Open Energy Networks Project

Energy Networks Australia
Position Paper

Citation
Open Energy Networks Project:
Energy Networks Australia Position Paper

Acknowledgements
Dr Jill Cainey, Energy Networks Australia

Contents

Figures

Tables

Preface

The Open Energy Network (OpEN) project was developed jointly with Energy Networks Australia and the Australian Energy Market Operator (AEMO).

There is a great deal of current work, including the Energy Security Board's (ESB) Post-2025 market design project, that is related to the outcomes of the OpEN project. The **Two-sided market paper** from the ESB was published on 23 April 2020, with submissions due on 18 May 2020.

This paper proposes significant changes to the way the market and distribution network service providers (DNSPs) operate and envisages a distribution market like those considered in OpEN.

In order to meaningfully contribute to the two-sided market paper and the broader design of the energy sector post-2025, Energy Networks Australia has chosen to publish this position paper at this time to share the current findings of the OpEN project with wider stakeholders. This is intended to help facilitate discussions on the best pathway to integrate distributed energy resources into local electricity grids around the country.

While OpEN is a joint project undertaken with AEMO, any views in this position paper are those of Energy Networks Australia only, unless otherwise noted. Energy Networks Australia and our members continue to work actively with AEMO on a variety of DER integration projects and there may be a Final OpEN Report published jointly with AEMO in the future.

Abbreviations

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
ARENA	Australian Renewable Energy Agency
DEIP	distributed energy integration program
DER	distributed energy resources
DMO	distribution market operator
DNSP	distribution network service provider
DSO	distribution system operator
ERA	Economic Regulation Authority
ESB	Energy Security Board
EV	electric vehicles
IDSO	independent distribution system operator
LV	low voltage
NEM	national electricity market
OpEN	Open Energy Networks project
PV	photovoltaics
SIP	single integrated platform
TNSP	transmission network service provider
TSO	transmission system operator
TSO-DSO	transmission system operator – distribution system operators
TST	two-step tiered (framework)
VPP	virtual power plant
WEM	wholesale electricity market (Western Australia)

Summary

The Open Energy Networks Project (OpEN) aims to demonstrate that through a distribution market, we can better integrate distributed energy resources (DER) into local distribution networks.

A distribution market should allow benefits to be captured across the entire system while minimising risks and costs to consumers.

The continued uptake of DER is changing the way that electricity networks and markets behave and is causing technical challenges for AEMO and distribution network service providers (DNSPs).

OpEN investigated solutions to optimise and manage DER on the distribution network, and to facilitate DER participation in the wholesale energy markets. Distribution markets are just one potential solution to enable this participation. The project has undertaken extensive stakeholder engagement and established both technical and consumer working groups.

OpEN published an interim report in July 2019. The report included data, and key milestones and actions associated with incorporating DER into Australia's electricity system. The report also discussed the potential technical frameworks for incorporating DER into the electricity network.

The four frameworks are:

1. Single integrated platform (SIP)
2. Two-step tiered platform (TST)
3. Independent distribution system operator (IDSO)
4. Hybrid

Examination of these frameworks has been undertaken and is explored further in Chapter 8. A cost-benefit analysis of each framework has also been completed, along with modelling of the implementation of each framework under multiple DER-uptake scenarios produced by AEMO. The cost benefit analyses showed that significant upfront investment is required, and net benefits are only delivered in shortly before 2039 and only at very high levels of DER deployment.

This report also includes information on relevant national and international initiatives. OpEN has established a knowledge sharing arrangement with the UK's Energy Networks Association to facilitate this.

The 2020 COVID-19 pandemic has had a significant short-term impact on renewable electricity uptake, but the medium to long-term impact on the deployment of DER is yet to be determined. As the benefits of implementing a distribution market is dependent on very high levels of DER, it is suggested that an incremental approach is adopted during this period of economic uncertainty.

It is important to note that the two-step tiered (TST) and single integrated platform (SIP) frameworks represent two contrasting market designs. There is no single definition of the Hybrid, it is a conceptual solution that sits between the SIP and the TST and ideally incorporates the best aspects of both. It is likely some version of the Hybrid framework is the most appropriate for Australia, final assessment of this will be dependent on the results of trials, see Chapter 4.

