Distributed Energy Resources Roadmap

December 2019

GOVERNMENT OF WESTERN AUSTRALIA

Energy Transformation Taskforce

The energy industry is undergoing a rapid transformation.

An appropriate citation for this paper is: DER Roadmap

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Energy Transformation Taskforce
On 20 May 2019, the Hon Bill Johnston MLA, Minister for Energy established the Energy Transformation Taskforce to deliver the Western Australian Government's Energy Transformation Strategy.
The Taskforce reports directly to the Minister for Energy and comprises five members, including an Independent Chair and four senior State Government officials:

- Mr Stephen Edwell – Independent Chair
- Mr Michael Court – Deputy Under Treasurer, Department of Treasury
- Ms Kate Ryan – Executive Director, Energy Policy WA
- Mr Brett Sadler – Director, Department of the Premier and Cabinet
- Ms Katharine McKenzie - Principal Policy Adviser to the Hon Bill Johnston MLA, Minister for Energy

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Abbreviations

The following table provides a list of abbreviations and acronyms used throughout this document. (A glossary is provided at the end of the document.)

TERM	DEFINITION
AEMO	Australian Energy Market Operator
AMI	Advanced Metering Infrastructure
DER	Distributed Energy Resources
DMO	Distribution Market Operator
DSO	Distribution System Operator
EPWA	Energy Policy WA
ESS	Essential System Services
EV	Electric Vehicle
kW	Kilowatt
kWh	Kilowatt hour
MW	Megawatt
MWh	Megawatt hour
PV	Photovoltaic
RCM	Reserve Capacity Mechanism
REBS	Renewable Energy Buyback Scheme
SRES	Small-scale Renewable Energy Scheme
SWIS	South West Interconnected System
UFLS	Under Frequency Load Shedding
VPP	Virtual Power Plant
WEM	Wholesale Electricity Market

Chair's foreword

The rapid advance in renewable energy technology is fundamentally changing the dynamics of power systems across the globe.

Here in Western Australia the penetration of renewable energy resources in both the South West Interconnected System (SWIS) and our regional electricity systems has occurred with unprecedented swiftness.

This technology revolution in renewable energy presents an amazing opportunity for Western Australia given its world class wind and solar resources. With free fuel and low operation costs renewable generation will, over time, put downward pressure on electricity prices and deliver cleaner energy. It is a no-brainer that we should be seeking to optimise the level of renewable energy across our electricity systems.

However, achieving high levels of renewable generation presents some immediate challenges. In fact, without significantly modifying the way our electricity systems operate, higher levels of renewable participation present risks to power system security and reliability.

In short, this is because power systems weren't designed for high levels of intermittency and two-way flow of power. In the SWIS, where nearly one in three households have installed rooftop solar PV, there is already a clear and present risk to power security.

The big picture dynamic of the SWIS is that we are moving rapidly from a power system dominated by upstream large scale, synchronous, thermal generation, centrally controlled and distanced from load, to one with more intermittent generation and an increasingly decentralised supply chain comprising a variety of downstream distributed energy resources (DER). In this new paradigm the distribution network will take centre stage. The Western Australian Government wisely recognises this transition needs a plan and some very careful management.

In May 2019, the Minister for Energy, Bill Johnston, announced an Energy Transformation Strategy and established an Energy Transformation Taskforce to implement it. The Taskforce has until May 2021 to complete its mission.

Delivery of the Strategy involves three work streams. We need to:

- develop a Roadmap for a transition to a decentralised, democratised, and highly data driven power system – the DER Roadmap,
- undertake comprehensive long-term modelling of the power system to assist Government policy and sector wide investment decisions, and
- make major modifications to the design and operation of the SWIS.

The reliability and security of the power system is central to all this work.

The DER Roadmap is the Taskforce's first major deliverable. We have adopted a structured approach to the Roadmap's development. The Roadmap provides our analysis of the challenge, our vision for the SWIS in 2025 and our proposals for transformative response.

Overall, what needs to happen is for DER to be fully integrated into the power system. Importantly, if DER is to become a central player it needs to be subjected to similar discipline as traditional generation and contribute to, rather than detract from, the security of the overall power system, whilst still providing a return to DER owners.

The suite of actions we propose is broad – covering technology integration, removing barriers to DER participation (including battery storage), piloting alternative electricity tariffs, and customer protection and engagement.

Urgency has necessitated the Roadmap be output oriented. We have identified 36 individual required actions. We have also developed a detailed and prioritised implementation plan for delivery of these actions – highly focussed on the next two years.

The strong view of the Taskforce is that the Roadmap is not a menu of possible initiatives. Rather, all 36 actions are necessary to achieve a complete and successful transition to a DER future.

I would particularly like to acknowledge the exceptional commitment and skill of Jai Thomas and team in the Electricity Transformation Implementation Unit in developing the Roadmap in only seven months.

I also acknowledge electricity market participants for their input across two public workshops and many one-on-one sessions, and especially the major contribution made by people in Western Power and AEMO. Both Agencies will continue to have a significant involvement in implementation.

I would also like to thank my Taskforce colleagues for their diligence and very valuable strategic oversight of this project during what has been an intense period of work.

We are all looking forward to implementing the Roadmap and delivering on the other elements of the Energy Transformation Strategy in 2020 and beyond.

Stephen Edwell,
Independent Chair,
Energy Transformation Taskforce

Executive summary

Distributed Energy Resources (DER) are transforming our electricity system, presenting both challenges and opportunities.

Distributed Energy Resources, or 'DER', are smaller–scale devices that can either use, generate or store electricity, and form a part of the local distribution system, serving homes and businesses.

DER can include renewable generation such as rooftop solar photovoltaic (PV) systems, energy storage, electric vehicles (EVs), and technology to manage demand at a premises.

DER is a great opportunity

Customers in the South West Interconnected System (SWIS) are installing DER at unprecedented rates. Now, almost one in three households in the SWIS have a rooftop solar PV system installed, with around 2,000 households adding a new system each month.

Customers choosing to install DER are already enjoying the benefits of lower electricity bills, and are contributing to de-carbonising the power system. As DER capabilities improve and technology costs continue to fall, customers will be able to enjoy new and greater benefits from their DER.

DER also offer additional opportunities that complement and amplify the benefits of customer investments. These opportunities include services that help ensure the security and reliability of the power system, and innovative business models that offer new value for customers.

But it's causing problems that need to be solved

However, the speed and scale of the uptake of DER is presenting serious risks to the power system.

If not properly managed, high levels of DER, most notably rooftop solar PV, will impact customers by eroding the security and reliability of the electricity system, higher costs, and an emerging divide between those that can afford to install DER and those that cannot.

The continued uptake of rooftop solar PV will see daytime demand fall to levels at which there is significant risk that the stability of the SWIS will be compromised – this is forecast to occur around 2022.[1] In response, the the Australian Energy Market Operator (AEMO) will be required to intervene more frequently and to a greater extent to maintain system security, increasing costs for customers.

1 AEMO, March 2019, *Integrating Utility-scale Renewables and Distributed Energy Resources in the SWIS*, available at https://www.aemo.com.au/-/media/Files/Electricity/WEM/Security_and_Reliability/2019/Integrating-Utility-scale-Renewables-and-DER-in-the-SWIS.pdf

DER is also contributing to technical issues at the distribution network level. The existing network was not designed to handle large amounts of generation from rooftop solar PV, which is now flowing two ways and causing problems for network operation as the physical limits of infrastructure are reached. Without improving DER integration in the network, resolution will require costly infrastructure investment by Western Power, or imposition of limits on the size and number of rooftop solar PV systems customers can install on the network. Neither outcome is good for customers.

If DER is to become a central component of the power system, it needs to be fully integrated into the operation of the power system and actively provide support, in a manner similar to larger generators.

As well as low demand in the middle of the day causing system security issues, the system load profile also features high peak demand and associated costs to service that peak. Existing flat electricity tariff structures are increasingly unsuitable because they do not reflect the true cost of electricity supply, particularly as more DER is installed. There are minimal incentives under these existing tariff structures for customers to use their energy in a way that helps keep supply costs at a minimum and ensures the system is stable and secure.

Further, customers who install DER contribute less than their share of system costs and are disproportionately benefiting from lower bills. This means customers who are unable to access DER are cross-subsidising those who can. In short, the current tariff structures are incompatible with a high-DER energy system.

Further, customers who install DER contribute less than their share of system costs and are disproportionately benefiting from lower bills.

The Taskforce has a vision to solve these problems now and set the system up for the high-DER future

Addressing these challenges through integration and orchestration of DER involves measures to manage the risks and realise new opportunities across the entire electricity supply chain.

The Energy Transformation Taskforce's vision for DER by 2025 is:

A future where DER is integral to a safe, reliable and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers.

There are three parts to this vision:

1. **A safe and reliable electricity system where customers can continue to connect DER and where DER supports the system in an efficient way.**
2. **DER capability can offer value throughout the electricity supply chain.**
3. **DER benefits are flowing to all customers, both with and without DER.**

The DER Roadmap is how to get there

The DER Roadmap is the set of actions, action owners and timeframes required to realise this vision. The Roadmap outlines the way to achieving key milestones on the journey, and will:

1. Address the imminent danger of system stability issues occurring as soon as 2022.

Upgrades to DER functions and settings (like those for inverters) will see DER automatically help mitigate network and system disturbances, rather than exacerbate them.

Grid support measures by Western Power will assist in maintaining system security and reliability, particularly in the short term. Improved visibility of DER for Western Power and AEMO will further support this.

Distribution battery storage deployment, provided by a range of parties, will provide a cost-effective way to manage network and system issues caused by DER, and offer customers new opportunities to access storage.

2. Pilot tariff structures that support the high-DER future.

Current electricity tariffs are contributing to inefficient and inequitable outcomes for customers, and the power system. A high-DER future is not sustainable under current tariff structures.

It is important to pilot potential new tariff structures that are more sustainable, reflecting the underlying cost of energy services and incentivising efficient use of the system. That is, pilots for tariff structures that incorporate time-based price signals with low rates during the day when there is excess rooftop solar generation, while signalling for peak demand and the associated costs to support the peak.

This will provide insights into how customers respond to alternative tariff structures, including how they use and invest in DER (e.g. battery storage) under those tariffs.

3. Ensure customers are protected and are provided with clear and simple information.

Customers can continue to install DER, and access information that helps them make choices about how they use electricity and better manage their costs.

The protection of customers, including data protections, will be maintained even as changing business models provide new electricity services and customer offerings.

4. Build a future where DER is an active participant in the power system.

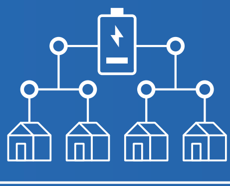
The Roadmap sets out the requirements for the integration of DER into electricity markets, so that customers may eventually provide services that support the system and are rewarded for doing so. This will lead to the natural evolution of Western Power and AEMO's roles and the introduction of innovative 'DER aggregators' to the system.

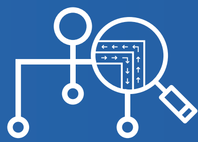
The coordination of many individual customer DER by aggregators will allow customers to participate in the provision of services that benefit the power system, but in a simple way. The development of mechanisms that allow DER to provide these services and receive payment will open up new value streams for customers, and lower system costs.

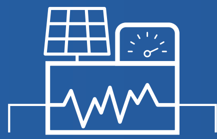
A future where DER is integral to a safe, reliable and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers.

The DER Roadmap

2020



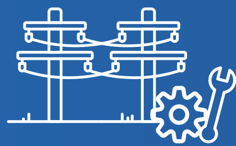


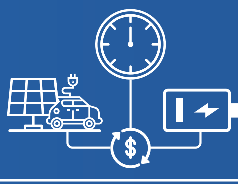


Distribution Storage
Western Power PowerBank installations commence, providing opportunities for network and customer benefit whilst adding to power system stability

Distribution Network Visibility
Distribution network visibility program commences to enhance the understanding of distribution network power flows and constraints

Inverter Settings & Functionality
SWIS-specific autonomous inverter settings that provide better performance during disturbance events are enabled



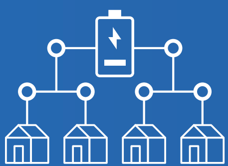


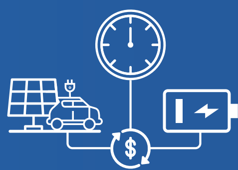
DSO/DMO
DSO/DMO roles, functions, practical operations, regulatory requirements, as well as costs and benefits have been identified

Grid Response
Investment in grid support technologies (including reactors, storage and voltage control equipment) by Western Power is contributing to maintaining system stability on low demand days

Tariff Pilots
Pilots for alternative tariff structures have commenced, demonstrating value to consumers who can move electricity use to the middle of the day

2021



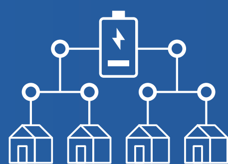


Distribution Storage
Western Power has identified emerging network needs and has access to network storage services from the market

System Operations
The System Operator's dynamic system modelling adequately incorporates DER and arrangements adequately address power flows during system events

Tariff Pilots
Learnings from tariff pilots are guiding the transition to new pricing, driving system-efficient behaviours and investment in storage that have the potential to lower energy bills

2024



Distribution Storage
Distribution storage continues to be deployed under a variety of business models, and can access value across the supply chain

DER Roadmap Complete

- DER is being leveraged for value across the supply chain, including to secure the network, and providing value to customers;
- Innovative business models with appropriate licensing are providing value to customers and the system as a whole; and
- The DSO and DMO are coordinating effectively to ensure customers can continue to connect their DER into the future

Figure A: the DER Roadmap workplan and priority actions

The Energy Transformation Taskforce's DER Roadmap provides an integrated set of actions designed to deliver a future where DER contributes to a safe, reliable and efficient system where all customers can enjoy the benefits of DER.

Customer Engagement
Customer engagement program commences on challenges and opportunities of the high-DER future

DER Orchestration Pilot
A comprehensive VPP technology and market participation pilot has commenced, testing the incorporation of aggregated DER into the WEM

Technology Integration
- Inverter Standards
- Distribution Battery Storage
- Grid Response
- Power System Operations
- Distribution Network Visibility
- Planning for EV Integration

Tariffs and Investment Signals
- Tariff Pilots
- DER for Tenants

DER Participation
- Network Investment Process
- DER Orchestration Pilot
- DSO/DMO Function Set

Customer Protection and Engagement
- Data
- New Business Models
- Customer Engagement

2022

DSO/DMO
Changes to wholesale market arrangements necessary to enable the participation of DER in the WEM via a DER aggregator are introduced

Customer Engagement
Customer engagement program continues

Network Investment Process
An amended Access Code is providing increased opportunities for DER innovators to provide services to Western Power and receive revenue for doing so

2023

DSO/DMO
DSO and DMO goes live in the SWIS, with DER able to respond to meet network needs as well as be dispatched into the WEM, and be compensated appropriately

DER Orchestration Pilot
A comprehensive VPP technology and market participation pilot has tested the incorporation of aggregated DER into the WEM (including market dispatch and settlement arrangements)

Inverter Settings & Functionality
Communications-linked inverter standards are enabled, providing for DER orchestration and the capability to participate in multiple markets

Introduction

Our energy system is changing. Increasing levels of renewable generation, much of it located on homes and businesses, produces electricity that fluctuates depending on the time of day and the weather.

New technologies to store energy and manage energy usage are emerging, and the costs of these technologies are falling. The electricity system is transforming from one built around big centralised generators to one where thousands of individual generators line the rooftops and garages of modern Australian homes and businesses (Figure 1).

Distributed Energy Resources are transforming our electricity system, creating an exciting opportunity to leverage customer investment to reduce electricity costs and lower emissions from the energy sector.

However, if not properly managed, DER can also present a risk to power system security and network reliability, leading to extra costs and potential disruption for customers. Self-supply from rooftop solar PV systems and the export of excess power back to the grid is reducing daytime grid-served demand to very low levels. In only a few years from now, continued uptake of rooftop solar in the SWIS will see daytime demand fall to levels which significantly threaten the stability of the power system. According to the Australian Energy Market Operator's (AEMO) forecasts, this could occur as early as 2022.[2]

To alleviate this system stability risk and capture the significant benefits of higher levels of DER, changes are required across the electricity supply chain. These changes range from increasing the minimum performance standards of equipment that customers connect to the network, to the way electricity and system support services are priced.

Specifically, reforms are needed to integrate DER into the power system in a way that allows the benefits of this technology to be fully captured while minimising the risks. These arrangements must also be equitable and share benefits to all customers, irrespective of whether the customer owns DER or not.

The Energy Transformation Taskforce has developed this DER Roadmap of actions to meet the following objectives:

- allow customers to continue to utilise DER to manage their own energy bills;
- enable all electricity customers to share in the benefits from higher levels of DER; and
- integrate increasing volumes of DER into the SWIS without adversely affecting the security of the power system.

2 AEMO, March 2019, *Integrating Utility-scale Renewables and Distributed Energy Resources in the SWIS*, available at https://www.aemo.com.au/-/media/Files/Electricity/WEM/Security_and_Reliability/2019/Integrating-Utility-scale-Renewables-and-DER-in-the-SWIS.pdf

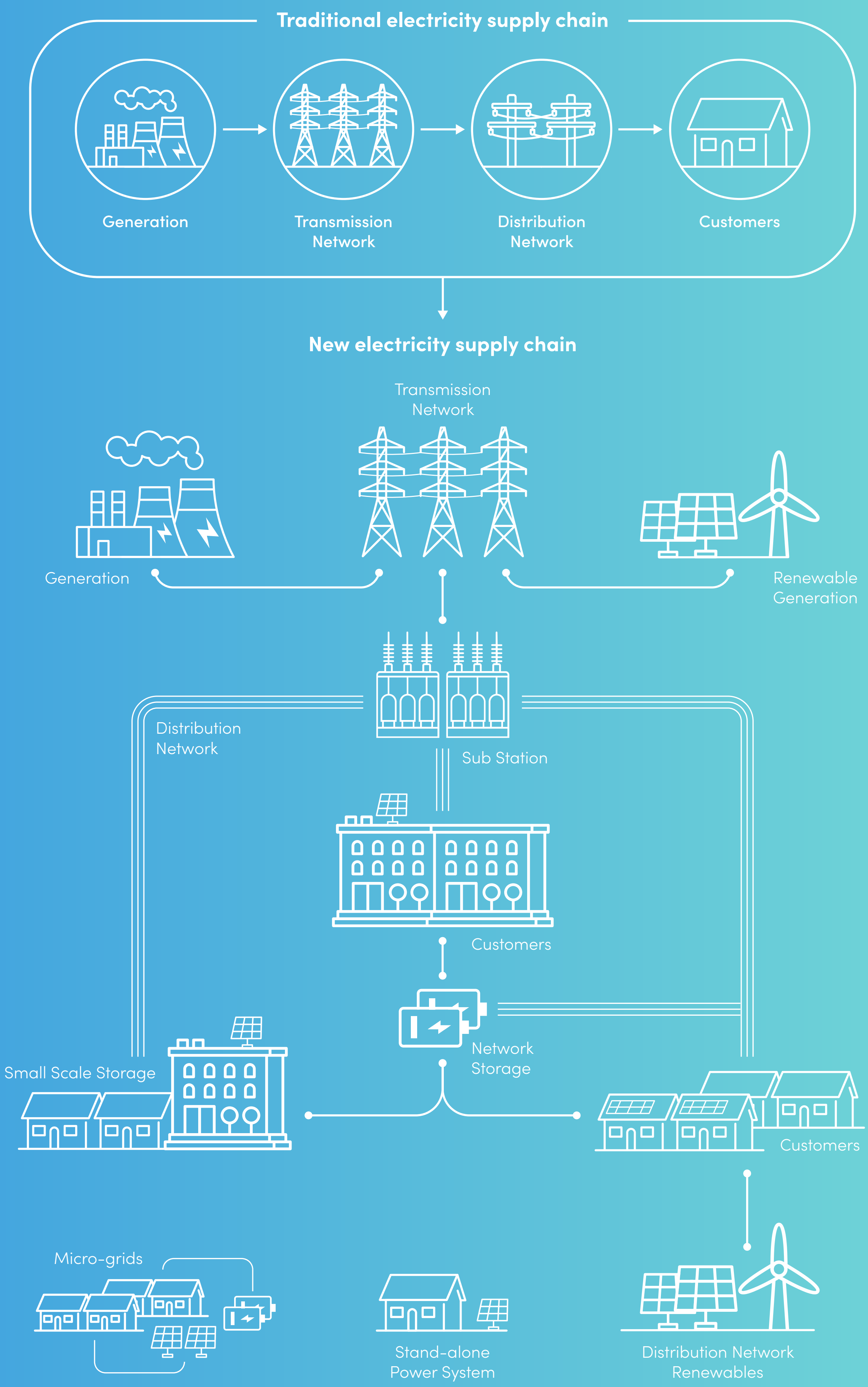
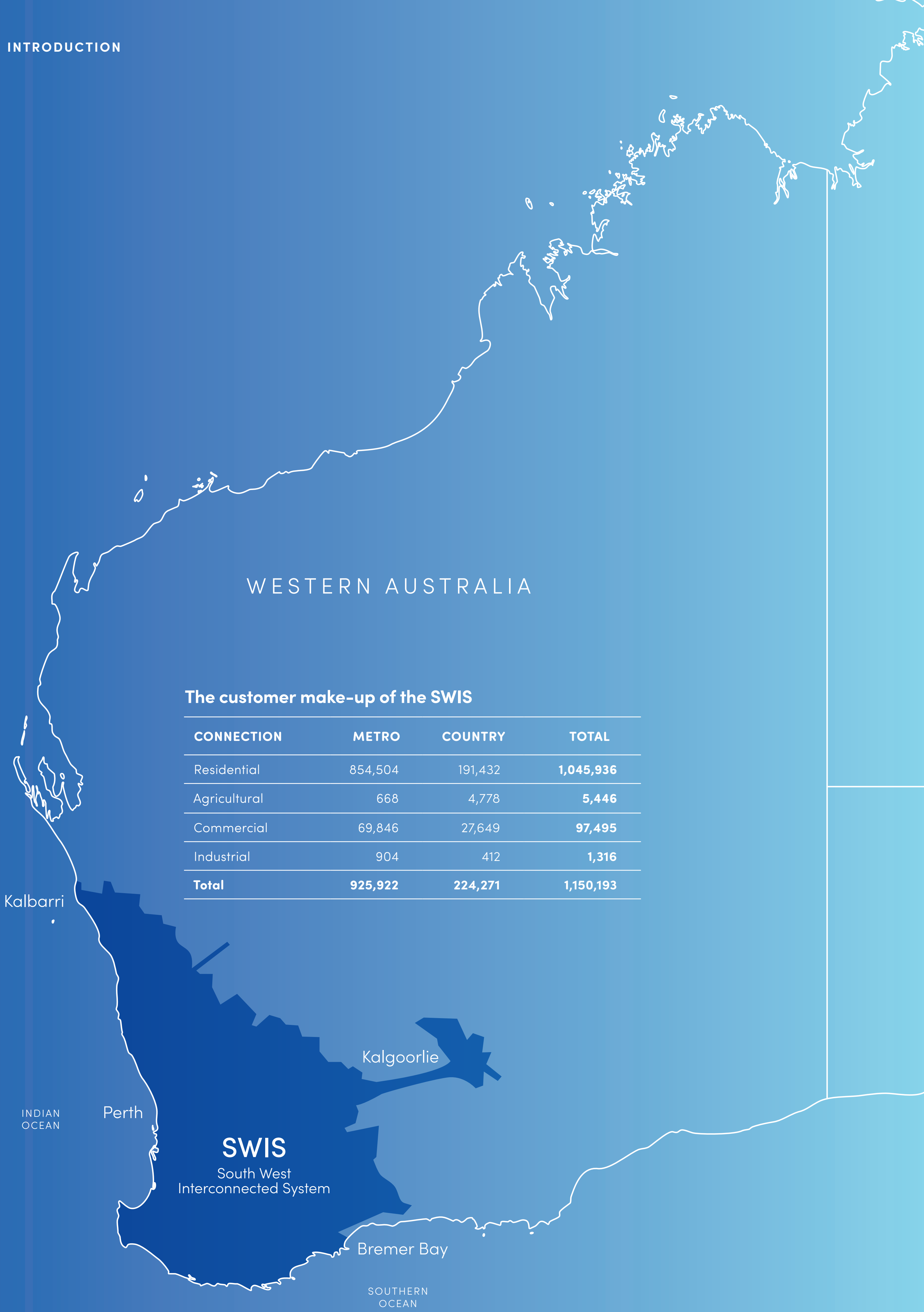


