor, control and optimise the performance of generation, particularly rooftop solar. Generation management controls the output of rooftop solar, and allows more renewable energy to be hosted by across our electricity systems.
grid / off-grid	The electrical grid is the interconnected network delivering electricity from producers to consumers, consisting of generation, transmission and distribution assets. Off-grid power systems are not connected to the main electricity network and can be stand-alone power systems that provide a smaller community with electricity.
grid-scale battery	Batteries over 500kW that allow store energy when production exceeds consumption and can be returned to the grid when production from intermittent sources, such as renewable energy production falls below consumption, as well as ancillary services.
intelligent consumer services	Used to help consumers control their energy use, avoid peak power rates, and maximise savings. Horizon Power's MyPower, similar to mobile phone plans, enables customers to stay under a set monthly allowance and manage their electricity costs.
IoT internet of things	Refers to the collection of common devices that collect and transmit and receive data via the internet.
microgrid	A geographically confined collection of electrical resources that act together and with centralised generation typically playing a key role. Micrograds can be remote, embedded, or interconnected and may begin their life either detached or attached to a larger grid.
microgrid operating platform	Horizon Power's microgrid operating platform is built around DER, leveraging the value of diverse information sources and a localised operating model that offers significant value to stakeholders and customers.

modular generation	A modular power station is designed to efficiently contract (or be ramped up) as the renewable energy contribution changes to meet energy needs.
MPS micro power system	Micro Power Systems are a new utility asset class designed to provide remote customers with a full electric utility service, only without requiring a 'poles and wires' network connection. Distinct from privately-owned stand-alone power systems (SPS), they are fully integrated across all utility back-office systems, designed for multi-decade life cycle efficiencies and capable of being fleet-managed in the thousands.
multi-flow network	Network incorporating high levels of DER sees the flow of energy becoming bi-directional as opposed to one-directional.
NEM National Electricity Market	Wholesale market through which generators and retailers trade electricity in Queensland, New South Wales, Victoria, South Australia, the ACT, and Tasmania. Delivers around 80 per cent of all electricity consumption in Australia.
network augmentation	Upgrade of existing distribution network capacity in order to meet customer demand. Can now be done through grid-scale batteries.
REV Reforming the Energy Vision	Comprehensive energy strategy for New York State designed to help consumers make more informed energy choices, develop new energy products and services, and protect the environment while creating new jobs and economic opportunity.
Pilbara integrated market	Increased access to Horizon Power's network by others (Alinta) through a light handed regulatory regime. For Horizon Power this means maximising the value of our NWIS business whilst supporting the Government's reform agenda.
platform service provider	A platform is a business based on enabling value-creating interactions between external producers and consumers. The platform provides an open, participative infrastructure for these interactions and sets governance conditions for them. The platform's overarching purpose: to consummate matches among users and facilitate the exchange of goods, services, or social currency, thereby enabling value creation for all participants.
prosumer	Electricity customers that are connected to the electricity system, have installed DERs and function as both energy producers and energy consumers.
PV	Photovoltaic is the conversion of light into electricity using solar panels.

SPS stand-alone power system	Most commonly used to describe privately owned off-grid power systems that provide electricity to a single customer through a combination of energy storage and both renewable and fossil-fuel generation.
SWIS South West Interconnected System	One of the three major electricity networks in Western Australia, the SWIS serves the Perth metro area and stretches from Geraldton to Albany, with a feeder to Kalgoorlie-Boulder. Managed by Western Power, this is the only regulated network in the state.
system blueprints / design blueprints	The system Horizon Power uses to determine the optimal supply models for each of its microgrids over the long term.
transactive energy	The economic and control techniques used to manage the flow or exchange of energy within an existing electric power system in regards to economic and market based standard values of energy.
UTP uniform tariff policy	All retail electricity customers in Western Australia are charged the same rate, even though the true cost to supply differs by system and region.
virtual power plant	A virtual power plant (VPP) is a cloud-based distributed power plant that aggregates the capacities of Distributed Energy Resources (DER) for the purposes of enhancing power generation, as well as trading or selling power on the open market. This is distinct from a microgrid, which is a geographically bound system, while VPPs can be widely dispersed and aggregated across a large grid.
WEM Wholesale Electricity Market	The Wholesale Electricity Market (WEM) for the South West Interconnected System of Western Australia (SWIS) commenced operation in September 2006. This market facilitates greater competition and private investment and allows generators and wholesale purchasers of electricity (such as retailers) greater flexibility as to how, and with whom, they sell or procure electricity. This market includes mechanisms for ensuring: adequate generation and demand-side management capacity is available; market participants can adjust, trade or balance their contractual positions; and there is a competitive supply of Load Following Ancillary Services.

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