To effectively incorporate DER some reform of the rules and regulations governing the operation of the national electricity market will be required to support the transformation.

1 Introduction

In November 2017, Energy Networks Australia and the Australian Energy Market Operator (AEMO) agreed to commit to the Open Energy Networks Project (OpEN), a major collaboration to help transform the way that we integrate distributed energy resources (DER) into local distribution networks, allowing benefits to be fully captured while minimising risks and costs to consumers.

Launched in June 2018, OpEN sought to address the challenges associated with the high uptake of DER by assessing the ability of distribution markets to:

- enable greater market access to energy and service markets for distribution-level DER
- enable customers to benefit from contracting with network service providers for DER services
- ensure efficient investment in DER to deliver a lower cost energy system for all customers

Electricity is an essential service. The operators of Australia's electricity system must meet challenges associated with DER while continuing to deliver safe and secure system operation. New approaches must allow efficient and timely access to networks, while continuing to provide value for money for all customers.

Effective integration of extensive DER into the electricity network as well as the use of DER services for wholesale markets and distribution network services will require operational and market coordination between a range of partners, including retailers, aggregators, innovative new service providers, AEMO and DNSPs. OpEN has explored distribution markets by developing new system architectures, including market designs and operational structures.

2 Open Energy Networks Project

The *Electricity Network Transformation Roadmap* (CSIRO and Energy Networks Australia, 2017) stated that if the deployment of DER was not fully optimised and managed, the cost to consumers would be over $100 billion (Figure 1).

Optimising DER deployment and managing its operation as envisaged in the Roadmap would lead to an annual average savings on a household's electricity bill of $414 per year in 2050.

OpEN explored whether a distribution level market was the best way to optimise and manage DER on the distribution network, while also facilitating the provision of services to both DNSPs and AEMO. A distribution market is just one approach of many to optimise and utilise DER for the benefit of all consumers.

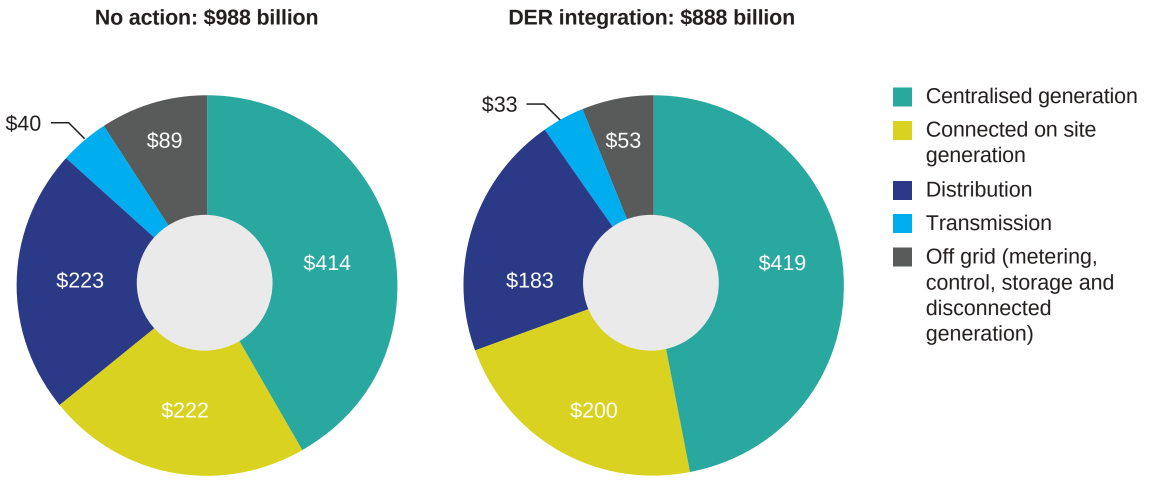
EA Technology was engaged to develop three new frameworks for a distribution market (Chapter 7):

1. Single integrated platform
2. Two-step tiered
3. Independent distribution system operator

Following stakeholder engagement, a fourth framework was proposed and developed, the hybrid model. The hybrid model is a pragmatic approach combining aspects of the single integrated platform and the two-step tiered model. However, due to the relatively late addition of the hybrid framework to OpEN, more work will be needed to clearly define how variants of the hybrid would operate in the real world and the relative costs and benefits.