Figure 1 – The electricity system transformation



The customer make-up of the SWIS

CONNECTION	METRO	COUNTRY	TOTAL
Residential	854,504	191,432	**1,045,936**
Agricultural	668	4,778	**5,446**
Commercial	69,846	27,649	**97,495**
Industrial	904	412	**1,316**
Total	**925,922**	**224,271**	**1,150,193**

The purpose of this Roadmap is to identify an integrated set of actions for implementation from 2020 through to 2024 to achieve these three objectives. The proposed actions will enable the benefits of DER to be maximised while positioning the SWIS for resilience into the future as the generation mix and the pattern of electricity consumption changes.

How DER is integrated to capture the benefits it can provide to the system will play a key role in delivering the WA Government's Energy Transformation Strategy. Effective DER integration will help to manage the transition towards cleaner energy and improve market efficiency.[3]

This Roadmap will complement other activities being implemented under the Energy Transformation Strategy.

These include:

- developing a Whole of System Plan – modelling long term scenarios to identify the best options for investment in the power system, to maintain security and reliability at the lowest sustainable cost; and
- modernising the design and operation of the power system[4] – which has two core components:
  - improving access to the SWIS – delivering network access arrangements that make the best use of available transmission capacity and the existing investment in the network; and
  - enhancing market design for the SWIS – delivering a future power system to ensure that electricity is dispatched at the lowest sustainable cost.

3 Energy Transformation Taskforce, October 2019, *Program Implementation Plan, available at* https://www.wa.gov.au/sites/default/files/2019-10/ETS%20Program%20Implementation%20Plan%20Oct%2019_0.pdf

4 This is referred to as the "Foundation Regulatory Frameworks" workstream of the Energy Transformation Strategy

1. The clear and present challenge

This Chapter of the DER Roadmap considers the uptake of DER by consumers and the current trajectory for installation in the SWIS. It outlines how increasing levels of DER impact the wider power system, and the immediate challenges and risks it presents.

Chapter 1 also explains the role of the DER Roadmap in meeting this clear and present challenge, and the guiding principles that have been used to identify changes to current arrangements.

1.1 What is DER?

This section explains the technologies and services captured by Distributed Energy Resources and the current state of uptake in the SWIS.

DER cover a wide range of new technologies and services that can deliver value across different parts of the electricity supply chain (Figure 2). In this Roadmap, we have adopted the following definition:

Distributed Energy Resources, or 'DER', are smaller–scale devices that can either use, generate or store electricity, and form a part of the local distribution system, serving homes and businesses.

DER can include renewable generation, energy storage, electric vehicles (EVs), and technology that consumers can use at their premises to manage their electricity demand (e.g. hot water systems, pool pumps or smart appliances). DER can be located within a customer's premises or connected directly to the distribution network.

DER on a consumer's side of the meter are known as 'behind the meter' and operate for the purpose of supplying all or a portion of the consumer's electricity. The behind the meter DER may also be capable of supplying power into the system or providing a demand management service.

DER that are connected directly to the distribution network, or 'in front of the meter', can include some types of renewable generation (e.g. small solar PV and wind farms), and grid-scale batteries (e.g. community batteries).

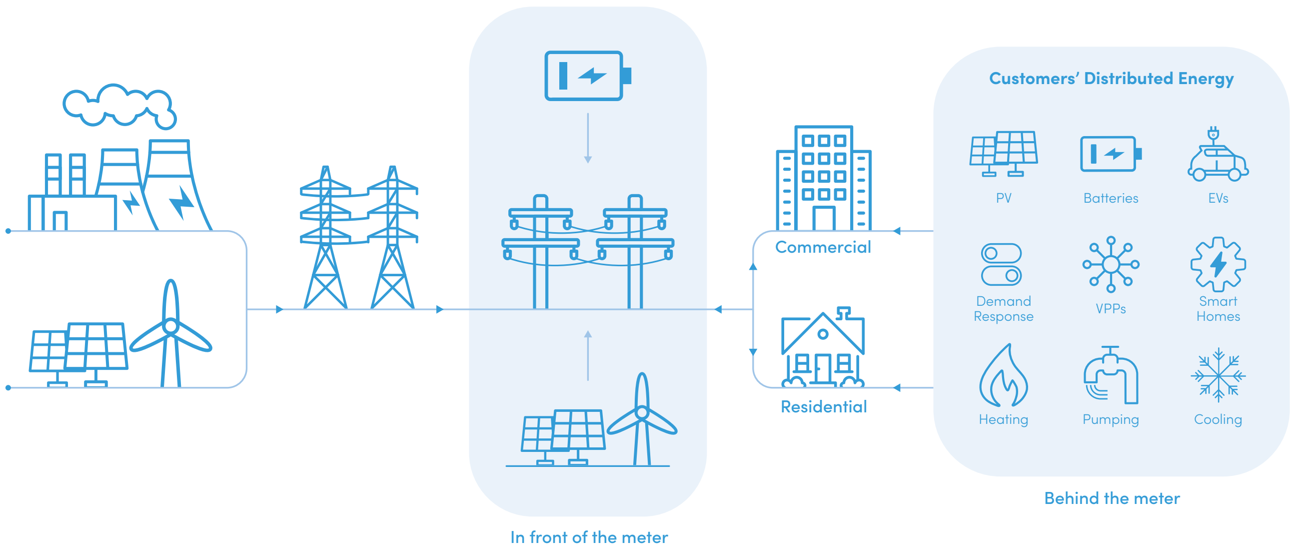


Figure 2 – Illustration of DER located within an electricity network

DER can be 'active' or 'passive'. Active DER adapts its behaviour in response to control signals from an external party or system, whereas passive DER simply responds to available resources (such as rooftop solar PV generation responding to sunlight) or pre-set internal programming and settings. Typically, the DER installed in Western Australia to date is passive. The DER Roadmap evaluates both active and passive forms to ensure the system can manage the impacts.

While DER is often referred to in terms of specific technology types (such as rooftop solar PV or batteries), it is important to consider DER in terms of the potential range of services it can provide across the supply chain. Where DER can provide services, they can add value. Understanding what services DER can provide will help unlock the potential value of DER across the power system, facilitating higher levels of DER penetration and encouraging new business models to emerge.

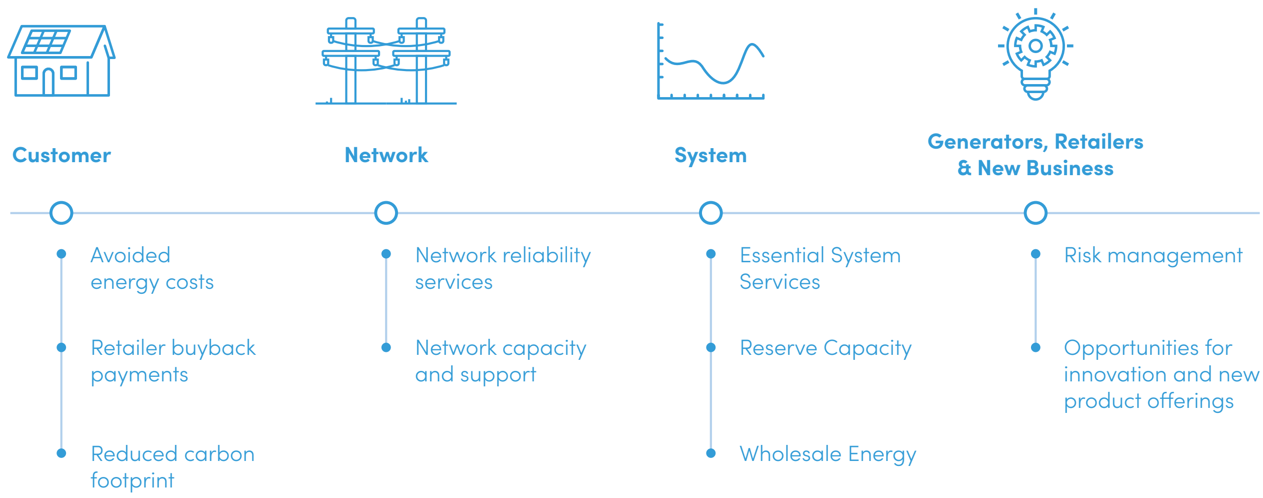


Figure 3 – Potential DER benefits and services

An essential element of this Roadmap is that the greater the contribution of DER to the SWIS energy supply increases, the greater the need to move newly-installed DER from passive operation towards active operation. Active DER offers an array of benefits and services that can support the system, reduce electricity costs to the consumer, and maintain reliability of electricity supply (Figure 3).

These DER services will be provided for defined periods of time across certain days, or under certain market conditions to different types of buyers and sellers (Table 1). DER services would be delivered through the existing competitive market (the Wholesale Electricity Market (WEM)), provided directly to those who need it via bilateral contracts, or be delivered using new market arrangements where required. Because all markets cannot be participated in concurrently, a key challenge will be to optimise the services DER can provide across the supply chain.

Table 1: Potential DER services

POTENTIAL DER SERVICE	DESCRIPTION	SPECIFIC SERVICES DER CAN PROVIDE
Network reliability	Some DER can provide network support services, including reliability, that can help Western Power supply customers when main grid supply is lost.	• Autonomous inverter responses create more resilient distribution networks. • Operate in island mode to maintain continuity of supply when network supply is disrupted.
Network capacity and support	DER provide distribution-level capacity value by deferring or avoiding investment in network assets. This value depends on the location and utilisation capability of DER during local peak periods.	• Supply active power during evening peak to reduce power transfer through network elements (particularly when thermal limits are breached). • Absorb (over-voltages) or supply (under-voltages) reactive power to maintain voltage profiles.
Essential System Services (ESS)	DER may provide flexibility value to AEMO across a range of ESS. Subject to successful pilots, DER may provide services including contingency, frequency and voltage regulation and location-specific services.	• Upwards/downwards contingency reserve. • Frequency regulation up/down.
Reserve capacity	DER could be used as an alternative supply of capacity into the Reserve Capacity Mechanism. The value of the capacity would be assessed from the generation or demand response capability of the DER during system peak periods.	• Demand reduction. • Generation capacity.
Wholesale energy	DER provide energy value when it displaces the need to produce energy from another generating resource.	• Wholesale energy generation. • Avoided losses on the transmission and distribution system, due to the proximity of DER to end-use loads.
Risk management	In certain instances, purchases of energy from DER may be used to hedge against pool price exposure and/or broader portfolio management.	• Generator support. • Energy arbitrage services.

The DER Roadmap aims to facilitate the integration of all forms of DER, including those to be developed in future, allowing consumer investments in DER to attract returns from the provision of services that will ultimately enable lower costs for all consumers. The integration of DER across the supply chain will enable the true value of the services being provided by DER to be accounted for.

It is also recognised that if DER are to displace traditional synchronous generation, they must contribute to the physical demands of the electricity system. DER need to become active (rather than passive) , integrated into the operation of the power system, and subject to remote management and operating standards in order to keep the power system stable. Power systems need to operate within defined tolerances for frequency and voltage and require certain services to provide system support for it to operate securely.

1.1.1 Current DER uptake in the SWIS

Western Australians are among the leaders nationally in their take-up of DER, most notably rooftop solar PV (Figure 4). This sub-section provides an overview of how this DER uptake is progressing and its expected trajectory over the coming years.

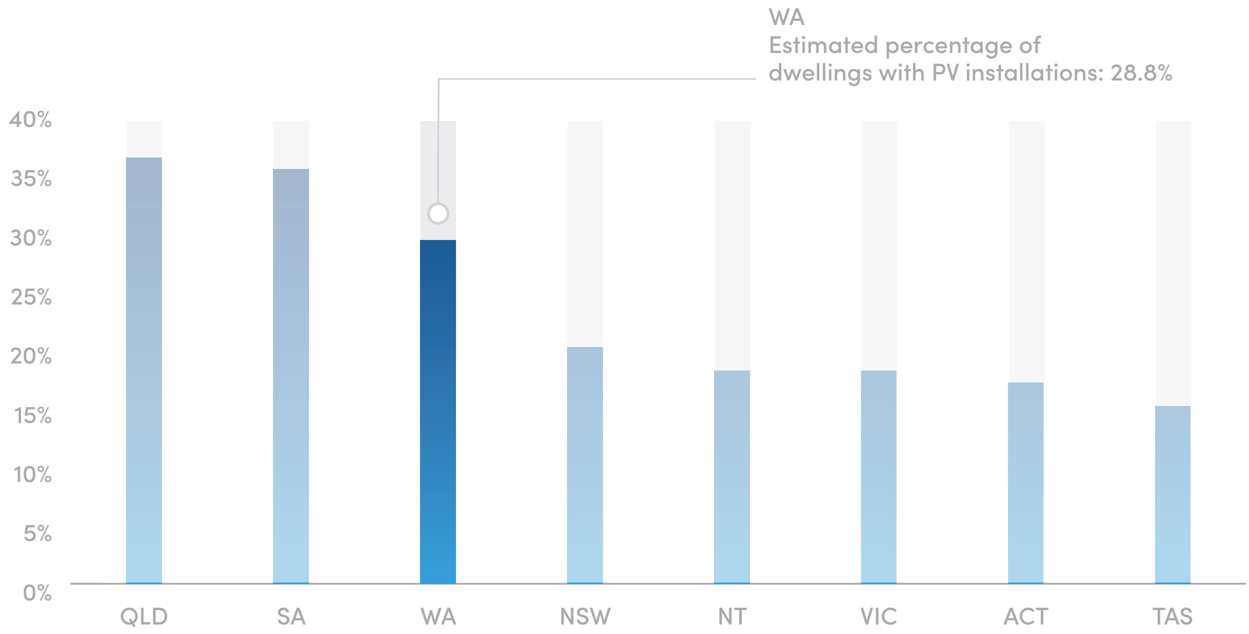


Figure 4: Percentage of dwellings with a solar PV system by Australian jurisdiction[5]

Rooftop solar PV

Of all the DER technologies, rooftop solar PV is the one that has the greatest impact on the power system in Western Australia today. Almost one in three households in the SWIS now have a rooftop solar PV system.[6] Cumulatively, this amounts to over a billion dollars of customer investment in electricity generation over the last decade.[7] Around 2,000 households are adding rooftop solar PV every month. This growth is expected to continue, with the CSIRO and AEMO forecasting uptake by residential customers will reach 50% in the next ten years.

5 APVI, 2018, *Solar Trends Report for Solar Citizens*, available at http://apvi.org.au/wp-content/uploads/2018/12/Solar-Trends-Report-for-Solar-Citizens-FINAL_11-12-18_2_logos.pdf

6 Ibid.

7 This is a high-level conservative estimate based on an average price over the 10 years of $5,000 per system multiplied by 250,000 installed systems. The actual value may be significantly higher than this.

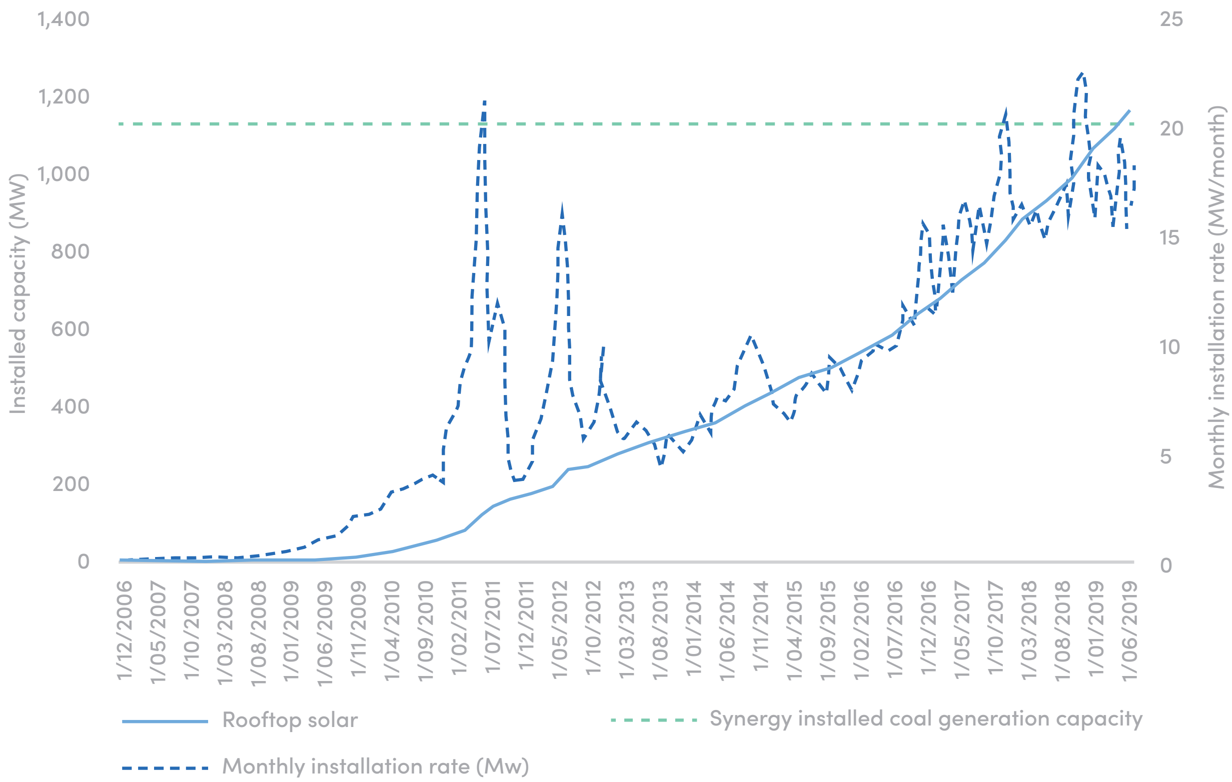


Figure 5: Cumulative installed inverter capacity in the SWIS[8]

With over 1,100 MW presently installed (Figure 5), rooftop solar PV represents the largest energy source in the SWIS. This is the equivalent of an output capacity three times the size of the largest dispatchable generator, the 340 MW Collie Power Station, and this amount is increasing each month.[9] Solar PV's contribution to daytime electricity production is similarly increasing, and it recently fulfilled 45% of underlying energy demand for a trading interval in September 2019.[10]

The SWIS provides ideal conditions for rooftop solar PV performance with an annualised average of 8.8 hours of sunshine a day and has the highest number of cloud free days of all Australian capital cities.[11]

The current regulated tariff structure for residential households tends to encourage self-consumption. The current A1 flat tariff structure (which applies to almost all households) combined with the Renewable Energy Buyback Scheme means the best value for energy generated by rooftop solar PV systems comes from self-consumption, using these behind the meter generators to reduce energy supplied from the grid. However, for the system overall the current tariffs disproportionally recover supply costs. The A1 variable consumption charge over incentivises actions that reduce grid energy use, such as installing rooftop solar PV.[12]

8 ERA, 2019, *Report to the Minister for Energy on the Effectiveness of the Wholesale Electricity Market 2019* Issues Paper https://www.erawa.com.au/cproot/20789/2/Wholesale-Electricity-Market-review-2019---Issues-paper---Final-for-publication.PDF

9 AEMO, 2019, Fact Sheet: *The Wholesale Electricity Market (WEM)*, available at https://www.aemo.com.au/-/media/Files/About_AEMO/About_The_Industry/Wholesale-Electricity-Market-Fact-Sheet.pdf

10 AEMO, 2019, *Quarterly Energy Dynamics – Q3 2019*, available at https://www.aemo.com.au/-/media/Files/Media_Centre/2019/QED-Q3-2019.pdf

11 Geoscience Australia, 2013, *Australian Energy Resource Assessment* https://arena.gov.au/assets/2013/08/Chapter-10-Solar-Energy.pdf

12 This tariff structure, where a small proportion of the fixed system costs are recovered through fixed charge, creates a cross subsidy to customers who have solar PV from customers who do not.