For each of the four frameworks, OpEN explored the roles and responsibilities required to deliver a successful distribution level market. Each framework was then assessed by Baringa Partners to determine the costs of creating a distribution market and whether the benefits would outweigh the costs. Baringa Partners undertook this cost-benefit analysis for the National Electricity Market (NEM) (Chapter 8) and a further study by Baringa of the wholesale electricity market (WEM) in Western Australia is currently underway.

Figure 1. Cumulative electricity system total expenditure to 2050 (in real terms) under the no action and DER integration scenarios



Stakeholder engagement

Any new approach to integrating DER through operating a distribution level market would represent a significant change to the current approach (Chapter 6 presents information on the current arrangements). The frameworks developed for OpEN envisage a much more active role at the distribution network level for consumers, their agents, DNSPs and AEMO.

Stakeholders from the energy industry were engaged through a series of workshops, discussion papers and a consultation to identify the approaches, capabilities and actions desired by stakeholders to facilitate increased DER integration and provide the building blocks for any future market framework.

Engagement involved a series of workshops to consider the **initial discussion paper** describing the frameworks and resulted in over **60 submissions** on the proposed approach. There were additional stakeholder workshops prior to the July 2019 publication of the Interim Capabilities Report (AEMO and Energy Networks Australia, 2019).

Following feedback from consumer advocates at an update workshop in September 2019, a customer forum was established. The customer forum attended workshops in October and December 2019 to help establish a more technical consumer understanding of OpEN and to understand consumer needs more directly. Chapter 6 presents views of the Customer Forum.

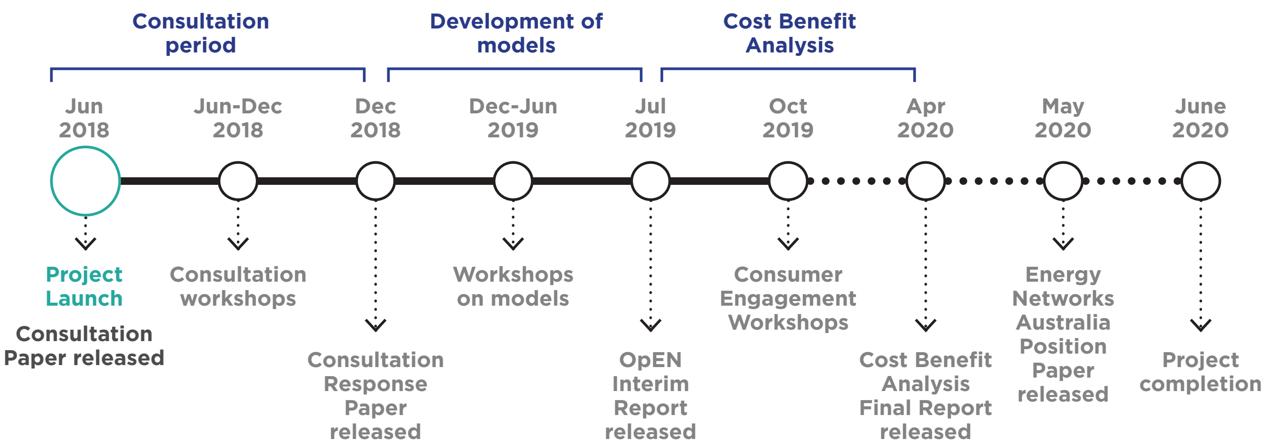
Progress to date

OpEN delivered an interim report in July 2019 (AEMO and Energy Networks Australia, 2019). The report identified three 'least regrets' milestones for required capabilities for DNSPs. These 'least regrets' actions will be required regardless of the timing of the development of distribution level markets:

DNSPs defining network visibility requirements and network export constraints

DNSPs are actively seeking to increase the visibility of their network assets in order to better manage DER, quantify hosting capacity and deliver dynamic arrangements.