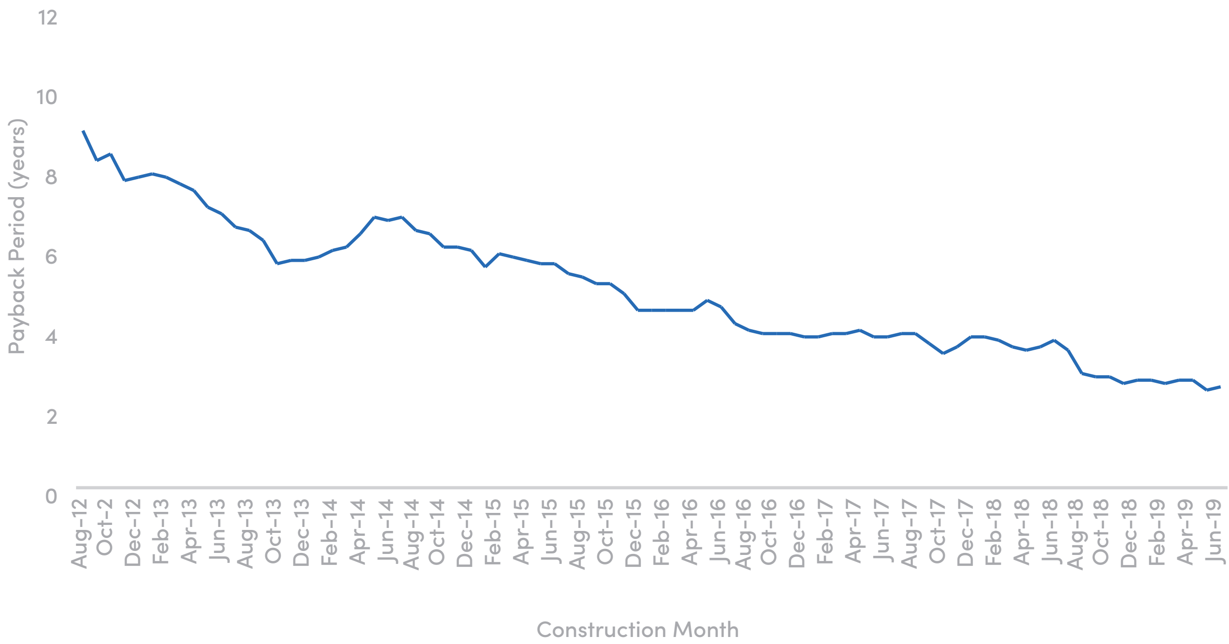


Figure 6 – Payback period for a 4kW solar PV system

With a highly competitive market for rooftop solar PV system installation and the up-front subsidy provided under the Australian Government *Small-scale Renewable Energy Scheme*[13], as well as significant reductions in component and manufacturing costs, the cost of installing solar PV has come down dramatically over time. This has led to the total installed cost of rooftop solar PV today being less than half the cost per kilowatt than in 2012.

The payback rates for rooftop solar PV have dramatically improved over the ten years from 2010. Some households can now recover the initial investment in less than three years (Figure 6). There has also been an increase in the average system size installed by customers. Systems have grown from an average size of around 2.2kW in 2009-10 to 4.6kW in 2019 (based on inverter capacity).

To date, investment in rooftop solar PV has primarily been driven by the expected savings in energy costs for the individual customer, which is heavily influenced by current regulated tariff structure. The financial incentives under the current flat tariff structure do not provide the same level of return for other forms of DER such as behind the meter battery storage.

Battery storage

Distributed battery storage has not yet seen anywhere near the same levels of uptake as rooftop solar PV. As at June 2019, there were less than 1,000 customers with behind the meter battery installations.

The primary factor that has limited the uptake of battery storage on the SWIS is price. The installed cost of behind the meter battery storage remains a significant barrier, with 2019 prices around the $800 – $1,000 per kWh mark.[14]

13 The SRES is a component of the Commonwealth Renewable Energy Target Scheme. Payment is based on the available solar resource, so systems installed in the SWIS receive higher payments than most other states. The scheme is scheduled to end in 2030 and the value of payments is currently decreasing each year until then.

14 Solar Choice, 2019, *Battery Storage Price Index – November 2019*, available at https://www.solarchoice.net.au/blog/battery-storage-price

Payback periods vary depending on a range of factors, however at this price, the average payback period for households under the A1 flat tariff structure is near or longer than the warranties provided by manufacturers and the expected lifespan of the batteries. However, forecast reductions in battery prices could trigger faster uptake rates in the future.

The primary benefit to households of battery storage is avoiding purchasing electricity at the flat rate tariff (28c/kWh) after sunset. Households with certain load profiles (such as low daytime and high evening loads) will, at a certain price point, find battery storage beneficial in reducing costs.

An alternative to behind the meter battery storage is for households to rent storage capacity in a community-scale battery that sits on Western Power's distribution network, to stockpile their excess generation. However, this approach is fairly new, so there are not yet widespread opportunities to participate. In addition, customers are unable to participate in the provision of network and system services from their own behind the meter storage and benefit financially from such participation.

Community battery storage

- A community battery allows customers to access a shared storage resource as an alternative to investing in their own battery, which reduces the up-front costs for households, whilst unlocking additional value to the network and potentially within the system.
- The Alkimos Community Battery and Meadow Springs PowerBank trials highlight different ways of delivering a community battery solution to customers.
- Alkimos is a retailer-led project with the equipment owned by Synergy. Customers take up a time-of-use tariff and pay a monthly fee to export an unlimited amount of excess solar to the battery during the day and draw back on it between 4pm and midnight.
- The Meadow Springs project was initiated by Western Power in response to a network constraint caused by high levels of solar PV. Western Power owns the equipment and Synergy delivers the customer side product. Customers take up a time-of-use tariff and are charged a daily value to access up to 8kWh per day of storage and draw back on it when required.

Electric vehicles

Electric vehicles (EVs) have seen very slow uptake in Western Australia compared to international jurisdictions. At October 2019, there were only around 750 registered electric cars in Western Australia, and EVs represent only 0.1% of new car sales. The low adoption rate is due to several factors, including price, lack of charging infrastructure, limited incentives to encourage take up and a minimal number of vehicle models currently available.[15]

The Western Australian EV Working Group is looking at a range of issues related to electric vehicles in Western Australia, including a plan to increase the number of electric vehicles in the State Government fleet, electric vehicle infrastructure, and standards and incentives to encourage uptake.

Air conditioners and other appliances

The most recent Australian Bureau of Statistics data on air conditioner use in households shows that as at 2014, 89% of residential houses in the Perth Metropolitan area had at least one air conditioner installed.[16] Historically, air-conditioning has played a significant role in driving peak demand during summer months. The rapid increase in system demand experienced during the 2000s has been partially mitigated by improved energy efficiency of air conditioners.

What is a flexible load?

- Flexible loads are loads that deliver the same value to the customer independent to the time of day the load consumes energy
- Common examples of flexible loads are electric hot water systems or pool pumps
- Flexible loads can be orchestrated to minimise whole of system costs via load control or pricing signals

The use of air conditioners as well as other appliances such as electric water heating strongly influence the load profile of the electricity system. Over time, these technologies have increased their communications and smart technology capabilities, and, as a potentially flexible load, they can play a meaningful role in mitigating the challenges encountered in the high-DER future and helping customers manage their energy costs.

INSIGHTS:

- DER covers a wide range of technology types including distributed generation such as rooftop solar PV, energy storage, electric vehicles, household appliances like air conditioners, as well as more traditional demand response resources from commercial sites.
- Almost one in three households in the SWIS now have a rooftop solar PV system, and this is expected to continue to increase. Conversely, uptake of other forms of DER such as a batteries and electric vehicles is currently low.
- Tariff structures incentivise the size and type of DER installed by customers and how it is used. Tariff structures also impact the return on investment for other forms of DER such as battery storage and electric vehicles.

1.2 Where is DER uptake going?

Drawing on AEMO's high rooftop solar PV uptake scenario forecasts for the SWIS, this section sets out the current trajectory of DER take-up across multiple DER technologies.

The SWIS generation mix is transforming, relying less on traditional utility-scale thermal generation and more on large scale renewable generation and DER. Current trends in the growth, diversity and energy contribution of DER connected to the distribution system is expected to continue.

15 Energeia, May 2018, *Australian Electric Vehicle Market Study*, available at https://arena.gov.au/assets/2018/06/australian-ev-market-study-report.pdf

16 ABS, March 2014, *Energy Use and Conservation Questionnaire*, available at https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4602.0.55.001Mar%202014

1.2.1 Rooftop solar PV

The CSIRO, on behalf of AEMO, has forecast installed behind the meter rooftop solar PV uptake in the SWIS under three energy demand growth scenarios: low growth, expected growth, and high growth (Figure 7).

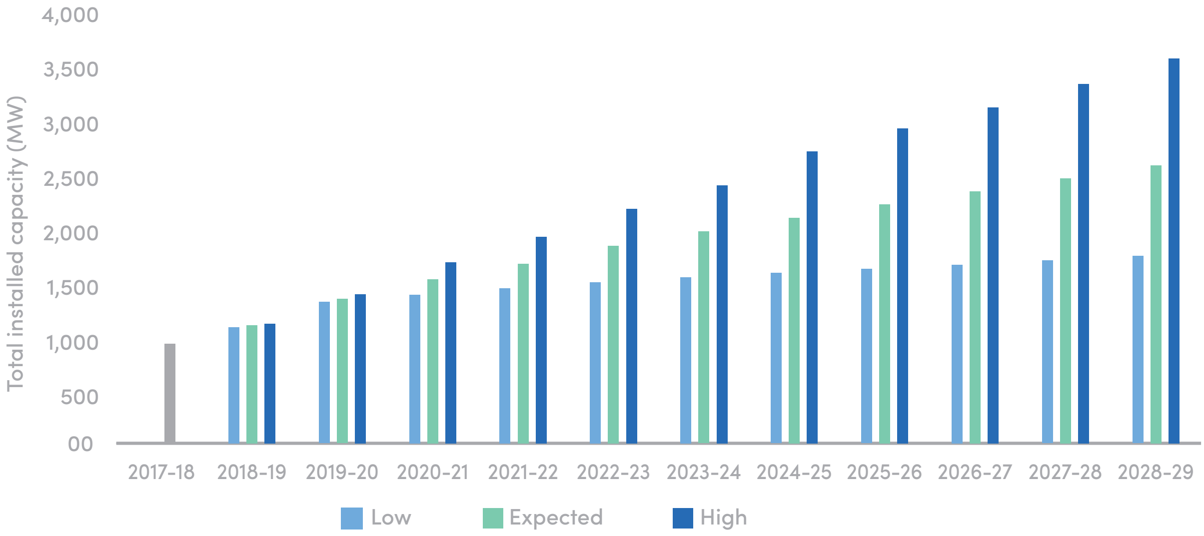


Figure 7 – Forecast installed behind the meter PV system capacity[17]

Under the expected growth scenario, installed behind the meter solar PV capacity is forecast to grow at an average annual rate of 7.6% (122 MW per year) to reach 2,546 MW by June 2029. The high growth scenario estimates an annual average growth of up to 11.1% to reach 3,525 MW by June 2029.[18]

1.2.2 Battery storage

The CSIRO has forecast adoption of behind the meter battery storage in the SWIS to grow rapidly (Figure 8). Under the expected growth scenario, installed capacity of behind the meter battery storage systems is forecast by the CSIRO to achieve an annual average growth rate of 24.9%, increasing from 54 MWh in June 2020 to 398 MWh in June 2029. While there is a high expected growth rate for storage, it is starting from a low base and still trails expected additions of rooftop solar PV by a significant factor.

Recent updates to the Australian Standard (AS/NZS 5139:2019) that applies to installation of behind the meter battery storage could increase costs and delay uptake rates.[19]

17 Data provided by CSIRO as at June 2019, as referenced in AEMO, June 2019, *WEM Electricity Statement of Opportunities*, available at https://www.aemo.com.au/Electricity/Wholesale-Electricity-Market-WEM/Planning-and-forecasting/WEM-Electricity-Statement-of-Opportunities.

18 These forecasts largely align with the growth rates seen in the "Groundhog Day" scenario of the Whole of System Plan. Energy Transformation Taskforce, August 2019, Whole of System Plan Modelling Scenarios, available at https://www.wa.gov.au/sites/default/files/2019-08/Information-paper-Whole-of-System-Plan-Modelling-Scenarios.pdf

19 These requirements include additional non-combustible materials for installation on walls as well as limits on the proximity to windows, ventilation, hot water systems, air conditioning units or other appliances. The standard places a higher requirement than the international standard (IEC 62619) which applies in Europe, and some major manufacturers have argued that the standard is too strict compared to other jurisdictions where batteries that meet IEC 62619 are deemed sufficiently safe to be installed inside houses.

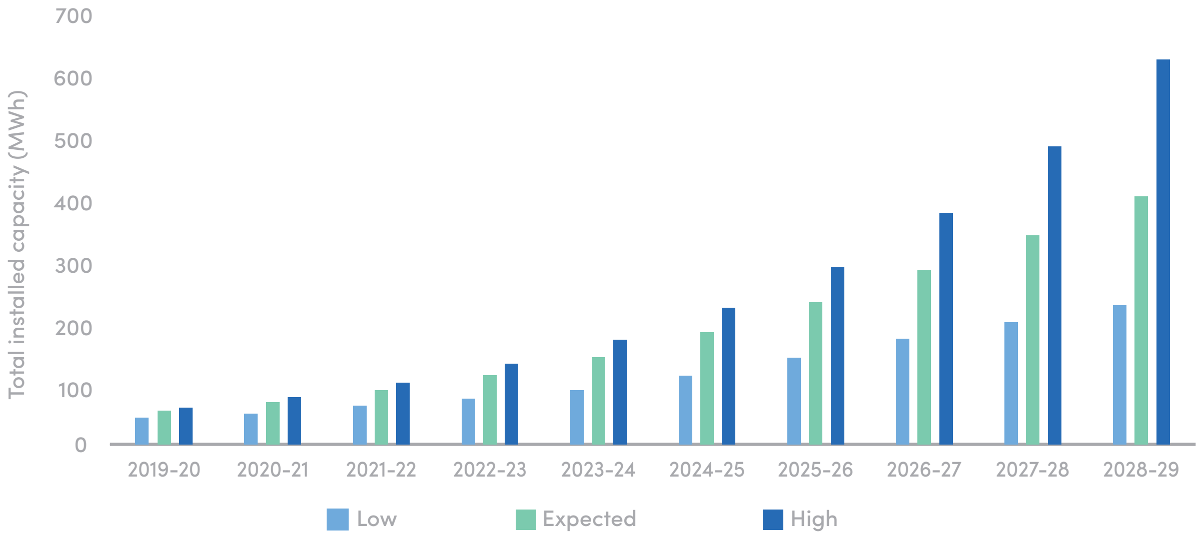


Figure 8 – Forecast installed capacity of battery storage systems (behind the meter)[20]

1.2.3 Electric vehicles

The CSIRO forecasts EV numbers growing from the current number of around 500 to reach 44,000 by June 2029 under the expected growth scenario, or 128,000 under the high growth scenario.[21] Using this forecast, EV sales and associated vehicle-to-grid capabilities remain limited and do not achieve enough uptake to be a significant factor in load growth or grid management before 2025.

1.2.4 Smart appliances and metering

DER can also comprise new technology like data services, home automation and smart appliances such as air-conditioning.[22] These types of new and enhanced technologies can become active DER within the electricity system, able to be co-ordinated to provide services on the demand side of the system.

The challenge will be for the electricity market to interact with and capture the benefits of smart technology. A range of initiatives will be needed, including new and/or improved standards,[23] to allow smart appliances to be actively used in the market in a meaningful way.

20 Data provided by CSIRO as at June 2019, as referenced in the 2019 Electricity Statement of Opportunities.

21 Ibid. In forecasting EV numbers in the SWIS, the CSIRO assumed a slow start due to limited infrastructure, the narrow range of models currently available, and higher cost relative to vehicles with internal combustion engines. The difficulty in estimating EV uptake, due to diverging cost projections and uncertainty regarding the evolution of the industry and of government policy, translates to a wide range of growth forecasts.

22 Some companies, such as Google and Apple, are already active in this space and many appliances have some remote-control functionality available.

23 The Commonwealth recently published a report reviewing the *Greenhouse and Energy Minimum Standards Act 2012* (GEMS Act). This report recommended on mandating standards for demand response in key appliances. https://www.energy.gov.au/sites/default/files/gems_review_-_final_report-accessible.pdf

Advanced metering allows for improved tariff products and can improve visibility of DER impacts on the network. Western Power has commenced deployment of advanced meters and associated communications infrastructure (Advanced Metering Infrastructure, or AMI). In the first phase of the AMI program, Western Power is aiming to install around 300,000 units across existing network connections and for new homes over the next three years to June 2022. Horizon Power completed an upgrade of its entire customer base to AMI in 2016.

1.2.5 Embedded networks and microgrids

Embedded networks and microgrids such as caravan parks, shopping centres and apartment blocks have been a part of the SWIS for some time. These arrangements typically have a number of individual customers grouped behind a single network connection. The rise of DER is driving innovation in customer offerings and services within such arrangements, as well as emerging models across new sub-divisions and local communities. These models are expected to continue to grow into the future, and will require appropriate policy, technical, market and regulatory settings.

1.3 What is the impact of increasing levels of DER?

This section discusses how increasing levels of DER in the SWIS impacts system security, market efficiency and network investments as well as what this means for customers.

The continued uptake of passive DER is changing the way the electricity system is operated and managed. In the last quarter of 2018, for the first time since the WEM commenced in 2006, energy produced by residential and small business customer[24] DER was, at times, greater than their total demand.

The Energy Transformation Taskforce has worked closely with Western Power, AEMO, Synergy and other stakeholders to understand the implications of DER uptake in the SWIS. This engagement has included reaching an understanding of when risks to the electricity system are likely to start manifesting.

Without changes to policy, technical, market and regulatory arrangements, there is a very high risk that increasing solar penetration will threaten the secure, safe and efficient operation of the SWIS as early as 2022. This is due to:

- declining minimum system demand due to the volume of rooftop solar PV output, which will continue to reduce the dispatch and ultimately the viability of traditional generators that presently provide the ESS required for the security of the power system;
- high intermittent solar penetration, which will increase volatility of prices and system operations; and
- technical challenges (such as managing voltage levels) at the distribution network level, which will increase due to DER generation and growth of two-way power flows.

The lack of visibility of DER capability and its location will compound these challenges. Western Power does not have the same level of visibility, control and situational awareness of DER on the distribution network as the system operator (AEMO) does with transmission connected generators. Similarly, the system operator does not have visibility of the location or output of DER on the distribution network, and sudden changes to output caused by cloud and weather events can significantly impact system operations.

This problem will multiply as more DER enter the system. The following sub-sections identify how these challenges present at a system and network level, and the impacts on customers.

24 Non-contestable customers are those who consume 50 MWh or less of electricity per annum and includes most residential households and small businesses in Western Australia. In the SWIS, only Synergy can supply non contestable customers.

1.3.1 Power system impacts of DER

The SWIS daily load profile, which represents the energy drawn from the grid by customers, has evolved in recent years to resemble what is known as the 'duck curve', due to its shape. The self-consumption of energy from rooftop solar PV generation is leading to low customer demand from the grid in the middle of the day – the 'belly of the duck'. It is followed by a sharp increase in system demand in the late afternoon as consumers usage increases as they return home and rooftop solar PV generation decreases to zero as the sun sets.

The shape of the duck curve is more pronounced during days of low demand for energy, for example during a sunny, mild autumn or spring weekend day, when total customer energy requirements are low and rooftop solar PV generation is high.