Figure 2. **Project timeline**



What is visibility?

Previously, distribution networks were just designed to ensure electricity flowed to consumers. There was little need to understand what was going on in real-time. The two-way flows and greater activity of today's distribution network requires more active monitoring. As DER deployment increases and DER seek to actively provide energy and services, DNSPs need to be able to dynamically manage the network and its assets to ensure reliability. This is not possible without actively monitoring the performance of the network in real-time. Being able to understand how DER is behaving adds additional information that will support dynamic operation of the distribution network.

Monitoring delivers visibility of what is happing at any given time from many locations and requires the acquisition of data, via monitoring devices like smart meters and supports modelling, forecasting and operation.

A key requirement of operating increasingly complex networks in the future is enhanced visibility and data. This will require investment in monitoring, and a number of different approaches are being explored including:

- state estimation, using a combination of monitoring and modelling to fill the gaps
- smart meter data
- inverter data

The Australian Energy Regulator (AER) is **developing guidance** relating to funding requests from DNSPs to support the real-time monitoring that will be necessary to deliver dynamic arrangements for DER.

Third party data, while useful for planning and forecasting, is not suitable for real-time operation of distribution networks.

Most DNSPs do not intend to deploy monitoring over their entire network. Rather, they will take a proportionate approach to deploy monitoring in the areas of their networks where it is essential to facilitate the increased deployment of DER through, for example, dynamic connection arrangements (versus static or zero export requirements).

Defined communication requirements for operating envelopes

These "envelopes" are needed so customers know how much electricity they can export and/or import from the grid. These operating envelopes define the limits that customers' DER must operate within for the safe and secure running of the network and the overall electricity system. For limits to be established, real-time data must be collected and communicated, based on standard protocols.

The ability to have uniform communication protocols with DER (or the inverter) is already being considered (e.g. SA Power Networks).

Establishing an industry guideline for operating envelopes for export limits

There needs to be agreement on how to communicate these 'operating envelopes' in a standard way to aggregators, retailers, owners of DER and AEMO to help ensure the safe and secure operation of the network.

Interim report recommendations

The following table describes progress made on the recommendations in the OpEN Interim Report (AEMO and Energy Networks Australia, 2019).

Table 1: Progress on Interim Report Recommendations

	Recommendation	Progress
1	Customers require simple messaging and all customers (with and without DER) must be involved in decision making	Engaged with customer representatives and inclusion of Customer Chapter – further engagement planned via AEMO and DNSP customer forums.
2	Define the role of the aggregator and the services it will provide	New participant category 'demand response service provider' proposed under **Wholesale Demand Response Rule Change**.
3	Define aggregator, customer, and product or service relationship	VPP Demonstrations testing aggregator model in provision of FCAS. Further trials will explore the provision of Network Services from aggregated VPP portfolios.
4	Aggregators, retailers and market customers provide improved load and generation forecasts	This is an issue being explored in the ESB NEM 2025 Two-Sided Market design initiative.
5	Create a joint transmission and distribution investment plan	While the integrated system plan (ISP) should incorporate information and inputs from DNSPs (e.g. DER register), planning and investment decisions in the distribution networks are best made by the DNSP which has better knowledge of local complexities and operational issues
6	Trial DER participation in wholesale market	The VPP Demonstrations Project has successfully piloted the ability of DER to provide FCAS; further demonstrations are planned.
7	Trial real time dispatch of DER	This is the subject of several different trial proposals with a demonstration likely in 2021
8	Provide visibility of bilateral network services arrangements	To do
9	Trial a network services market	Projects under development as part of AEMO's DER- Max proposal and others including Networks Renewed (complete) and ACT DER Integration project.
10	Trial an AEMO dispatched market for transmission network services	This is an issue being explored in the ESB NEM 2025 Essential System Services design initiative.
11	Investigate appropriate price signals for customer DER	Complete (ARENA-funded project with **Oakley Greenwood**. Also, ARENA-funded **access and pricing project**.