In its March 2019 report *Integrating Utility-scale Renewables and DER in the SWIS* paper, AEMO outlined its forecasts for rooftop solar PV uptake and the evolution of the duck curve. The paper provides an indication of the levels at which the SWIS would likely experience significant problems with market efficiency and system stability resulting largely from rooftop solar PV (Figure 9), noting that the decline in minimum operational demand may breach technical limits (around 700 MW) as early as 2022.[25]

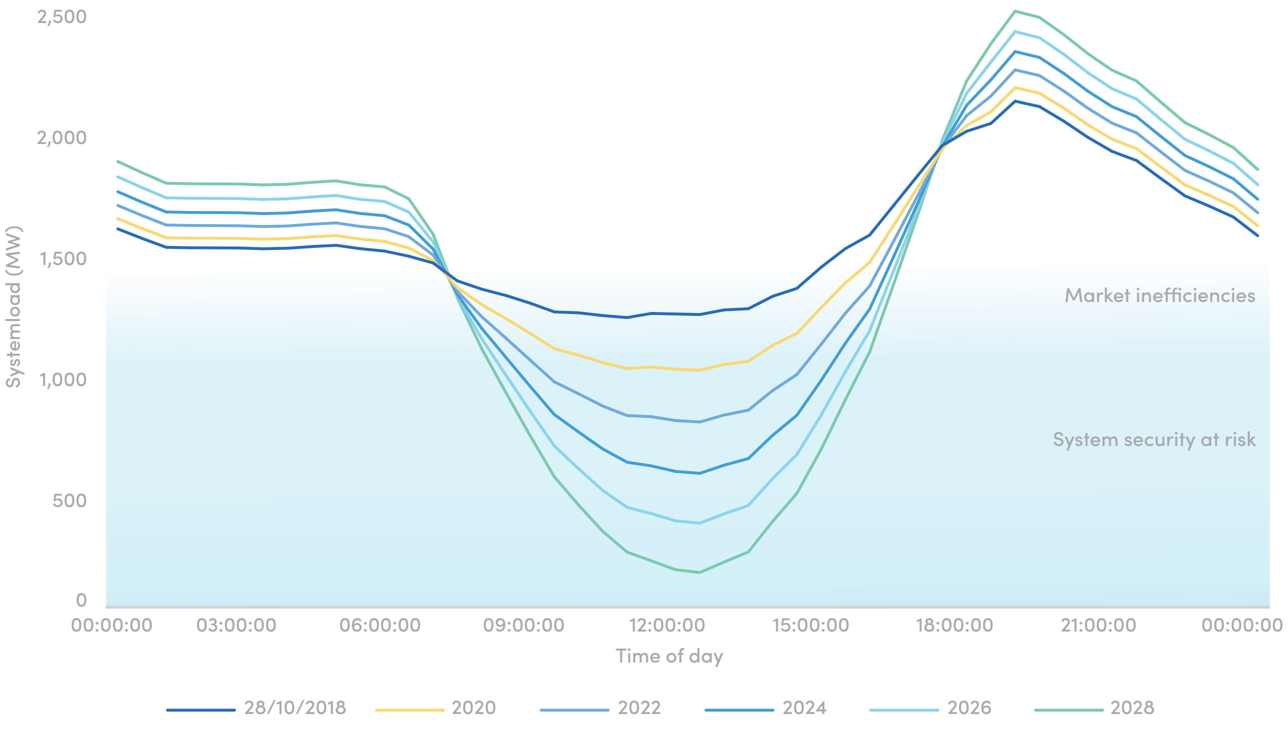


Figure 9 – AEMO analysis on the shape of the load curve on the minimum demand day[26]

25 AEMO, Integrating *Utility-Scale Renewables and Distributed Energy Resources in the SWIS*. p 3, available at https://www.aemo.com.au/-/media/Files/Electricity/WEM/Security_and_Reliability/2019/Integrating-Utility-scale-Renewables-and-DER-in-the-SWIS.pdf.

26 Ibid. p 28

The evolution of the duck curve can be seen by comparing system load for the same week in October 2008 and 2019 (Figure 10), which clearly shows the reduction in demand in the middle of the day, largely attributable to behind the meter rooftop solar PV. The light blue areas give an indication of energy that is now being supplied by rooftop solar PV.

As the capacity of rooftop solar PV generation has increased over time, midday system load (depicted as Operational Demand) has decreased in line (Figure 11).[27] Traditionally minimum system demand has occurred overnight.

However, as a result of continued rooftop solar PV installation, minimum system demand was first experienced in the middle of the day in 2017. Now, at certain times of the year, the daily minimum is observed to occur in the middle of the day on a regular basis, upturning the historical view of what is normal for grid demand.

Already, power system security issues are manifesting at times of low load and high solar generation, such as weekends in spring and autumn. Over time, with increasing penetration of rooftop solar PV, the risk of such issues will become more prevalent, as incidences of very low load will occur more often and for longer periods.

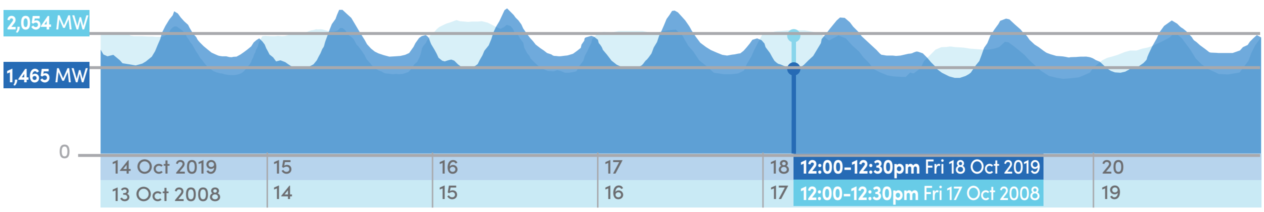


Figure 10 – AEMO generation data for the same week in October 2008 and 2019[28]

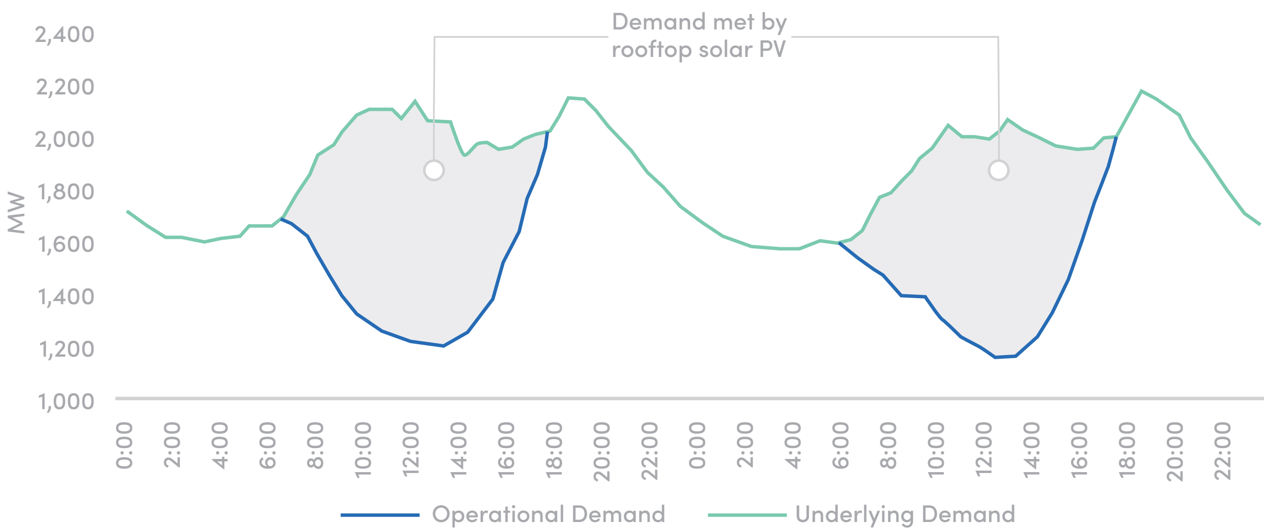


Figure 11 – Operational vs underlying demand 12-13 October 2019[29]

27 AEMO, 2019, data available at https://www.aemo.com.au/Electricity/Wholesale-Electricity-Market-WEM/Data

28 AEMO, 2019, *Integrating Utility-Scale Renewables aed Energy Resources in the SWIS*. p 26.

29 Data provided by AEMO. In simple terms, underlying demand is the amount of energy needed to satisfy total consumer demand; and operational demand is that amount less the contribution of behind the meter generation from DER as well as generation from some other small wind and gas tri-generation locations.

Increasing DER penetration, in combination with the anticipated increases in large-scale renewable generation, will displace the dispatchable synchronous generators that provide ESS such as inertia, frequency control, system strength and voltage control. At times of low load, such generators will bid into the energy market at low prices to ensure they get dispatched (in order to avoid high costs of shutting down and re-starting). Increasingly, the wholesale market is experiencing negative prices during some trade intervals – generators are now paying to stay on[30]. Over time, it will no longer be economic for these generators to remain online, decreasing the availability of ESS.

To maintain power system security, AEMO will be required to intervene in the market more frequently and to a greater extent to ensure sufficient synchronous generation is dispatched. This intervention results in inefficient market outcomes, increasing wholesale electricity system costs, which are passed through to consumers.[31]

Soon, DER output will reach a level where there is insufficient demand to keep the required level of synchronous generation online. At this point, without sufficient synchronous generation providing ESS, there will be a real risk of a SWIS blackout due to cascading failure or widespread load shedding. Further, the increasing suppression of wholesale prices below cost can impact the viability of power generators, leading to the premature exit of existing thermal generation and dampening of new investment in utility scale plant, exacerbating security issues.

Soon, growing DER output will reach such a level where...there will be a real risk of a SWIS blackout due to cascading failure or widespread load shedding.

The intermittency of rooftop solar PV also provides power system security challenges. Unlike large generators, installed rooftop solar PV systems are currently passive installations that are not monitored or dispatchable, and they are especially intermittent in their delivery of energy. Fluctuations in rooftop solar PV output, typically occurring on days with cloud variability, are increasingly having a material impact on the overall supply-demand balance of the system, requiring more frequent and costly intervention by AEMO to maintain the security of the system. As an example of this, on 18 October 2018 the maximum solar PV generation ramp was around 300 MW over 35 minutes, nearly the equivalent of the Collie Power Station nameplate capacity (Figure 12).

30 On Saturday 12 October 2019, the price of wholesale electricity reached the market floor ($1,000/MWh) in the WEM for the first time, and was repeated on Sunday 13 October 2019.

31 For example, while a non-synchronous generator may offer a cheaper price than a synchronous generator, it may not be dispatched for system security reasons. In addition, these non-synchronous plants are likely to experience higher maintenance costs due to increased ramping and cycling.

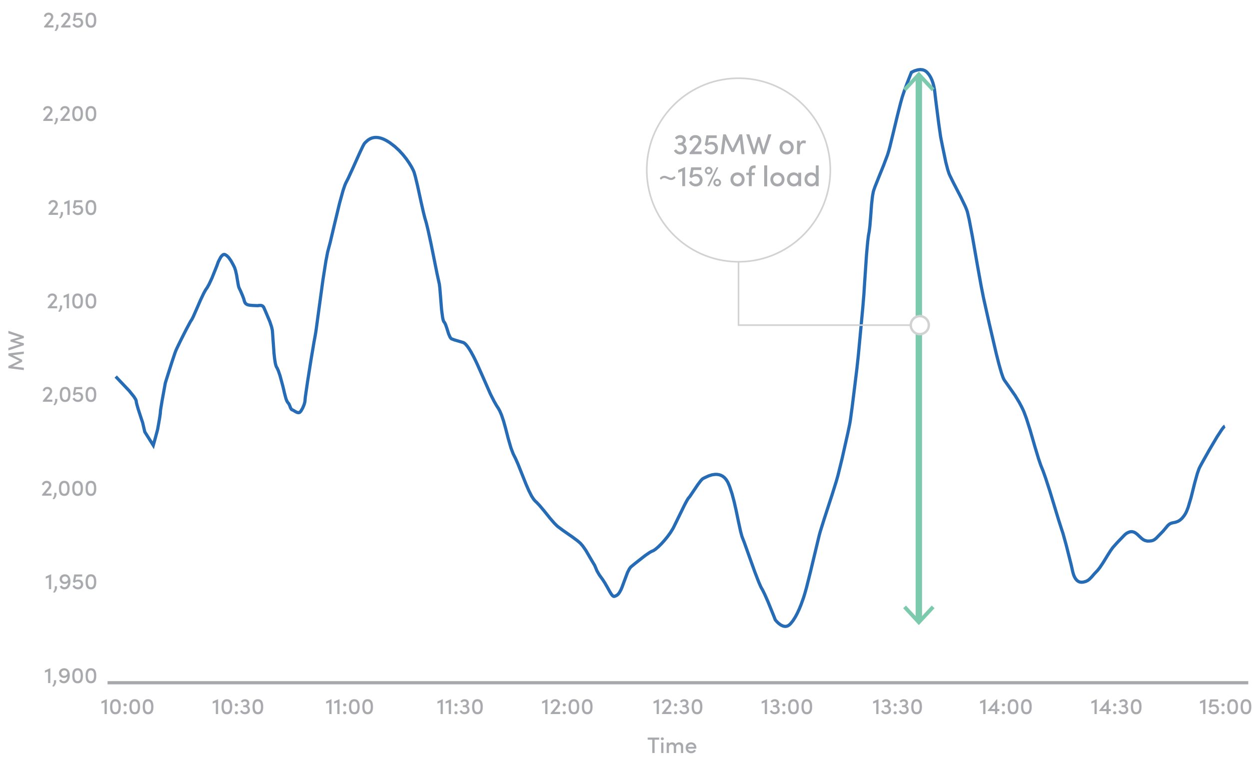


Figure 12: System load fluctuations due to PV volatility, as observed by AEMO between 10am and 3pm on 18 October 2018[32]

Due to the interaction of many variables it is difficult to pinpoint whether the circumstances outlined above will occur on a particular date or time. What is certain, is that the risks are increasingly likely to occur as the uptake of passive rooftop solar PV continues. This means preventative action is needed sooner rather than later.

1.3.2 Network impacts of DER

DER will also present challenges for Western Power as the network operator. Increased penetration of rooftop solar PV has begun to cause technical issues in the distribution network that require intervention.

Large volumes of power from rooftop solar PV exported onto the grid can result in local and system-wide voltage rises and reverse power flows, causing issues for network operation as the physical limits of infrastructure are reached. The number of incidences of these issues has been growing resulting from high rooftop solar PV adoption has been growing and will require more active management from the network operator.

The impact of DER and renewable generation on Western Power is likely to be varied and inconsistent across geographical locations and times. Certain areas may be more (or less) amenable to penetration of DER than others, creating varying network requirements. In addition, traditional network supply issues may remain in areas of the network that experience high demand at evening peaks, which may require augmentation investment over time.

Western Power will need to respond to these challenges to manage the network as DER uptake increases. In some cases, this may include expenditure on reactive power equipment, asset upgrades to manage reverse power flows and active transmission line switching to manage transmission voltages, where this is the most most efficient solution.

32 AEMO, 2019, Ancillary Services Report for the WEM 2019, available at https://www.aemo.com.au/-/media/Files/Electricity/WEM/Data/System-Management-Reports/2019-Ancillary-Services-Report.pdf.

What is hosting capacity?

- DER hosting capacity is defined as the typical amount of DER that can be connected to a distribution network without requiring network augmentation while the network (and the electricity system as a whole) remains within its technical limits
- Hosting capacity is generally available on a first come, first served basis and when capacity is reached connection applications are refused or customers are required to pay augmentation costs
- Greater knowledge of the size and location of connected DER will give the network operator more confidence about where issues are likely to arise, and allow it to continue to support DER
- Beyond this, the ability to dynamically manage DER, can potentially allow all customer applications to be connected, as the network operator can manage individual capabilities to ensure the system stays within technical limits

An alternative approach may be to limit the total capacity of rooftop solar PV connected to the network, or the sizes of new PV installations, based on hosting capacity. However, the imposition of static limits on customer rooftop solar PV size may not always be the most efficient solution from a whole of system perspective and may cause a range of equity issues.

Notwithstanding the changing environment, the traditional core role performed by Western Power will continue to be essential to the overall operation of the system.[33] These responsibilities include, among others, planning, investment, operation and maintenance of the distribution network to ensure continued system security, safety and reliability of supply.

The challenge is how Western Power can transition into a more active distribution system operation role, utilising available technology advances to optimise the use of renewable generation on the existing distribution network.

There is a need to consider how Western Power can transition into a more active distribution system operation role, utilising technology advances to optimise the amount of renewable generation on the existing distribution network.

At the same time, enabling innovative businesses to offer new technologies and new services to consumers – many of which could build upon the advanced meter infrastructure and the data Western Power collects – will also help to integrate DER.

1.3.3 Customer impacts of DER

Irrespective of whether a customer installs DER technology or not, all customers will be impacted by DER through potential issues on the power system or local network, and by any extra costs needed in addressing these risks. As noted above, equity of access must also be preserved – customers who wish to connect DER in the future should typically not be prevented in doing so.

While customers who have been able to install rooftop solar PV have generally seen substantial reductions in their electricity bill, there are some significant related issues.

Electricity supply is largely a fixed cost business. The underlying costs of providing capacity to meet peak demand and the network infrastructure associated with servicing a relatively small number of consumers across a large area are predominantly fixed. However, the structure of household electricity tariffs aims to recover the bulk of supply costs through the variable (or per kWh) component, despite the rebalancing of tariffs that has occurred in recent years.

33 Western Power is responsible for providing non-discriminatory access to their network and for the safety and reliability of the local distribution system. These responsibilities involve regular reconfiguration or switching of circuits and substation loading for scheduled maintenance, isolating substation and distribution feeder faults, and restoring electric service. Under the WA Technical Rules and Access Code, Western Power must also ensure that local voltage, power factor and power quality are maintained within engineering standards.

The disconnect between tariffs and underlying costs can contribute to the incentive for customers to produce and consume their own energy from rooftop solar PV. Under the current structure, the high fixed costs of supply to these customers largely remains, while rooftop solar PV customers' contribution to these costs, recovered mostly by the variable charge, reduces significantly.[34] This in turn provides a shortfall in revenue across the electricity system, leading to pressure to increase tariffs, which similarly increases the attractiveness of installing rooftop solar PV. This cyclical effect has commonly been referred to as the 'electricity death spiral,' and illustrates that current tariff structures are incompatible with a high-DER energy system.

In addition to the above, the rate of purchase of energy from PV customers is fixed and does not reflect the value to the market of the energy produced (i.e. the value is low when the market is well supplied). Synergy and Horizon Power are required to offer to buy excess generation from households under the Renewable Energy Buyback Scheme (REBS). Analysis suggests that the REBS rate no longer reflects the market value of the exported electricity in the SWIS. Synergy estimates that the cost associated with the REBS rate being above the market value is around $17 million in 2019-20, escalating every year as more residential customers invest in rooftop solar PV systems.

While customers who have installed rooftop solar PV have gained significantly, there is a sizable proportion of households without rooftop solar PV that are not able to access the benefits. For many, this is simply through circumstance rather than choice. Renters, residents of apartments and others who are not able to install rooftop solar PV are at risk of becoming disadvantaged.

Increasingly there is an emerging divide between the energy rich and the energy poor. It is important that tariff structures result in all customers paying a fair and equitable share of the costs of the SWIS.

INSIGHTS:

- Increasing variability between minimum system demand and evening peak that results from rooftop solar PV is putting pressure on system and network operation and the viability of existing generators
- Utilising technology advances, DER can be a solution to the problems it creates
- Western Australia faces similar emerging problems to other jurisdictions as a result of high levels of DER but is at the forefront as a result of its superior renewable resources and policy settings that incentivise solar PV uptake

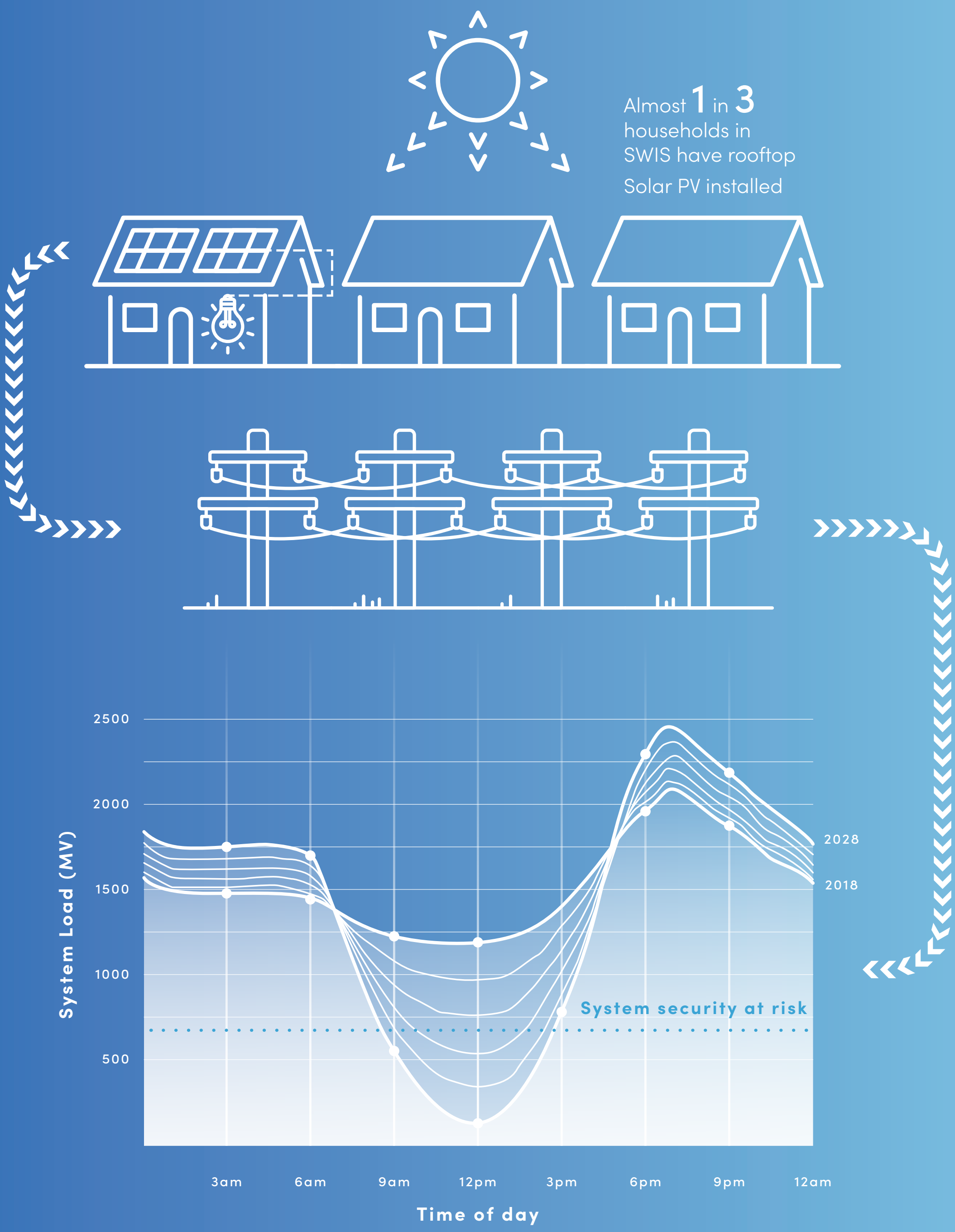
1.4 What are we doing to fix this problem?