Further steps

Since the Interim Report, OpEN has taken the following steps:

- Completed a cost-benefit analysis of each of the four frameworks for a distribution market
- Undertaken further stakeholder engagement to test the outcomes of the cost-benefit analysis and the potential model frameworks
- Engaged consumer groups and ensured a consumer focus

3 Distributed energy resources

Distributed energy resources are technologies and services that can either use, control, generate or store energy and are connected to the distribution network.

Common DER include commercial and household photovoltaics (PV), energy storage, electric vehicles (EVs), and other technologies that can be used to actively manage consumer demand, such as hot water systems, pool pumps and smart appliances.

Typically, DER is located on the consumer side of the meter. However, it can also be directly connected to the distribution network. Directly connected DER is likely to be larger-scale stand-alone renewable generation or storage, including community (shared) batteries. Figure 3 shows where and how DER can be connected to an electricity network. When DER is connected on the consumer side ('behind-the-meter'), the DER can provide energy directly to the consumer (self-consumption) and/or export energy to the network.

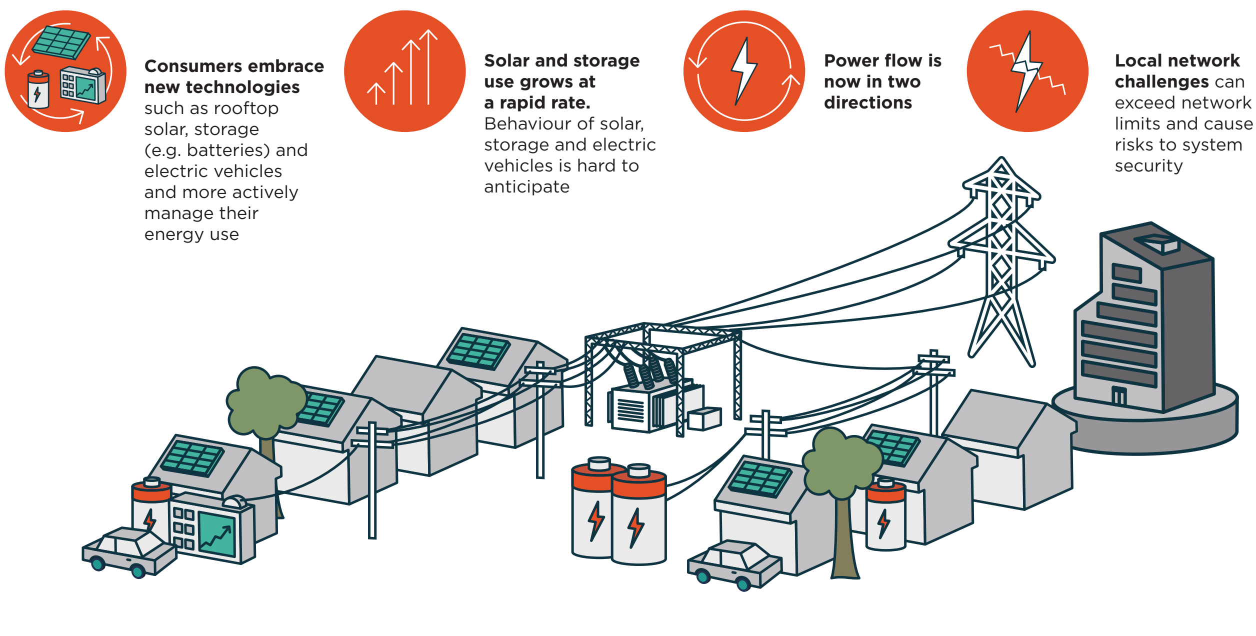
DER is often described as being either passive or active. More recently, as result of changes in standards, deployed DER is likely to be active and can be remotely controlled and managed. Passive DER is often assumed to be unresponsive, such as PV cells generating when the sun is shining and offering no ability to control energy production. However, even passive devices can be managed through the addition of energy management systems or by motivating the owner/operator of the DER through demand side response programs.