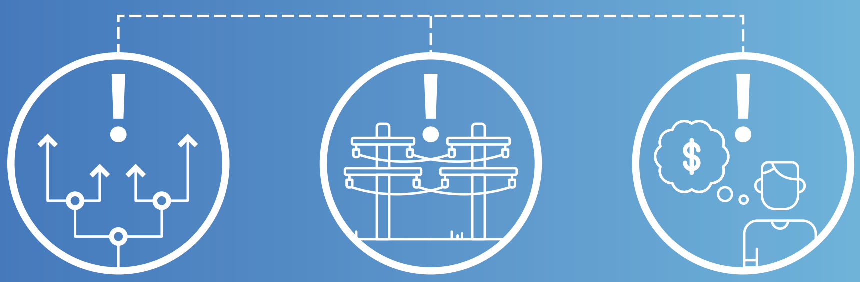
The Energy Transformation Strategy

Simply put, an action plan is required. This plan is being established through the Energy Transformation Strategy.

The DER Roadmap forms one of three work streams within the Energy Transformation Strategy. The other work streams involve modifying the design of the Wholesale Electricity Market and identifying long-term investment options for the power system (Figure 13).

34 See Synergy Annual Report 2019 for more information.





Power system issues

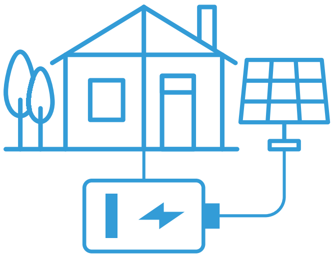
Lower demand means fewer dispatchable generators online to provide essential services increasing blackout risk.

Network issues

Two way energy flows and variability place strain on infrastructure creating local and network-wide issues.

Customer issues

All customers will be impacted by system and network issues and the costs to address them.



DER Roadmap

Facilitate the integration of growing levels of DER into the power system in a safe and secure way, and to ensure customers can continue to benefit from small-scale solar systems and other new technologies.

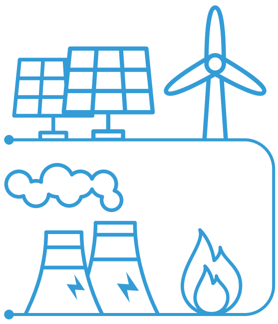
Timeframe: for delivery to the Minister in December 2019

Whole of System Plan

Identify the best options for investment in our power system to maintain the security and reliability of electricity supply at the lowest sustainable costs.

Assist in the transition to a lower-emissions power system, guiding the efficient integration of renewable generation and energy storage.

Timeframe: for delivery in mid-2020



Foundation Regulatory Frameworks

Ensure power system security and reliability by improving the performance framework for large-scale generators and establishing a new framework for procurement and dispatch of essential system services.

Redesign the Wholesale Electricity Market to enable participation of new technologies (for example, large-scale batteries) and ensure electricity is delivered at the lowest sustainable cost on a constrained network.

Timeframe: for completion ahead of market start in October 2022

Figure 13: Energy Transformation Strategy work streams

Following its formation in May 2019, the Energy Transformation Taskforce has moved swiftly to develop the DER Roadmap as a priority action within the Energy Transformation Strategy.

Development of the DER Roadmap has included:

- establishing a working group led by the Energy Transformation Implementation Unit within Energy Policy WA, Western Power and AEMO to identify and develop solutions for key technical, network, customer and market issues;
- a full day guided workshop with stakeholders from across the sector to incorporate input on a wide range of DER issues;
- more than 45 one-on-one meetings with stakeholders;
- review of the existing regulatory and policy settings that drive DER uptake and use by consumers, included as Appendix A to this Roadmap; and
- review of 32 DER and related projects across Western Australia, Australia and internationally via the DER Project Stocktake, included as Appendix B to this Roadmap.

Solving the challenges presented in a high-DER future is a complex problem. The Roadmap makes many recommendations across a broad range of DER-related themes. In some instances, these recommendations recognise and build on work that is already underway across the sector, including activities by Western Power, AEMO, Synergy and innovative third parties.

1.4.1 Principles guiding the DER Roadmap

In releasing this Roadmap, our overall objective is to set out a clear and transparent plan to deliver outcomes for DER that are in the long-term interests of Western Australia. In developing a plan to address the challenges and opportunities presented by DER, we have been guided by the following principles (Table 2).

Table 2: DER Roadmap guiding principles

GUIDING PRINCIPLE	APPLICATION OF THE PRINCIPLE
System security and reliability	There is a critical need to keep the lights on and the network operating within technical limits under increased DER. This is achieved when: 1. the power system operates within defined technical limits and returns within those technical limits after a disruptive event occurs (system security); and 2. the system can supply adequate power to satisfy consumer demand, allowing for credible generation and transmission network contingencies (reliability).
Value for money solutions are identified and implemented	The regulatory framework should promote efficient decision making, both by Western Power in addressing issues on its network and by customers in investing in and utilising DER. Further, the effect and contribution of DER into the wholesale market must be recognised and leveraged to ensure prices will be no higher than is necessary to deliver a reliable and secure supply.
Technology neutrality	Policies should be agnostic with respect to the technology deployed, instead focusing on the most efficient solution that meets technical requirements. Hence the Roadmap will allow for the full potential of different technologies to be explored while also recognising the technical impacts that various DER technologies have on the electricity system.
Customer protections	Customers must continue to be adequately protected as business models evolve and new entrants emerge. The high-DER future is likely to see many changes to the customer experience with new business models and product offerings. The Roadmap identifies areas where existing protections may need to be strengthened where appropriate, such as analysis of customer data, which to date has not been a main part of traditional energy services.
Regulatory flexibility	We need the regulatory framework to be able to adapt to an uncertain technology future. Regulatory flexibility is necessary to allow different business models to enter the energy services market on an equal footing with existing business models; and to give different functionality to AEMO, Western Power and Synergy to support those different business models. Doing so will help ensure customers and Western Power make the right choices on DER technologies, achieving both value for money and system security principles.
Feasibility and practicality	We need to act now due to the urgency of addressing system security issues. We must also plan for a future that opens up further opportunities to deliver good outcomes for SWIS customers.
Impact on State finances	In developing the Roadmap, we have been cognisant of likely financial implications for Western Australian taxpayers, both in terms of the Government's budget (e.g. funding subsidies) and via the operation of Western Power and Synergy.

The approach set out in this Roadmap is adaptive. As we progress the implementation of the Roadmap's recommendations we will work with industry and consumers to monitor progress, assess the energy landscape, and seek to maximise benefits.

There are inherent uncertainties regarding how DER technology will evolve and the longer-term consequences of DER transformation for the SWIS. In light of this, the Roadmap needs to first and foremost be grounded in protecting power system security while providing optionality for innovations that offer the best value for consumers.

2. The future of electricity in the SWIS

While the rapid uptake of passive DER presents clear risks to the security of the power system, a change in policy settings will enable DER to provide new ways to manage these risks with new value opportunities across the entire electricity supply chain.

Customers now have greater choice in how they source and use electricity, and as DER capabilities improve and technology costs continue to fall, all electricity users can be major beneficiaries.

The proliferation of DER across the power system can also present new opportunities for Western Power to support its network. As demonstrated by the trials outlined earlier at Alkimos Beach and Meadow Springs, DER can provide network support services at a low cost, optimising the use of existing infrastructure and reducing or deferring the need for costly network augmentation.

As demonstrated by other trials, DER can also provide system-level support, where customer DER is aggregated and coordinated to promote market efficiency and assist with maintaining the security and reliability of the system. This chapter of the Roadmap sets out a vision for electricity in the SWIS in 2025, explains the role of DER in this future, and outlines the barriers to achieving the vision.

2.1 What is our vision?

This section presents the desired future state of the distribution system as it relates to DER, and the necessary outcomes identified as crucial to the achievement of the objectives of this Roadmap

A Roadmap is about going somewhere. In the context of DER the question is: "What is the medium term vision for the SWIS and what is the best route for getting there?"

A vision for DER in the SWIS in 2025

Our vision is a future where DER is integral to a safe, reliable and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers.

There are three parts to this vision:

1. **A safe and reliable electricity system where customers can continue to connect DER and where DER supports the system in an efficient way.**
2. **DER capability is active and can offer value throughout the electricity supply chain, reducing total costs.**
3. **DER benefits are flowing to all customers, both with and without DER.**

Our vision is a future where DER is integral to a safe, reliable and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers.

2.1.1 Building the vision

The integration of DER is multifaceted and complex and the factors driving investment in DER, its technical capabilities and how it is used are interrelated.

Given this complexity, to guide the approach to the DER Roadmap, four key themes have been identified (Table 3). These themes provide a framework against which barriers can be assessed and required actions can be identified.

Progress against each of these themes is necessary to achieve the vision.

Table 3: DER Roadmap themes

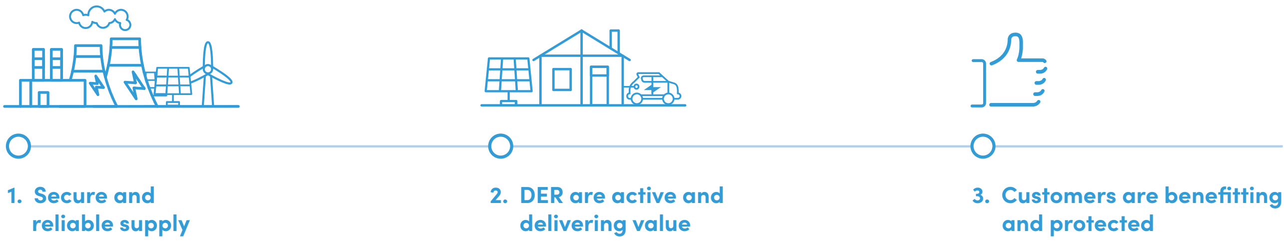
Technology integration	Technology integration refers to the technical capabilities of DER itself, as well as the network and power system operators. It relates to the type and performance of devices, effects on the power system, network infrastructure and management, and system operations.
Tariffs and investment signals	Tariffs and investment signals refers to the financial and other incentives that influence customer decisions about investment in and operation of their DER, as well as when and how they use energy. It includes tariff design, payments to customers for energy exports and other schemes that influence investment decisions and behaviours.
DER participation	DER participation refers to the ability of customers to provide services that support the power system and/or network, and access markets that provide value. It includes the aggregation and orchestration of multiple DER to provide distribution network support and can extend to participation in the WEM (including energy, ESS and capacity).
Customer protection and engagement	Protecting customers refers to the frameworks that provide customers with safe, reliable and fairly-priced electricity, ensure their privacy and data are protected, and make available clear and comprehensive information to assist customer decisions. It includes customer protection obligations on third parties with innovative business models, requirements of parties holding customer data, and customer engagement and education to keep customers informed.

2.1.2 Where do we want to be by 2025?

The Roadmap vision sees DER playing an integral role in the operation of the electricity system. The targeted future state is one where technology, tariffs and incentives, opportunities for DER participation, and customer protection and engagement all act to achieve the vision (Figure 14).

The targeted future is one where the challenges associated with increasing DER have been resolved, and DER are being leveraged as an opportunity within the power system. DER have been integrated and are able to actively provide services to support the system, and customers are rewarded for doing so (Figure 15).

This future has tariff structures that incentivise efficient use of the system, and customers with and without DER share in the benefits. During the transition to the high-DER future, customers are supported with clear and simple information to understand the changes and are able to select innovative products and services knowing customer protections are in place to support them.



Technology integration	Inverter standards support the continued installation of DER, and they now help mitigate system events rather than exacerbate them Western Power dynamically manages the hosting capacity of the network, as a Distribution System Operator (see "Who is doing what in the high-DER future?") optimising DER and existing infrastructure investments Technical capabilities of innovative DER such as VPPs have been demonstrated in the SWIS and they can now provide services more widely across the energy system AEMO, as system operator, is able to incorporate DER into its modelling, forecasting and operational processes to predict and manage system impacts Battery storage on the distribution network is being deployed by a range of parties and can provide services across the value chain The system is prepared for the rise of electric vehicles
Tariffs and investment signals	Retail and network tariffs are more reflective of the underlying costs of providing energy services Retail tariffs provide customers with price signals that incentivise efficient investment and usage of DER and energy, and limit cross-subsidies that shift costs onto those without DER The approach to valuing the services provided by DER is consistent and transparent, with payments for exported energy accurately reflecting its value Vulnerable customers are supported throughout the transition with targeted programs and information
DER participation	Western Power can see distribution network power-flows and issues in real time, and procures solutions to these network issues, including via aggregators using DER DER can easily participate, via aggregators, in energy markets, and have the necessary capabilities and standards to dispatch into these markets safely Western Power (as network and distribution system operator) and AEMO (as system and market operator) effectively communicate to co-ordinate dispatch of DER services and keep local networks and the system stable DER customers have certainty about how their DER can be used and access value All customers can access the benefits of DER, including residential and commercial tenants
Customer protection and engagement	Customers can access DER through innovative third-party business models within an effective customer protection regime Customer data is protected but is available to customers to support their decision making Customers are provided with clear and simple information about the energy sector, allowing them to make informed choices to manage their usage and costs

Figure 14: DER in the SWIS in 2025

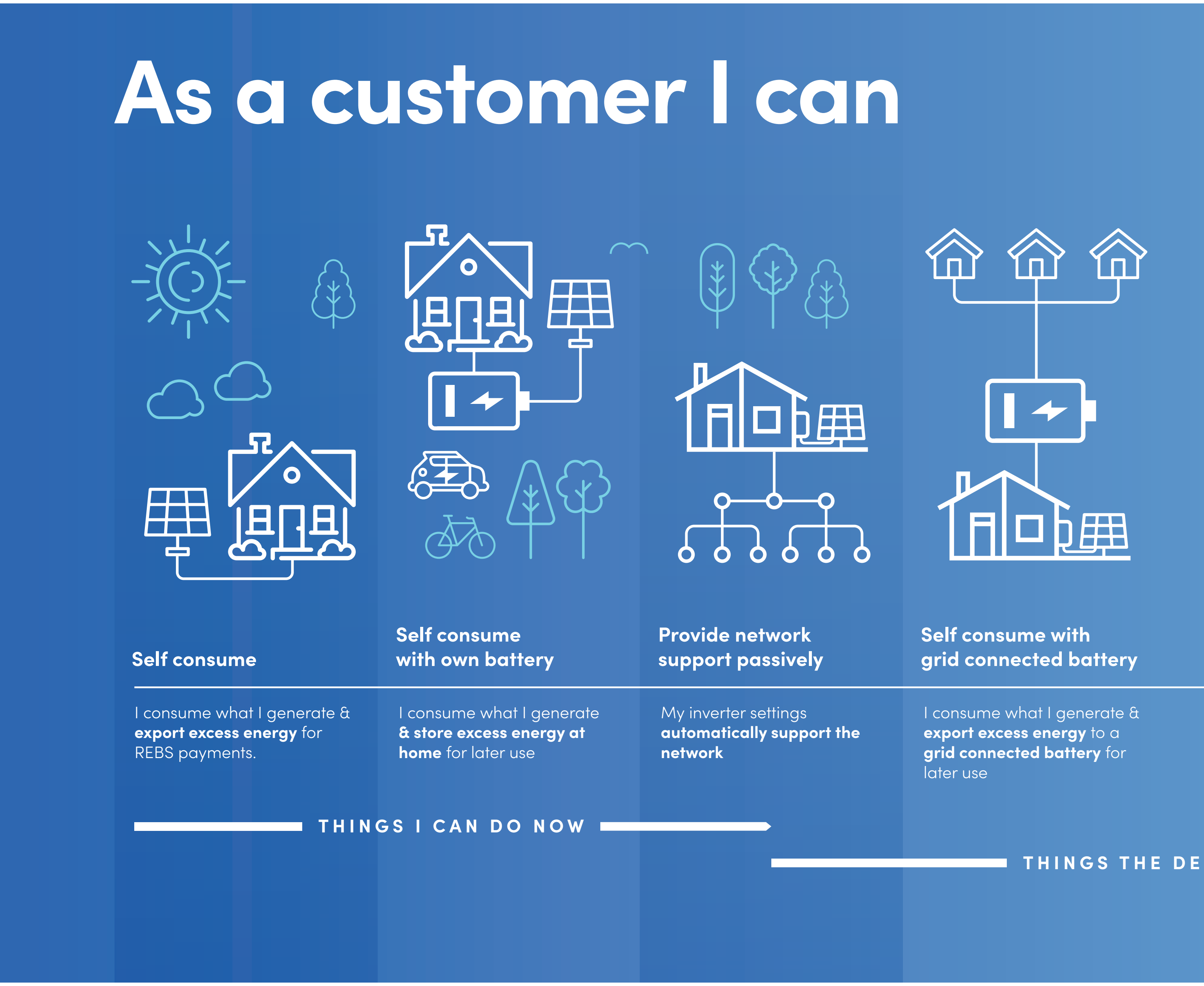
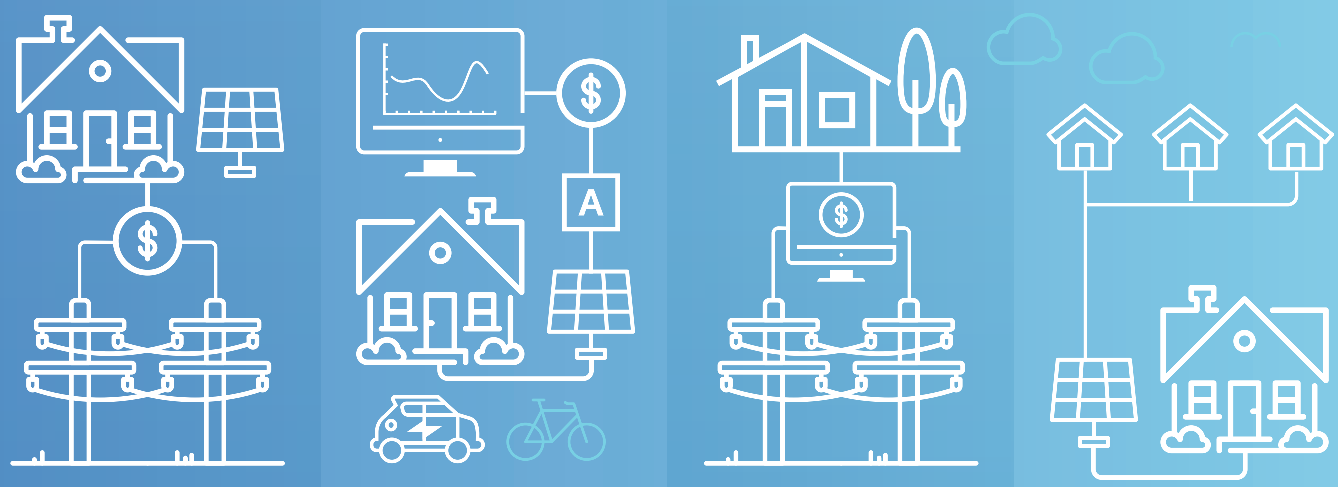


Figure 15: Customer participation and the DER Roadmap



Provide services to the network

Through my aggregator, I actively **provide network services** to the DSO and **I am compensated** for this

Participate in the Wholesale Market

Through an aggregator I participate in **energy markets** via the market operator

Provide services to a new Distribution Market

Through local aggregation, I participate in a **distribution system market** via the market operator

Share excess with others

I trade my excess energy via the market operator

R ROADMAP WILL ALLOW ME TO DO

THINGS I CAN DO IN THE FUTURE

Customer DER will participate more actively in the energy chain. In the majority of cases, this will be delivered via an aggregator. Customers will have simple "set and forget" arrangements with their aggregator who in turn orchestrates the DER and monetises the services

2.1.3 Who is doing what in the high-DER future?

DER generation from rooftop solar PV is an increasing component of the total energy generated in the SWIS. The power system has been designed around large generators being dispatched remotely by AEMO as the system and market operator. This includes the capability to dynamically manage generator dispatch to resolve system issues.

In order to overcome the system security risks described in Chapter 1 and provide for continued uptake of DER by consumers, the Roadmap looks to build similar capabilities in small-scale DER to those that are in place for large generators. That is, equipment standards need to be updated to require new installed DER to transition from passive to active. In addition, new entities will be required to facilitate the different business models to support active DER participation in the energy supply chain as DER uptake continues.

A variety of new roles and functions will be required in the high-DER future.

Aggregators

The management of active DER systems will require them to be communications enabled, typically via a customer's home internet. In most cases, the interaction of active DER installations with the power system will be managed by market entities (aggregators or the customer's electricity retailer) on a simple 'set and forget' basis.

Aggregated DER is often referred to as a 'Virtual Power Plant' or VPP. Aggregators will develop portfolios of DER market support services based on contracts with DER owners and will access the market to provide value to the customer. These services include:

- energy scheduling for economic dispatch and consumption of electricity;
- ESS (frequency control, system restart) in the WEM, where the cost to provide these services from DER is cheaper than traditional providers (generators and interruptible loads); demand side management dispatch for the provision of additional dispatchable capacity in the WEM Reserve Capacity Mechanism; and
- network support, where this is more economic than network augmentation.

Distribution System Operator (DSO)

A Distribution System Operator, or DSO, with visibility of power flows and DER on the network, will be required to manage the network within technical limits, identify when network issues emerge and act to manage these issues. To do this, the DSO will need to see the flow of power across the distribution network in real time.

Where an issue on the network emerges, the DSO may communicate with DER aggregators in real time, and request assistance to mitigate. In such cases DER may provide a service to the network business and, accordingly, consumers via their aggregators would expect to be compensated for the network services they provide.

There is also the requirement to ensure the DSO interacts with the broader system (i.e. at a transmission network level) to avoid any action on the distribution network compromising system security. Where a distribution network issue has emerged, and a DER aggregator has been instructed to alleviate the issue, these instructions must be communicated with AEMO as the whole of system operator. This ensures that the power system at all levels remains secure.

In the high-DER future, the Distribution System Operator is a natural evolution of Western Power's role as network service provider.

Distribution Market Operator (DMO)

In the SWIS, AEMO as the Market Operator operates and settles the Wholesale Energy Market and its various components including energy, ESS and capacity. Where DER are participating in the market to provide these services, AEMO would be dispatching DER in line with the registration requirements of the market, along with large-scale registered facilities. This ensures the security and reliability of the whole electricity system and enables co-optimised dispatch of distribution-level DER.

As the number of installations that can provide network services become more widespread, there may be the need to create a market for the provision of network services, as well as system services. Therefore, as the role of DER evolves in the energy supply chain, the DMO would:

- administer platforms to enable access for aggregators to market trading for energy, capacity and ESS (such as voltage and frequency control);
- operate and manage the platform to ensure that participants meet registration requirements and provide information transparency, dispatch reconciliation and market settlement; and
- interface with the DSO to ensure distribution network issues are resolved in a co-ordinated manner.

Importantly, a market operator is independent of any market participant, network or resource owners (suppliers) so that:

- the market is operated in a manner that is fair and impartial;
- DER (and other resources) can be utilised in the most efficient and least-cost manner; and
- all trading (including any third-party activities and customer trading) at the distribution level is aligned with the market and power system security and reliability objectives.

In the high-DER future, the Distribution Market Operator is a natural evolution of AEMO's role as market operator.

2.2 What is stopping this vision from being realised now?

This section identifies barriers in current arrangements to the effective integration of DER in the SWIS to realise the DER Roadmap vision.

Existing regulatory and policy frameworks in Western Australia have been developed to meet the requirements of the traditional electricity supply model and have not accounted for the capabilities and consequences of DER.

As a result, they are no longer fit for purpose, and present barriers to achieving DER integration in the SWIS. Barriers and gaps in the existing frameworks have been identified in **Appendix A – Regulatory Settings Summary** and are summarised in the following sub-sections.[35]

Numerous pilots, trials and projects have been undertaken by Government and the private sector in Western Australia and other jurisdictions, to test concepts, technology and alternative business models. A thorough assessment of these projects can be found in **Appendix B – DER Project Stocktake**. The various barriers to the vision have been identified and are outlined below.[36]

Measures across the four themes of the Roadmap are needed to support a stable and secure system into the future and realise the benefits of DER to the power system.

2.2.1 Technology integration

DER and its enabling technology is constantly improving, however, the existing market framework does not adequately facilitate the required visibility, performance standards, and management capabilities for DER to become active in the electricity system.

35 More information and analysis is provided in Appendix A – Regulatory Settings Summary.

36 More information and analysis is provided in Appendix B – DER Project Stocktake.

Table 4: Barriers to technology integration

IDENTIFIED BARRIER	DESCRIPTION
Unpredictable and inconsistent DER device performance	Limitations in the present performance standards[37] that apply to DER, specifically rooftop solar PV inverters, mean that some devices can perform unpredictably or exacerbate system events. While recent updates to Western Power's Network Integration Guideline[38] have specified updated settings for newly installed inverters to help facilitate connection of additional DER in the short-term, additional or amended functions are required. In addition, monitoring of compliance with standards is likely to be required to ensure ongoing performance.
The current technical standards do not deliver active DER installations	The technical framework for connecting DER largely only contemplates passive interaction with the SWIS. It does not provide a framework for the connection of DER in a way that provides dynamic management or additional value to the system. Further, the existing registration regime does not provide for service providers to register as a DER aggregator, and the rules for market participation do not allow for aggregation of DER to participate in existing markets.
Lack of DER visibility for the network operator	Western Power's view of distribution network power flows and technical performance is limited. Western Power has minimal real time visibility on the distribution network (downstream of the zone substation) apart from field devices such as recloser and load break switches, but virtually no visibility at all on the low voltage network where most of the DER is connected. This impacts network operations and investment decisions (including non-network solutions) required to facilitate future DER installations. The lack of visibility presents a barrier to the establishment of a DSO that can actively optimise DER on the distribution network.
Lack of DER visibility for the system operator	There is limited information available to AEMO (as the whole of system operator) about the number, location, type and performance of DER installations. Given the substantial capacity of installed DER generation, this lack of visibility presents significant challenges to the safe and reliable operation of the power system and the transparent and efficient operation of the electricity market.
Battery storage systems as a network asset	The *Electricity Networks Access Code 2004* does not provide a clear method for valuation of the benefits provided by DER to the network. There are also limitations on the process for third-parties to provide services to resolve network needs. This prevents third parties seeking to provide storage as a service to Western Power from accessing a revenue stream for network support services. In addition, where a market for storage services to Western Power does not emerge to resolve network needs where it is efficient, the existing regulatory framework does not readily facilitate the ownership and cost recovery of distribution batteries by Western Power. The broad deployment of distribution batteries to manage network issues is also limited by uncertainty regarding metering arrangements.
Voltage management	The nominal voltage and voltage ranges specified in the *Electricity Act 1945* are misaligned with ranges in Australia and internationally. In their current form, they are inconsistent with a high-DER future,[39] and will require costly augmentation of Western Power's low voltage networks (that are otherwise safe and able to meet customer equipment needs) to allow for the continued uptake of DER.
Electric vehicle integration	Connection requirements do not comprehensively account for the uptake of electric vehicles and the associated demand on the distribution network for charging, which may have significant impacts on the network and system operations. The implications of emerging vehicle-to-grid capabilities in the SWIS are not yet understood.

37 For example, inverter devices connected to low voltage networks must be capable of meeting the functional requirements specified in AS/NZS 4777.2:2015.

38 On 9 August 2019, Western Power mandated volt-var and volt-watt response settings be enabled for all new inverters, commencing 1 November 2019. Volt-var and volt-watt settings adjust the active and reactive power output (or absorption) of inverters.

39 Customer installation of solar PV is contributing to substantial daily voltage variations in some parts of the low voltage network, and the management of these variations is likely to require network infrastructure augmentation.

2.2.2 Tariffs and investment signals

Existing tariff and investment signals present barriers to the efficient uptake and use of DER for the benefit of the system.

Table 5: Barriers to effective tariffs and investment signals

IDENTIFIED BARRIER	DESCRIPTION
Current tariff structures do not reflect the cost of electricity supply	Most households in the SWIS are on a flat retail tariff comprised of a unit rate for electricity (variable component) and a daily supply charge (fixed component). The structure recovers most of the costs through the variable component. However, the underlying costs are predominantly fixed. This means customers are disproportionately incentivised to reduce their bills by cutting their (variable) energy usage, including through the installation of DER. This creates an under-recovery in the contribution to system costs by DER owners. Consequently, customers who are unable to access DER are cross-subsidising those who can.
Current tariff structures do not reflect time-based costs	The use of a flat retail tariff provides no signal to customers to adapt their consumption to times that would reduce network and system costs, such as during the middle of the day when excess rooftop solar generation may be abundant. Further, customers are not provided with an appropriate signal as to the value of energy generated by their DER relative to that consumed from the grid.
REBS provides distorted signals	The Renewable Energy Buyback Scheme requires Synergy and Horizon Power to purchase energy exported by residential customer DER at the time it is generated.[40] While the financial benefits of REBS are minor compared to the benefits from self-consumption under existing tariff structures, it contributes to inefficient DER outcomes. The price of energy in the WEM and alternative sources of supply for Synergy are regularly lower than the REBS rate, which also places financial pressure on Synergy. Essentially the REBS in its current form is a subsidy to DER owners.
No mechanism or entity to coordinate DER's market participation	There is currently no mechanism or entity that can enable the coordination of DER within the distribution system and orchestrate its participation within existing market arrangements. Aggregators, together with DSO and DMO functionality and supporting market arrangements are required.
Current metering arrangements are a barrier to valuing DER	Metering is currently provided on a net basis, meaning that the amount of energy self-consumed is not captured. Greater data from behind the meter (i.e. from the PV system) can provide better value DER.[41] Where DER are being used in future market transactions, the net position at the connection point is unlikely to be sufficiently accurate for settlement purposes, and alternative approaches to capturing and validating data are likely to be required.
DER for tenants	Residential and commercial tenants are often at a disadvantage in accessing the benefits of DER including the ability to reduce power bills as in most cases the owner of the property has no incentive to install rooftop solar PV or other DER. Commercial customers within embedded networks may even be prevented from participating in programs as simple as demand reduction schemes.

40 At present, the REBS rate in the SWIS is fixed at 7.1350c/kWh. While there is no requirement for the rate to be flat, a flat rate is driven by metering and customer education considerations. Horizon Power can offer a higher rate that reflects local supply costs.

41 In other jurisdictions, third party providers are resolving this through installing separate measuring devices outside the utility meter which can add to costs to the customer.

2.2.3 DER participation

Existing arrangements do not fully support DER integration into the wider value chain. This limits transactions between consumers, third party providers, large-scale generators, Western Power and AEMO selling and buying various DER services that would benefit the system and consumers. There are also gaps in the way emerging business models for VPPs, embedded networks and microgrids are able to interact with the wider system and markets.

Table 6: Barriers to DER participation

IDENTIFIED BARRIER	DESCRIPTION
Existing regulatory framework does not contemplate DER participation	Registration, transaction costs, and prudential requirements present barriers to the participation of small generation in the wholesale market mechanisms, such as the Balancing Market, Reserve Capacity Mechanism and ESS markets. In addition, the broad range of requirements to support DER participation, such as communications protocols, dispatch standards and any required supporting technology, do not currently exist.
Opportunities for DER to provide network services are not well defined	Challenges exist under the current network planning and investment process regarding how Western Power provides information, identifies, value and procures non-network options to resolve a network issue. This limits the potential for DER to provide network services to Western Power. In addition, Western Power faces uncertainty within regulatory periods on the recovery of operational costs for non-network solutions.
Valuation of DER	When considering network investments, there is little guidance within the regulatory framework on how to value DER and its wider upstream and downstream benefits, potentially precluding DER from providing network support solutions or replacing traditional network assets.
Validation of dispatch capability of DER and supporting market arrangements	DER can provide a range of services across the value chain. However, the individual use cases for DER in the SWIS (i.e. for frequency regulation within the ESS framework) requires testing, and the supporting market arrangements must be determined, to ensure DER can explicitly provide the services required and be rewarded accordingly. Similarly, dispatching a portfolio of DER assets on an aggregated basis into the local market platform has yet to be tested in the SWIS operating environment. In simple terms, sending a command from a market platform and having a behind the meter DER respond within required timeframes and performance standards will require a SWIS-based pilot. Additionally, a pilot will inform on how market arrangements must be designed to support registration and settlement.
Barriers to third party provision	Current metering and settlement arrangements prevent parties other than Synergy from offering customers certain energy services. Potential new service offerings such as community batteries and virtual power plants cannot be accessed without changes to metering and settlement arrangements.
The value of batteries is not recognised or supported	Existing registration and technical requirements pertaining to battery storage apply only to facilities larger than 10 MW and are built around existing participant categories. There is no consideration currently for VPPs to participate in the various markets. In addition, REBS specifically excludes energy supplied from distributed batteries, which will require review in a VPP setting.
Risks under current connection arrangements	Connection of customer generation is currently processed on a first come, first served basis. If the network capacity is not able to support the further connection of rooftop solar PV, for example due to voltage issues, customers may be prevented from connecting new generation to the grid or need to pay network augmentation costs. Connecting customers with a dynamic management capability (i.e. ‘active’ DER) can maximise existing hosting capacity and ensure equity.

2.2.4 Customer protection and engagement

The customer protection framework must be able to adapt to the continuing transformation of the energy system and ensure that existing protections are not eroded in a high-DER future. Limitations to information availability and customer education may prevent customer's from taking up options to manage their energy use and reduce costs.

Customer engagement will also facilitate the evolution of retail tariff and REBS arrangements, through articulating the dangers facing the system and the unpalatable alternative of limiting DER capacity, as well as the opportunities for more active DER participation into the future.

The growth of VPPs, embedded networks and microgrids, while providing new opportunities, is outpacing the regulatory frameworks that are in place to ensure customers have equivalent protections, regardless of their energy service provider.

Table 7: Barriers to customer protection and engagement

IDENTIFIED BARRIER	DESCRIPTION
Licencing/Regulation regime may not be supportive of new business models	The current electricity supply regulatory and licensing schemes may not provide customers with enough protections in relation to new business models. Energy-specific consumer protections that cover important issues such as disconnections and hardship do not currently apply to energy service providers that are exempt from requiring a retail or distribution license. In addition, where a new market is created for distribution services, monitoring of market effectiveness will be required within the regulatory regime.
Access to data	The absence of secure and consistent arrangements for the access and sharing of customer data may compromise customer protections as new technology and business models proliferate.[42] Customer data ownership arrangements require further consideration to ensure that customers are protected, particularly as new business models emerge.
Lack of effective engagement with customers	Unengaged customers may avoid shifting to alternative tariff options, which would undermine the achievement of the end vision of a high-DER future. Without appropriate information availability, customers may inadvertently act in ways that add costs for themselves and the system. Programs that incentivise a change in customer behaviour, such as tariff pilots, rely on customers understanding the associated incentive mechanisms and how their actions impact their electricity bill.

42 The Consumer Data Right is being developed for energy nationally and may provide a framework for customer data access in future.

3. The DER Roadmap

Chapter 3 explains how the SWIS will move from a power system facing the clear and present challenge articulated in Chapter 1, to one with integrated and active DER, envisioned in Chapter 2. It will explain the structure of the DER Roadmap, before identifying the Actions and Recommendations required to achieve the vision for DER in the SWIS in 2025.

In order to breakdown a complex and interconnected set of actions, the DER Roadmap has been structured using the four themes (Technology integration, Tariffs and investment signals, DER participation and Customer protection and engagement) identified in Chapter 2.

3.1 The DER Roadmap

The DER Roadmap identifies the broad set of actions, action owners and timeframes required to deliver on the vision of

A future where DER is integral to a safe, reliable and efficient electricity system, and where the full capabilities of DER can provide benefits and value to all customers.

The DER Roadmap comprises 14 elements that are recommended to deliver the high-DER future (Figure 16). From these 14 elements, a series of priority milestones have been defined, as the core components along the Roadmap implementation timeline (Figure 17).

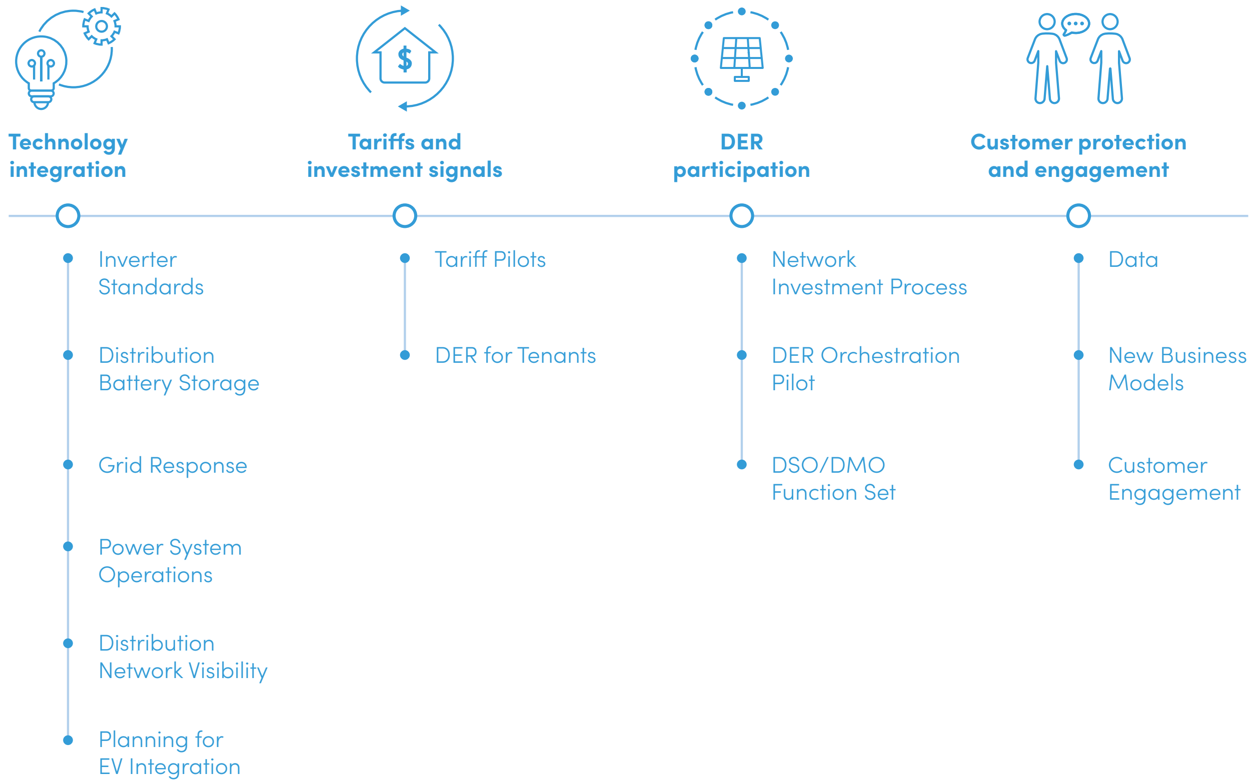


Figure 16: The DER Roadmap elements

These high priority actions form the backbone of the Roadmap. The full set of recommended actions is provided in section 3.3. Where actions are required to be progressed in the period up to May 2021, they will be overseen by the Energy Transformation Taskforce.

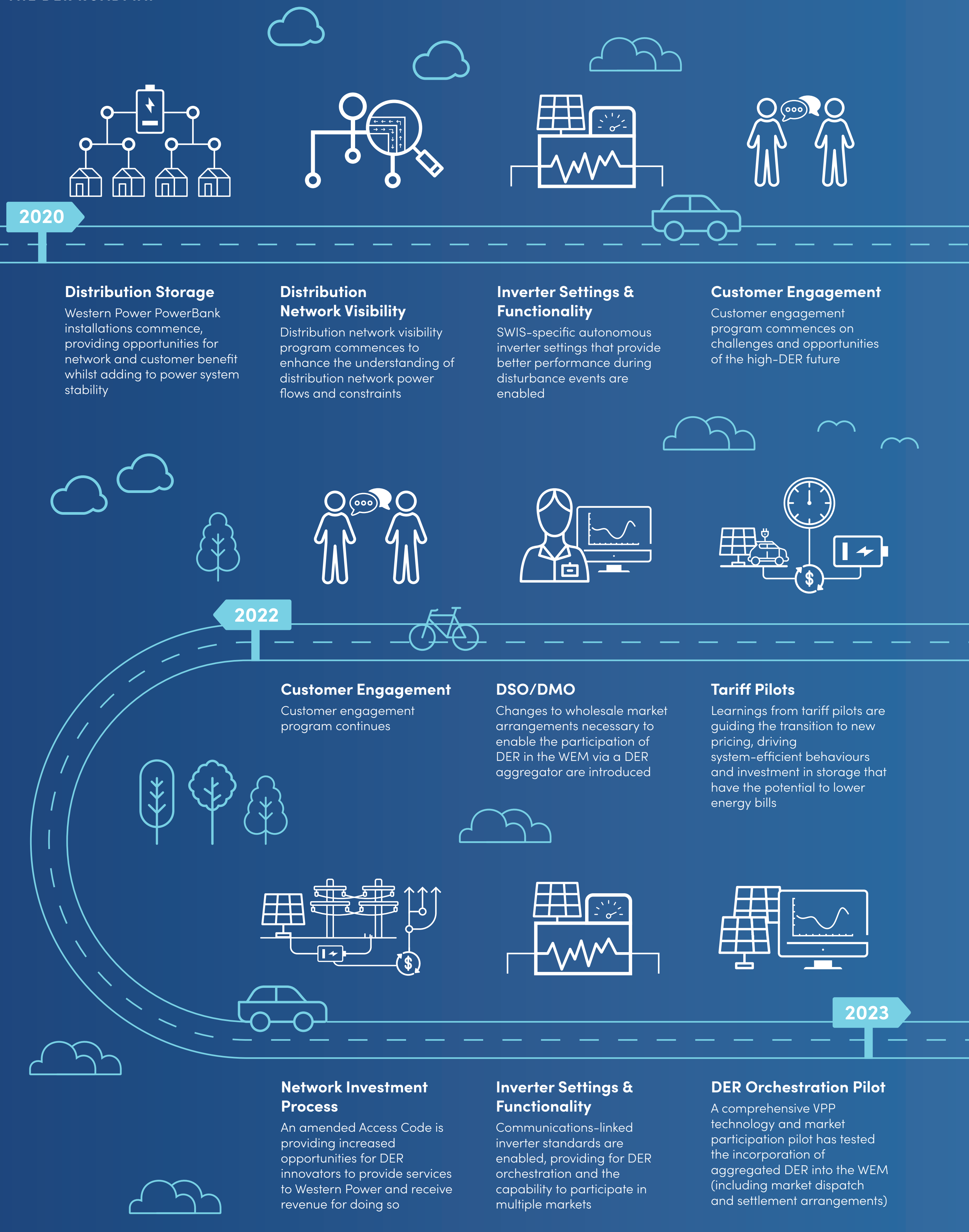
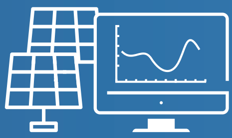
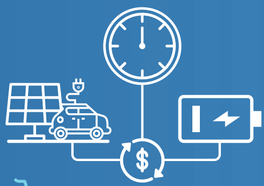
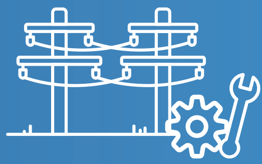


Figure 17: The DER Roadmap 2020-2024







DER Orchestration Pilot

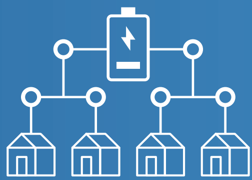
A comprehensive VPP technology and market participation pilot has commenced, testing the incorporation of aggregated DER into the WEM

Tariff Pilots

Pilots for alternative tariff structures have commenced, demonstrating value to consumers who can move electricity use to the middle of the day

Grid Response

Investment in grid support technologies (including reactors, storage and voltage control equipment) by Western Power is contributing to maintaining system stability on low demand days



2021

System Operations

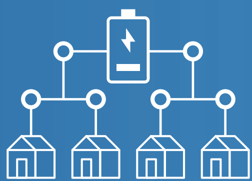
The System Operator's dynamic system modelling adequately incorporates DER and arrangements adequately address power flows during system events

Distribution Storage

Western Power has identified emerging network needs and has access to network storage services from the market

DSO/DMO

DSO/DMO roles, functions, practical operations, regulatory requirements, as well as costs and benefits have been identified



2024

DSO/DMO

DSO and DMO goes live in the SWIS, with DER able to respond to meet network needs as well as be dispatched into the WEM, and be compensated appropriately

Distribution Storage

Distribution storage continues to be deployed under a variety of business models, and can access value across the supply chain

DER Roadmap Complete

- DER is being leveraged for value across the supply chain, including to secure the network, and providing value to customers;
- Innovative business models with appropriate licensing are providing value to customers and the system as a whole; and
- The DSO and DMO are coordinating effectively to ensure customers can continue to connect their DER into the future

3.2 DER roadmap actions and recommendations

This section discusses the recommendations contained in the Roadmap. Each of the DER Roadmap elements depicted in Figure 17 is explained in further detail.