3.1 The need for a new operating approach

Australia's National Electricity Market (NEM) and Western Electricity Market (WEM) began operation in 1998. Since then, Australia's electricity system has changed significantly, moving from centralised large-scale, synchronous power plants serving passive consumption to a system that includes a multitude of resources and technologies.

The decarbonisation of electricity generation has impacts at both the transmission and distribution level. Yet it is the increasing deployment of DER on the distribution level that is driving the need to develop new approaches to managing both the distribution system and the wider system as a whole.

Figure 3. **Changes in the current landscape**



There are also significant regional variations. Tasmania's legacy hydroelectric generation means that more than 95 per cent of its electricity is delivered by renewable sources. Renewables represent over 50 per cent of South Australia's generation. Rooftop solar PV is a very small percentage of total generation, with South Australia, Queensland and Western Australia leading deployment. However, the relatively small contribution of rooftop solar PV to total generation does not tell the full story. A critical factor is the time when solar PV is generating at a maximum (noon) compared to the demand for electricity, which is typically at a minimum in the middle of the day.

On some occasions when demand is low and it is very sunny areas of South Australia (SA), Western Australia and Queensland can meet much of the required demand from renewable energy generation. However, generator management and interconnection between states can allow some of that solar PV generation to be shared. Footroom services (turning demand up) can also manage the increased generation at noon from solar PV. The NEM-connected states can also import system services to manage the power quality. This does not assist Western Australia, which is not interconnected. Western Australia solar PV generation must be managed locally.

AEMO forecasts suggest that the deployment of solar PV will continue at pace. Figure 3 shows three of the five scenarios developed by AEMO for their planning activities, including for the Integrated System Plan (ISP).

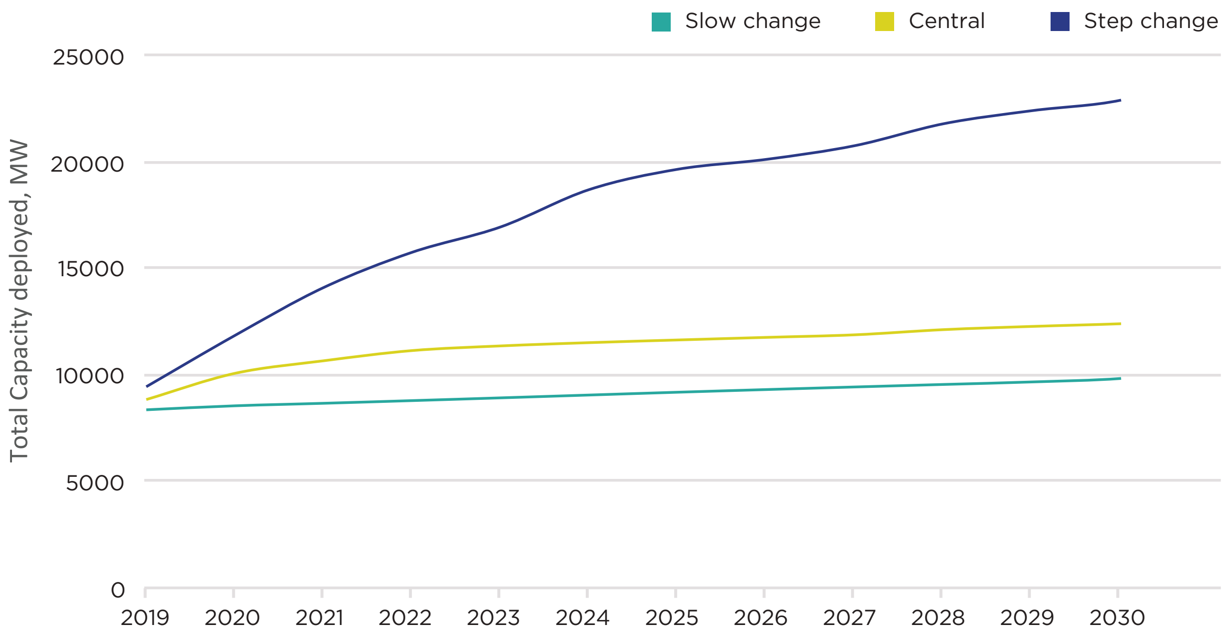
AEMO (2019) presents comparable data on battery and EV deployment. The central scenario and step change scenario were used by OpEN for the cost-benefit analysis of distribution market frameworks. Chapter 8 presents more information on the scenarios and the potential impact of COVID-19 on DER deployment rates.