3.2.1 Technology integration

Inverter standards

Managing high levels of DER into the future requires improvements to the technical and communication capabilities of new inverters beyond those currently in place. Enhanced inverter capabilities are essential to manage power quality on the distribution network in the short term. Eventually, when communications enabled, enhanced inverter capabilities will allow DER participation in the energy supply markets.

In August 2019, Western Power updated its *Network Integration Guideline for Inverter Embedded Generation* to mandate revised settings of new inverters, in line with existing functionality contemplated in the relevant Australian Standard for inverters (AS/NZS 4777.2:2015).[43] In this update, Western Power mandated volt-var and volt-watt response settings be enabled for all new inverters, commencing 1 November 2019. Volt-var and volt-watt settings support network voltage by adjusting the reactive and active power output / absorption of inverters respectively.

AEMO has identified a need for a range of further improvements to the Australian Standard, which will ultimately be progressed within the Standards Australia review process nationally, in a two-phase process.

The first phase, to be delivered in 2020, will seek to improve inverter autonomous functions. These changes will include specific sections within the Australian Standard for the WEM, with Western Australia leading the way in driving DER to respond to system security issues in a similar fashion to other generators.

As an example, in the event of an over-frequency event, Western Australia would require all inverter-based generation to start responding to over frequency issues quicker than currently required (from 50.025 Hz instead of 50.25 Hz). This would provide for alignment with the frequency settings for large generators to ensure that all generators, irrespective of size and location, will react in a similar way to frequency excursions and proportionately to the system need.

The second phase will deal with the development of communications functionality, which is a foundational technical requirement to enable future DER to supply into the various energy markets. Western Power and AEMO will take a lead role in developing these standards nationally, with the intent to have new standards operational by mid-2022.

In addition to the above, many existing inverters in the SWIS already possess functions and settings that can be remotely updated to the newest standards. There is likely to be benefit from a program targeting these existing installations, either broadly or in specific locations on the network based on local conditions.

43 This Standard specifies the electrical installation requirements (AS/NZS 4777.1) and the inverter performance requirements (AS/NZS 4777.2) for inverters connected to the electricity distribution network.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
1	Inverter standards	AEMO	By October 2020, deliver improved inverter functions through the Standards Australia national review process for AS/NZS 4777.	High
2	Inverter standards	Western Power Energy Policy WA (EPWA)	By October 2020, assess the opportunity to update latent capabilities in the existing inverter fleet.	Medium
3	Inverter standards	Western Power AEMO	By July 2022, introduce mandatory inverter communications functionality, including communications protocols, through AS/NZS 4777, to allow remote dynamic management of DER.	High
4	Inverter standards	Western Power AEMO	By July 2022, develop a process to ensure that inverters remain compliant with connection requirements and are upgraded to the latest settings over time.	Medium

Distribution battery storage

Deployment of storage within the SWIS will be needed as part of measures to ensure power system stability and security.

Large scale front-of-the-meter storage can unlock the full capability of storage to provide power system and network benefits and storage products that can be offered to customers or retailers. Under certain arrangements, customers could purchase 'virtual storage', similar to the PowerBank trial[44], as a more cost-effective option for households to access storage. Larger battery banks also achieve economies of scale and lower installation costs. Battery banks can also allow for centralised management of maintenance and quality control.

However, a lack of clarity exists as to how distribution storage devices fit within current Technical Rules, market (metering and settlement) arrangements and network investment regulations.

More guidance is needed within the regulatory framework as to how third party delivered community battery models can deliver services across the value chain, including to Western Power (see Network investment process in section 3.2.3 for more information).

At least in the immediate term, costs associated with distribution storage are unlikely to be recovered by a single participant. In order to contribute to the mitigation of the near-term system security risks described in Chapter 1, an immediate commencement of the deployment of distribution storage is required in 2020. This will be implemented at ten locations across the network, with preliminary locations identified as Canning Vale, Dunsborough, Ellenbrook, Kalgoorlie, Leda, Parmelia, Port Kennedy, Singleton, Two Rocks, and Wanneroo.

The Taskforce recommends Western Power develops a plan highlighting network issues that storage can help alleviate, and seeks market input on an approach to the widespread deployment of distribution storage in 2021-2024 and beyond. It is expected that a variety of third-party models will emerge to provide required services to Western Power.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
5a	Distribution storage	Western Power	By December 2020, deploy community PowerBanks to address network constraints in Canning Vale, Dunsborough, Ellenbrook, Kalgoorlie, Leda, Parmelia, Port Kennedy, Singleton, Two Rocks, and Wanneroo.	High
5b	Distribution storage	Western Power	By October 2020, develop a plan covering 2021-24 for Western Power to obtain additional distribution storage services (and installations where services do not emerge) across the SWIS to meet emerging network needs.	High
6	Distribution storage	EPWA	By December 2020, implement appropriate metering and settlement arrangements for distribution storage.	High
7	Distribution storage	EPWA Western Power	By December 2020, ensure that the *Electricity Networks Access Code 2004* allows Western Power to recover appropriate costs associated with efficient use of distribution storage under its regulated revenue. (See Network Investment Process for further information on proposed Access Code changes).	High
8	Distribution storage	Western Power	By December 2021, update the Technical Rules to clarify the requirements for distribution battery storage beyond the current treatment as both a generator and a load.	Medium

44 See Appendix B – DER Project Stocktake, Project 20: PowerBank for more information.

Grid response

High levels of DER present many localised challenges to the distribution network. In addition, high penetration of DER across the network can impact the stability of the system as whole. Rooftop solar PV is causing significant variations in voltage over the course of any given day and increasing customer exports to the grid are contributing to two-way power flows on a network designed for one-way flows. These changes are seeing power flows approach the physical limitations of the installed infrastructure in some locations.

Investment in grid support technologies (including reactors, storage [e.g. batteries], voltage control equipment, dynamic Under Frequency Load Shedding[45]) across the network, to meet compliance obligations and maintain system stability on low demand days, are an important component of alleviating the system security risks identified in Chapter 1.

The first round of grid support technology will be deployed by Western Power in April 2020, comprising five 5 MVAr reactor units providing reactive power compensation by April 2020.

Further investments will require detailed options assessments, including non-network solution options, and will be made progressively to contribute to the alleviation of system security risks.

In addition, the required action includes amending the Western Australian voltage compliance range to align with practice either nationally or internationally (where different, wider bands apply than is currently the case in Western Australia). This would mean Western Power is not required to invest in upgrading networks for compliance reasons, when those networks are otherwise safe and able to meet customer needs. Alignment with national standards as a minimum will provide Western Power with an improved investment profile, while supporting a high-DER future by managing existing network assets more dynamically.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
9	Grid response	Western Power	By April 2020, install 25 MVAr (five x 5 MVAr units) of reactive power compensation, and continue the assessment and delivery of network technology solutions to provide grid support and maintain system stability on low-demand days.	High
10	Grid response	Western Power AEMO	By June 2020, review Under Frequency Load Shedding arrangements, and assess implications for AA5 investment program.	High
11	Grid response	EPWA	By December 2021, draft updates to the *Electricity Act 1945* to reflect a voltage standard that is more suitable for a high-DER environment.	Medium

45 Under Frequency Load Shedding (UFLS) refers to the automatic procedures used to arrest a fall in frequency by disconnecting load, and facilitate the return of the power system to a secure operating state.

Power system operations

In a high-DER environment the system operator faces many operational challenges that can no longer be managed using traditional methods of managing contingency events. Where in the past a suburban distribution feeder was only seen as a load, it may now act as a generator sending power back into the power system at certain times. On cloudy days, feeders can even swing between being a load or a generator within a market trading interval (30 minutes), or even from minute to minute.

The increasing complexity and frequency of system operator interventions for the purpose of maintaining system security warrants an uplift in AEMO's functionality to give the system operator the capacity to manage these challenges.

Specifically, DER needs to be captured in the dynamic models used by the system operator to forecast the movement of energy and operate the system accordingly. The existing arrangements for system restart, established prior to the rapid rise of DER, will also require review and revision.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
12	Power system operations	AEMO Western Power	Beginning in June 2020, revise system restart arrangements to consider DER.	High
13	Power system operations	AEMO Western Power	By March 2021, ensure that the System Operator's dynamic system modelling adequately incorporates DER, and arrangements adequately address power flows during system events.	High

Distribution network visibility

Western Power requires greater visibility of the distribution network to better understand local power quality, flows, constraints and the real time capabilities of DER. Current methods for estimating network requirements have proved cost effective and sufficiently accurate. However, as levels of DER (particularly rooftop solar PV, behind the meter batteries, and electric vehicles) increase, existing measurement equipment and methods are becoming unsuitable. Without the appropriate depth of real-time network visibility, Western Power will be unable to manage the network as a DSO and publish distribution constraints.

So AEMO can effectively manage the power system as DER penetration levels increase, a DER register must be established for the SWIS. The register will capture all newly-installed (and previously installed) DER devices and will be largely facilitated by Western Power as the collector of data on customer DER connecting to its network.[46]

The benefits of implementing a DER register in the SWIS will enable AEMO to:

- efficiently manage market operations because of the availability of more accurate data on expected DER performance during power system events;
- refine its forecasting and planning decisions based on the latest DER penetration data;
- provide better information to market participants; and
- inform the direction of standards on DER performance requirements over time.

DER register data and the establishment of the processes to enable this data's usage in AEMO's operational planning are necessary first steps towards the collection and usage of dynamic DER needed for real time power system and market operation.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
14	Distribution network visibility	Western Power EPWA	By June 2020, undertake an assessment of distribution network visibility capability and develop an investment plan for deploying technology to improve that visibility, both static and dynamic, to support DSO and system/market operator requirements. The scope should include a review of the coverage of network visibility investments under the regulatory framework, including the *Electricity Networks Access Code 2004* and Technical Rules.	High
15	Distribution network visibility	AEMO Western Power EPWA	By September 2020, deliver a register of static DER data for the SWIS, with processes to support data collection and future DSO functionality.	High

46 The DER Register will not apply outside of the SWIS, that is, the Pilbara region in the north of Western Australia will not be included.

Planning for electric vehicle integration

At current uptake rates EVs are not expected to have a material influence on the grid prior to 2025. This is highly variable depending on local and national policies as well as actions from EV vendors. However, it is likely Western Australia will be able to learn from other jurisdictions with higher EV numbers and uptake rates on how to best integrate EVs to the grid. Vehicle-to-grid technology is also likely to be more mature by the time mass deployment occurs in Western Australia.

Undertaking technical trials and planning will ensure that EVs can be safely integrated and contribute to energy services, once capabilities are more advanced.

Additionally, there is a need to plan for the deployment of fast charge locations and other requirements for high levels of EVs. This action aligns with interdepartmental work that is already being undertaken by the WA EV Working Group.

EV charging will likely contribute additional demand, and the timing of this load can either exacerbate evening peak demand or provide system benefits by absorbing daytime rooftop solar generation. Implementing appropriate price signals to encourage EV charging at beneficial times is essential.

Ensuring EV charging points are captured within DER registers[47] will assist with improving forecasting around the impacts of EVs on the grid.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
16	Planning for electric vehicle integration	Western Power	By June 2020, commence work on planning to integrate electric vehicles in the grid, including for the deployment of charging points (household and fast charge) and trials to better understand the capabilities of vehicle-to-grid technology.	Low

47 This would only apply to fast charge locations and smart chargers in households and buildings. Simple charging via standard power point connection is not able to be captured at this time.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3.2.2 Tariffs and investment signals

Tariff pilots

Existing flat electricity tariff structures are increasingly unsuitable as more DER is installed. This is because they do not reflect the true cost to supply electricity. There are minimal incentives under these tariff structures for customers to use their energy in a way that helps keep supply costs at a minimum and ensures the system is stable and secure. Further, customers who install DER contribute less than their share of system costs and are disproportionately benefiting from lower bills. Conversely, customers who are unable to access DER are cross-subsidising those who can. In short, the current tariff structures are incompatible with a high-DER energy system.

To alleviate these equity issues and deliver price signals that incentivise system-efficient behaviour, including as electric vehicles emerge, new network and retail pricing structures are required.

Ideally, these structures should:

- encourage consumers to move their energy use to the middle of the day when costs are lower and there is an excess of rooftop solar PV generation, as well as signalling for peak demand and the associated costs to service the peak;
- continue to provide customers with the choice to use rooftop solar PV to reduce their bills, while also incentivising DER investments that have increased benefit to the system, such as battery storage;
- provide for continued payments for energy that DER exports to the grid, but these payments should better reflect the value of that energy; and
- ensure all customers contribute to their fair share of the costs of access to a safe, secure and reliable system – both those with and without DER.

The rate of transition to alternative tariffs is limited by the availability of advanced metering infrastructure in the SWIS. However, Western Power has now commenced the deployment of around 300,000 advanced meters over the next three years.

In order to understand the impact of alternative tariff structures and identify effective implementation strategies, retail tariff pilots are required. As a guiding principle, consumers participating in tariff pilots should be presented with pricing that is simple, as well as timely information including access to their own data.

Pilots of alternative tariff structures must include engagement with participating customers to help them to understand the new tariffs and how they work (see Customer protection and engagement in section 3.2.4), as well as specific planning to support vulnerable members of the community participating in the pilots. It is recommended that targeted vulnerable customer and hardship assistance be developed as part of the tariff pilots.

Delivery of the pilots will build upon the experience of Synergy and Western Power in implementing residential tariff trials in the SWIS and the Horizon Power 'MyPower' program in the North-West.[48]

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
17	Tariff pilots	EPWA Synergy Western Power Horizon Power	By March 2020, develop tariff pilot programs to explore tariff structures that encourage system-efficient use of and investment in DER and help to share the benefits of DER with all customers. The scope of the pilots should include measures to assist and protect vulnerable customers.	High
18	Tariff pilots	Synergy Western Power	Beginning in July 2020, commence implementation of the tariff pilots.	High
19	Tariff pilots	EPWA Synergy Western Power	From the end of 2020, commence reviewing the progress of and insights from the tariff pilots.	High

48 See Appendix B – DER Project Stocktake, Project 15: MyPower, for more information.

DER for tenants

Residential and commercial tenants are often at a disadvantage in accessing the benefits of DER, including the ability to reduce power bills, as in most cases the property owner has limited incentive to install rooftop solar PV or other DER.

As a result, renters could end up with higher energy bills than those who are able to install DER.

There is a need to facilitate the sharing of the benefits of DER between landlords and their tenants to improve equity around energy costs.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
20	DER for tenants	EPWA	By December 2021, deliver a program that reduces barriers to the installation of DER at commercial and residential rental properties.	Medium

3.2.3 DER participation

Network investment process

The existing processes regulating Western Power's network investment decisions, outlined in the *Electricity Networks Access Code 2004* (Access Code), theoretically provide the required guidance and incentives for the consideration of non-network solutions, potentially using DER, as an alternative to traditional network investment. However, in practice, these processes may not be delivering the required information and engagement to inform opportunities at the right time for non-network solutions to emerge as viable alternatives.[49]

The investment test applying to network investment under the Access Code (the New Facilities Investment Test) requires the consideration of net benefit across the value chain by Western Power when assessing investment options.[50]

In a landscape where innovative DER solutions (for example, third-party provided community storage) are emerging rapidly, guidance on how to value DER services across the supply chain would assist Western Power in conducting such options assessments.

A range of supporting updates to the Access Code and associated processes are required to ensure the opportunity for third parties to deliver network services to Western Power are adequately considered in the assessment of options to address network needs. Similarly, Western Power requires revenue certainty on these arrangements.

These changes should also ensure there is regulatory approval for appropriate expenditure on undertaking pilots or trialling innovative approaches to demand management and DER as part of its normal operations.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
21	Network investment process	EPWA	By July 2020, deliver a range of updates to the Access Code to facilitate better procurement of non-network solutions (using DER where appropriate) to address network issues by Western Power.	High

49 See Appendix A – Regulatory Settings Summary, Section 4. Network mechanisms influencing DER, for more information.

50 Net benefit means a net benefit (measured in present value terms, to the extent that it is possible to do so) to those who generate, transport and consume electricity in (as the case may be): (a) the covered network; or (b) the covered network and any interconnected system.

DER orchestration pilot

The coordination, or orchestration, of multiple DER offers opportunities for additional value for customers, the network operator, the system operator and electricity market. The ability for orchestrated DER to act as a virtual power plant (VPP) will allow it to participate in the provision of network and system services, and for customers to receive payment for providing those services. Typically, this would be facilitated by aggregators.

However, the experience of Horizon Power, Synergy and Western Power to date has identified limitations to the full demonstratable capabilities of DER, particularly in the context of dispatch into local markets.[51] Issuing a command to a behind the meter DER fleet from an operations control room and seeing the DER perform to the service expected in the timeframe necessary to meet the service standard requires validation across the full suite of market services.

This experience has also been shared nationally with trials in progress or proposed, to better test the maturity of DER capability when aggregated at scale as well as market integration.

The rapid pace of DER adoption necessitates a coordinated process, building from a VPP pilot demonstrating the technical capabilities of individual devices, to incorporating aggregated DER into WEM operations that can be expanded and scaled up across the SWIS. The pilot will be complemented by updates to regulatory frameworks that relate to VPP services and inform development of communications standards and protocols for inverters.

Demonstration of the ability for DER to be orchestrated under a VPP is essential to ensure the Distribution System Operator and Distribution Market Operator functions can be established in time for 2023, as well as the facilitation of WEM participation by aggregated DER portfolios for the provision of energy, capacity and ESS.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
22	DER orchestration	Synergy EPWA Western Power	By July 2020, commence a comprehensive VPP technology pilot to demonstrate the end-to-end technical capability of DER in the SWIS, and its ability to respond in a coordinated manner under central dispatch instruction. The pilot would commence with a focus on technical performance of DER and transition to market participation testing (see action 23).	High
23	DER orchestration	Synergy AEMO	By July 2022, complete a comprehensive VPP market participation pilot that tests the incorporation of aggregated DER into energy markets, including market dispatch and settlement arrangements from the market operator to individual customer.	High

51 See Appendix B – DER Project Stocktake, Project 8: DER Management Capability, and Project 22: Virtual Power Plant Technology Trials, for more information.

Distribution System Operator / Distribution Market Operator function set

The challenges presented by growing levels of DER are first felt on the distribution network through localised power quality issues and exceedance of physical network limits.

While the DER Roadmap specifies work to be undertaken to improve Western Power's network operations and visibility, there is currently little capability for the active management of DER in the distribution network. As noted in Chapter 2 (see section 2.1.3) this capability is a fundamental requirement in alleviating the system security and network reliability risks defined in Chapter 1.

While actions taken as a result of this Roadmap will defer these risks, the capability to dynamically manage the DER fleet over time will play a major role in avoiding these risks entirely. In addition, building DSO and DMO capability, and providing for the coordination of these capabilities within whole of system operation will allow the maximisation of existing hosting capacity in a secure power system operating environment while customers continue to uptake DER.

This lack of capability at the distribution level is not unique to the SWIS and is being examined in many jurisdictions. In Australia, AEMO and Energy Networks Australia have established the Open Energy Networks project (OpEN) to progress solutions to the issue nationally. This work includes understanding the need for, and functions of, a DSO and DMO. Western Australian stakeholders, including Western Power and EPWA are participating in this forum and assessing options for the Western Australian context.

With respect to a DSO/DMO, a model (based on the OpEN Hybrid model[52]) that sees the evolution of the existing network operator (Western Power) and power system and market operator (AEMO) to deliver the required functions appears to be the most suitable for the SWIS (Figure 18).

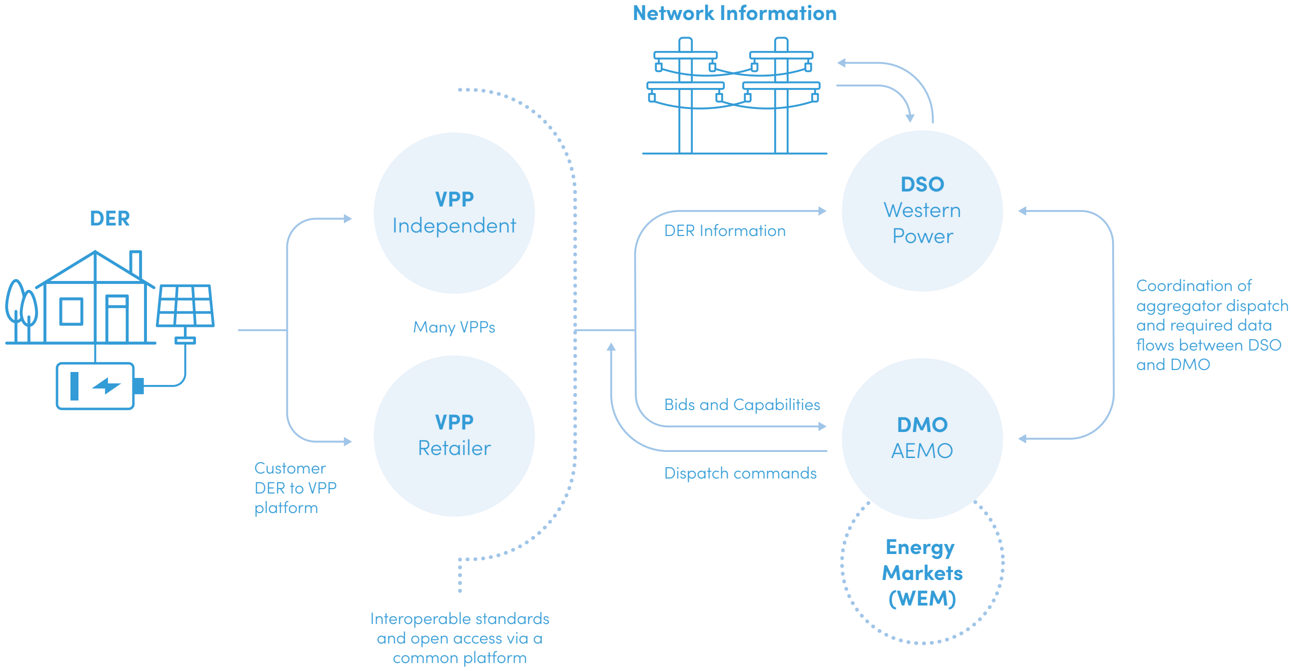

Figure 18: A possible DSO/DMO model for WA.

52 Energy Networks Australia, July 2019, *Open Energy Networks – Required Capabilities and Recommended Actions Report*, available at https://www.energynetworks.com.au/assets/uploads/open_energy_networks_-_required_capabilities_and_recommended_actions_report_22_july_2019.pdf

Under this model, the individual customers have a relationship with a VPP provider (aggregator), who may be their retailer. Information about customer DER is passed from various VPP operators to the DSO.The DSO takes this information and combines it with the information it receives from its own network monitoring capability to map constraints and power quality across the distribution network. In the short term the DSO can use this information to procure network support services directly or from DER by way of VPPs.

This information is also passed up to the system operator to help it understand the overall health of the power system, undertake forecasting and coordinate generation (and load) resources for dispatch in the market. Over time, as DER and VPP capability matures and reaches scale, AEMO as the existing market operator could manage bids and dispatch for distribution network services in a new distribution services market.

In order to reach the state where DER can participate in all aspects of the market, several interlinked pieces of work are required.

These will further define roles and functions (including dispatch processes), deliver regulatory and legislative enablers, as well as defining the data and communication standards that will underpin the flow of information.

It is recommended that the DMO functions be incorporated into the planning process, as they relate to the dispatch of DER within the WEM and all supporting requirements. However, the exact requirement to transition to a real time market for DER-based distribution services (in short, a real-time market for services to Western Power) should be assessed over the life of the Roadmap.

There will also be a need to update connection requirements for customers to ensure all DER is captured and can respond to requests from the system operator.

The DSO/DMO activities have a number of pre-requisite actions within the DER Roadmap, including those for:

- Inverter standards (specifically the communications capability component); Distribution network visibility and DER visibility; and
- DER orchestration pilot.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
24	DSO/DMO	EPWA AEMO Western Power	By December 2020, develop a plan for the establishment of a DSO and DMO in the SWIS, including the identification of roles, functions, costs and practical operations. This plan should include an assessment of the costs and benefits to the system for the establishment of these functions.	Medium
25	DSO/DMO	EPWA AEMO	By December 2020, identify legislation and regulatory framework requirements including timeframes for development and implementation to establish DSO and DMO functions.	High
26	DSO/DMO	Western Power	By September 2021, finalise communications protocols, data and technology requirements to accurately predict and publish operating constraints on the distribution network under a DSO, and requirements for coordination with the system operator.	Medium
27	DSO/DMO	EPWA AEMO	By December 2021, introduce changes to wholesale market arrangements necessary to enable the participation of DER in the wholesale market via a DER aggregator.	High
28	DSO/DMO	Western Power	By June 2022, introduce adapted network connection agreements that enable the DSO, once established, to interact with devices on the distribution network.	High
29	DSO/DMO	EPWA	By December 2022, deliver a DSO/DMO legislative and regulatory framework, for transition to commencement by 1 July 2023.	Medium
30	DSO/DMO	Western Power	At 1 July 2023, DSO and DMO goes live in the SWIS, with DER able to respond to meet network needs as well as be dispatched into the WEM and be compensated appropriately.	Medium
31	DSO/DMO	EPWA AEMO Western Power	By July 2023, develop the initial design of the framework for a distribution services market with fit for purpose arrangements for dispatch and settlement. Include an assessment of the cost and benefits of market creation.	Low
32	DSO/DMO	EPWA	By July 2024, commence the development of trials for a distribution services market for network support.	Low

3.2.4 Customer protection and engagement

Data

Customers using DER can be required to supply a significant amount of their data as part of normal energy service delivery. The ownership and availability of this data to the customer, as well as existing customer data protections requires further consideration, particularly as new business models emerge.

The introduction of the Consumer Data Right (CDR) by the Australian Government is intended to apply to the energy industry to give customers access to information companies hold about them. While initially focused on encouraging competition in the National Electricity Market, it is likely Western Australian customers will be able to benefit from access to their data in the future.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
33	Customer Data	EPWA	By September 2020, asses the applicability of the Consumer Data Right to Western Australian energy customers and commence assessment of an applicable customer data regulatory framework.	Medium

New business models

The continued development of DER technology is likely to lead to an emergence of new business models providing energy services to customers.

It is essential that appropriate customer protections are retained, and licencing or other regulatory arrangements applying to new business models ensure that market fees, hardship schemes and exemptions are appropriately applied. This includes where customers may be part of embedded networks, VPPs or microgrids.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
34	New business models	EPWA	By June 2020, commence a process to ensure new business models in the electricity sector, at a minimum, provide appropriate protections for consumers.	Medium
35	New business models	EPWA	By March 2022, establish a regulatory framework for new energy service business models to ensure access to the Energy Ombudsman, and that hardship schemes and exemptions are appropriately applied.	Medium

Customer engagement

The transition to a high-DER environment will require participants in the electricity sector, including customers and existing stakeholders, to adjust their expectations from the way the system operates today. Engaging with customer groups will facilitate an improved understanding of the imperative for reform and will provide an opportunity for input on aspects of reforms.

In general, customer understanding of the electricity market is currently low (for instance, the components of the electricity price cost stack, and the basis for the REBS price; the existence of negative pricing during low demand periods; the cost implications of increased variability, with an increasingly elongated duck curve; and the compounding of risks as the level of solar PV penetration increases over time).

Customer education will need to be incorporated in programs that incentivise a change in customer behaviour, such as the tariff pilots. However, a broader education program will assist customers to understand how their actions impact the system and their electricity bill. If appropriate information is not available, customers may inadvertently act in ways that add costs for themselves and the system.

To reduce the risk of resistance and to help participants understand the need for change there will be a need for a strong, ongoing education program.

Required actions:

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
36	Customer engagement	EPWA	By July 2020, engage with energy customers and commence an education program to ensure industry, government and the public are sufficiently informed about the need for changes being undertaken as a result of the Roadmap recommendations.	High

3.3 Required actions

The following tables provide a consolidated list of actions recommended by the DER Roadmap, ordered against the four Roadmap themes.

3.3.1 Technology integration

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
1	Inverter standards	AEMO	By October 2020, deliver improved inverter functions through the Standards Australia national review process for AS/NZS 4777.	High
2	Inverter standards	Western Power EPWA	By October 2020, assess the opportunity to deliver a program to incentivise the updating of latent capabilities in the existing inverter fleet.	Medium
3	Inverter standards	Western Power AEMO	By July 2022, introduce mandatory inverter communications functionality, including communications protocols, through AS/NZS 4777, to allow remote dynamic management of DER.	High
4	Inverter standards	Western Power AEMO	By July 2022, develop a process to ensure inverters remain compliant with connection requirements and are upgraded to the latest settings over time.	Medium
5a	Distribution storage	Western Power	By December 2020, deploy community PowerBanks to address network constraints in Canning Vale, Dunsborough, Ellenbrook, Kalgoorlie, Leda, Parmelia, Port Kennedy, Singleton, Two Rocks, and Wanneroo.	High
5b	Distribution storage	Western Power	By October 2020, develop a plan covering 2021-24 for Western Power to obtain additional distribution storage services (and installations where services do not emerge) across the SWIS to meet emerging network needs.	High
6	Distribution storage	EPWA	By December 2020, implement appropriate metering and settlement arrangements for distribution storage.	High
7	Distribution storage	EPWA Western Power	By December 2020, ensure the *Electricity Networks Access Code 2004* allows Western Power to recover appropriate costs associated with efficient use of distribution storage under its regulated revenue.	High
8	Distribution storage	Western Power	By December 2021, update the Technical Rules to clarify the requirements for distribution battery storage beyond the current treatment as both a generator and a load.	Medium
9	Grid response	Western Power	By April 2020, install 25 MVAr (five x 5 MVAr units) of reactive power compensation, and continue the assessment and delivery of network technology solutions to provide grid support and maintain system stability on low-demand days	High
10	Grid response	Western Power AEMO	By June 2020, review Under Frequency Load Shedding arrangements, and assess implications for AA5 investment program.	High
11	Grid response	EPWA	By December 2021, draft updates to the *Electricity Act 1945* to reflect a voltage standard that is more suitable for a high-DER environment.	Medium

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
12	Power system operations	AEMO Western Power	Beginning in June 2020, revise system restart arrangements to consider DER.	High
13	Power system operations	AEMO Western Power	By March 2021, ensure the system operator's dynamic system modelling adequately incorporates DER, and arrangements adequately address power flows during system events.	High
14	Distribution network visibility	Western Power EPWA	By June 2020, undertake an assessment of distribution network visibility capability and develop an investment plan for deploying technology to improve that visibility, both static and dynamic, to support DSO and system/market operator requirements. The scope should include a review of the coverage of network visibility investments under the regulatory framework, including the *Electricity Networks Access Code 2004* and Technical Rules.	High
15	Distribution network visibility	AEMO Western Power EPWA	By September 2020, deliver a register of static DER data for the SWIS, with processes to support data collection and future DSO functionality.	High
16	Planning for electric vehicle integration	Western Power	By June 2020, commence work on planning to integrate electric vehicles in the grid, including for the deployment of charging points (household and fast charge) and trials to better understand the capabilities of vehicletogrid technology.	Low

3.3.2 Tariffs and investment signals

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
17	Tariff pilots	EPWA Synergy Western Power Horizon Power	By March 2020, develop tariff pilot programs to explore tariff structures that encourage system-efficient use of and investment in DER and help to share the benefits of DER with all customers. The scope of the pilots should include measures to assist and protect vulnerable customers.	High
18	Tariff pilots	Synergy Western Power	Beginning in July 2020, commence implementation of the tariff pilots.	High
19	Tariff pilots	EPWA Synergy Western Power	From the end of 2020, commence reviewing the progress of and insights from the tariff pilots.	High
20	DER for tenants	EPWA	By December 2021, deliver a program that reduces barriers to the installation of DER at commercial and residential rental properties.	Medium

3.3.3 DER participation

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
21	Network investment process	EPWA	By July 2020, deliver a range of updates to the *Electricity Networks Access Code 2004* to facilitate better procurement of non-network solutions (using DER where appropriate) to address network issues by Western Power.	High
22	DER orchestration	Synergy EPWA Western Power	By July 2020, commence a comprehensive VPP technology pilot to demonstrate the endtoend technical capability of DER in the SWIS, and its ability to respond in a coordinated manner under central dispatch instruction. The pilot would commence with a focus on technical performance of DER and transition to market participation testing (see action 23).	High
23	DER orchestration	Synergy AEMO	By July 2022, complete a comprehensive VPP market participation pilot that tests the incorporation of aggregated DER into energy markets, including market dispatch and settlement arrangements from the market operator to individual customer.	High
24	DSO/DMO	EPWA AEMO Western Power	By December 2020, develop a plan for the establishment of a DSO and DMO in the SWIS, including the identification of roles, functions, costs and practical operations. This plan should include an assessment of the costs and benefits to the system for the establishment of these functions.	Medium
25	DSO/DMO	EPWA AEMO	By December 2020, identify legislation and regulatory framework requirements including timeframes for development and implementation to establish DSO and DMO functions.	High
26	DSO/DMO	Western Power	By September 2021, finalise communications protocols, data and technology requirements to accurately predict and publish operating constraints on the distribution network under a DSO, and requirements for coordination with the system operator.	Medium
27	DSO/DMO	EPWA AEMO	By December 2021, introduce changes to wholesale market arrangements necessary to enable the participation of DER in the wholesale market via a DER aggregator	High
28	DSO/DMO	Western Power	By June 2022, introduce adapted network connection agreements that enable the DSO, once established, to interact with devices on the distribution network.	High
29	DSO/DMO	EPWA	By December 2022, deliver a DSO/DMO legislative and regulatory framework, for transition to commencement by 1 July 2023.	Medium
30	DSO/DMO	Western Power	At 1 July 2023, DSO and DMO goes live in the SWIS, with DER able to respond to meet network needs as well as be dispatched into the WEM and be compensated appropriately.	Medium
31	DSO/DMO	EPWA AEMO Western Power	By July 2023, develop the initial design of the framework for a distribution services market with fit for purpose arrangements for dispatch and settlement. Include an assessment of the cost and benefits of market creation.	Low
32	DSO/DMO	EPWA	By July 2024, commence the development of trials for a distribution services market for network support.	Low

3.3.4 Customer protection and engagement

ACTION	ROADMAP ELEMENT	OWNER	DESCRIPTION	PRIORITY
33	Customer data	EPWA	By September 2020, asses the applicability of the Consumer Data Right to Western Australian energy customers and commence assessment of an applicable customer data regulatory framework.	Medium
34	New business models	EPWA	By June 2020, commence a process to ensure that new business models in the electricity sector, at a minimum, provide appropriate protections for consumers.	Medium
35	New business models	EPWA	By March 2022, establish a regulatory framework in the SWIS for new energy service business models to ensure access to the Energy Ombudsman, and that hardship schemes and exemptions are appropriately applied.	Medium
36	Customer engagement	EPWA	By July 2020 engage with energy customers and commence an education program to ensure that industry, government and the public are sufficiently informed about the need for changes being undertaken as a result of the Roadmap recommendations.	High

Glossary

TERM	DEFINITION
AA4 / AA5	AA4 is Western Power's fourth Access Arrangement, for the period 2017-2022. AA5 will be Western Powers fifth Access Arrangement. An access arrangement defines services to be delivered, service levels to be achieved and rates to be paid. The Economic Regulation Authority (is responsible for reviewing and approving Western Power's access arrangement.
Active power	The power which is actually consumed or utilised in an AC Circuit is called true power or active power or real power. It is measured in kilo watt (kW) or MW. It is the actual outcomes of the electrical system which runs the electric circuits or load.
AMI	Advanced Metering Infrastructure AMI typically includes smart meters (that measure bidirectional energy flows, in shorter time intervals), upgraded communications networks (to transmit large volumes of data), and requisite data management systems.
Aggregator	A party which facilitates the grouping of DER to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to the system operator(s).
AS/NZS 4755.3:2016	Australian Standard AS 4755 – Demand response capabilities and supporting technologies for electrical products. This Standard details requirements of Demand Response Modes for Energy Storage Systems (AS/NZS 4755.3) and the requirements for Demand Response Enabling Devices (AS/NZS 4755.6).
AS/NZS 4777.2:2015	Australian Standard AS 4777 – Grid Connection of Energy Systems via Inverters. This Standard specifies the electrical installation requirements (AS4777.1) and the inverter performance requirements (AS4777.2) for inverters connected to the electricity distribution network.
Behind the meter	Any technology located on the customer's side of the customer-network meter.
Contestable customers	Customers that consume greater than 50 MWh of electricity per annum, who can choose their electricity retailer.
DER	Distributed energy resources, or 'DER', are smaller-scale devices that can either use, generate, or store electricity and form a part of the local distribution system, which serves homes and businesses. DER can include renewable generation, energy storage, electric vehicles (EVs), and technology to manage load at the premises. These resources operate for the purpose of supplying all or a portion of the customer's electric load and may also be capable of supplying power into the system or alternatively providing a load management service for customers.
Dispatch	Dispatch refers to the instructions from AEMO to generators delivering power to the system. Dispatch instructions are provided in the form of generation, timing and ramp rate information. AEMO dispatches generation with consideration for the prices offered by generators, network limitations, and system requirements.
Distribution storage	Storage attached in directly to the distribution network as distinct from storage connected behind the meter at a customer site.
DMO	Distribution Market Operator The function of a distribution level market operator, as distinct to the wholesale market operator.
DSO	Distribution System Operator: • A Distribution System Operator (DSO) enables access to the network, securely operates and develops an active distribution system comprising networks, demand, and other flexible distributed energy resources (DER). Expanding of the network planning and asset management function of a DNSP, the DSO enables the optimal use of DER on distribution networks to deliver security, sustainability and affordability in the support of whole system optimisation.

TERM	DEFINITION
Embedded network	Embedded networks are private electricity networks which serve multiple premises and are located within, and connected to, a distribution or transmission system through a parent connection point (and an associated "master meter").
Essential System Services	Formerly known as Ancillary Services.
Frequency response	Primary frequency response is available relatively quickly to arrest the rapid decline of frequency and establish a temporary stable operating state. Secondary frequency response is characterised by system-wide control, typically through coordinated changes to the setpoints of multiple facilities.
Front of the meter	Any infrastructure located on the distribution network side of the customer meter (i.e. not behind the meter).
Hosting capacity	DER hosting capacity is defined as the typical amount of DER that can be connected to a distribution network without requiring network augmentation while the network (and the electricity system as a whole) remains within its technical limits.
Microgrid	Small-scale power grids that can either operate independently of a main electricity network or complement it to improve reliability.
Network constraints	When a section of an electricity network approaches its technical limits.
Non-contestable Customers	Non-contestable customers are those who consume 50 MWh or less of electricity per annum and includes most residential households and small businesses in Western Australia. In the SWIS, only Synergy can supply noncontestable customers.
Reactive power	The power which flows back and forth that mean it moves in both the direction in the circuit or react upon itself, is called Reactive Power. The reactive power is measured in kilo volt ampere reactive (kVAR) or MVAR.
Small-scale Renewable Energy Scheme	The Small-scale Renewable Energy Scheme is component of the Commonwealth Government Renewable Energy Target. It creates a financial incentive for individuals and small businesses to install eligible small-scale renewable energy systems such as solar panel systems, small-scale wind systems, small-scale hydro systems, solar water heaters and air source heat pumps.
System restart	System restart service allows parts of the power system to be re-energised by black start equipped generation capacity following a full (or partial) black out.
Time-of-use tariff	A retail tariff structure that includes different variable charges for energy depending on the time of day the energy is consumed by the customer.
Under Frequency Load Shedding	UFLS schemes are emergency mechanisms that are designed to arrest a fall in frequency.
Volt-watt response	The volt-watt response mode reduces the inverter power output when needed in order to prevent exceeding the voltage limits. If this mode is not enabled the inverter may experience frequent nuisance tripping when the network is lightly loaded.
Volt-var response	Volt-var function smooths the grid voltages by using the customer's inverter to absorb reactive power from the grid when voltage levels rise. Further to this, when voltages fall below (V2) 220V, the volt-var mode will cause the customer's inverter to generate reactive power to support the grid voltage.
VPP	Virtual Power Plant VPPs are the notional entities comprised of aggregated and controlled DER components, which can provide generation and system support functions, and participate in energy markets (like traditional generators).