Impact of increasing levels of DER at the distribution level

The continued uptake of DER (Figure 4) is changing the way the NEM and the WEM behave and causing operational challenges at the technical level for both DNSPs and AEMO.

The distribution network was designed to move electricity in one direction from large generators on the transmission system to the customer. The increased deployment of small-scale solar PV means that electricity now travels against this traditional path, creating reverse power flows and introduces greater swings in network voltages that directly impact reliability.

Figure 4. Projected rooftop solar PV deployment



Reverse Power Flows

Electrons flow in both directions in wires, but the distribution network was designed to operate like a car. A car can move backwards, but it only has one gear for reverse, while it has several for going forward. Reverse gear in a car is designed to be used for manoeuvring and then only in short bursts. It is not designed to be used for prolonged periods.

Protection equipment in the distribution network has not been designed or set up to accommodate electricity moving back through the network. To continue the analogy, this is like the protection and safety equipment on our roadways. Traffic lights are set up for cars moving forwards. When cars are being driven in reverse the driver can only see the back of the traffic light and so can't know whether it is safe to proceed. Newer distribution network protection equipment can be set up for electricity flows in both directions.

Figures 5 and 6 use modelling to predict the likely timing and impact of reverse power flows on distribution networks. Red areas indicate network areas (related to individual zone sub-stations) where roof-top solar PV installations reach 40 per cent, which is the amount assumed to cause reverse power flows. Figure 5 shows the prediction for a "slow" DER uptake, while figure 6 shows the prediction for "fast" DER uptake.

For more information on DER deployment and uptake scenarios, please see chapter 8.

Energy Networks Australia is currently working with CSRIO Energy to update these "reverse power flow" maps.

An assessment (ESB, 2020) on a single DNSP on clear sky days indicates that voltage issues related to the export of electricity from rooftop solar PV impacts less than 1 per cent of generation. High voltages may cause solar PV to disconnect, preventing electricity from being exported from the home to the wider network.

The assessment indicated that the financial impact of this curtailment was between $3-$12 per year. However, while for the vast majority of rooftop solar PV this technical issue had very little impact, in a few locations the impact, in terms of disconnection and cost, was significant

The OpEN Interim Report (2019) provides more information on the technical impacts of DER on distribution networks.

Why voltage matters

Voltage is like the water pressure in a pipe. As more electricity is added to the system, without corresponding demand to use it, voltage increases. This would be the same if water was added to a pipe, with no outlet (demand) causing the pressure in that pipe to rise.

When solar PV is generating and exporting its generation into the network, voltage will rise if there is no need for that electricity.

A solar PV panel must produce sufficient voltage to allow its electricity to be exported. When the voltage of a network is high, the inverter of a solar PV panel will disconnect from the network for safety reasons.

If the water pressure in the main pipe is high, then the pressure of any water in a pipe trying to flow into the main pipe must be higher. If it is lower, then the water backs up and floods on the consumer side. Disconnection means that the risk of flooding the network or home is removed, but the consumer then doesn't have access to their generation and doesn't have the option to export.

Any disconnection of an inverter due to high voltage is bad for the consumer who may have to buy electricity and/or miss out on incentive payments. It is also bad for the environment because low carbon electricity is being lost.

The loss of access and low carbon electricity also results if inverters are disconnected to keep the network or wider system secure at times of minimum demand.

Figure 5. **Projected decade in which the zone substations within each Australian postcode within the NEM and WEM will reach a threshold penetration of rooftop solar adoption (40 percent) indicative of reverse demand/power under the ESOO 'Slow DER uptake scenario'**

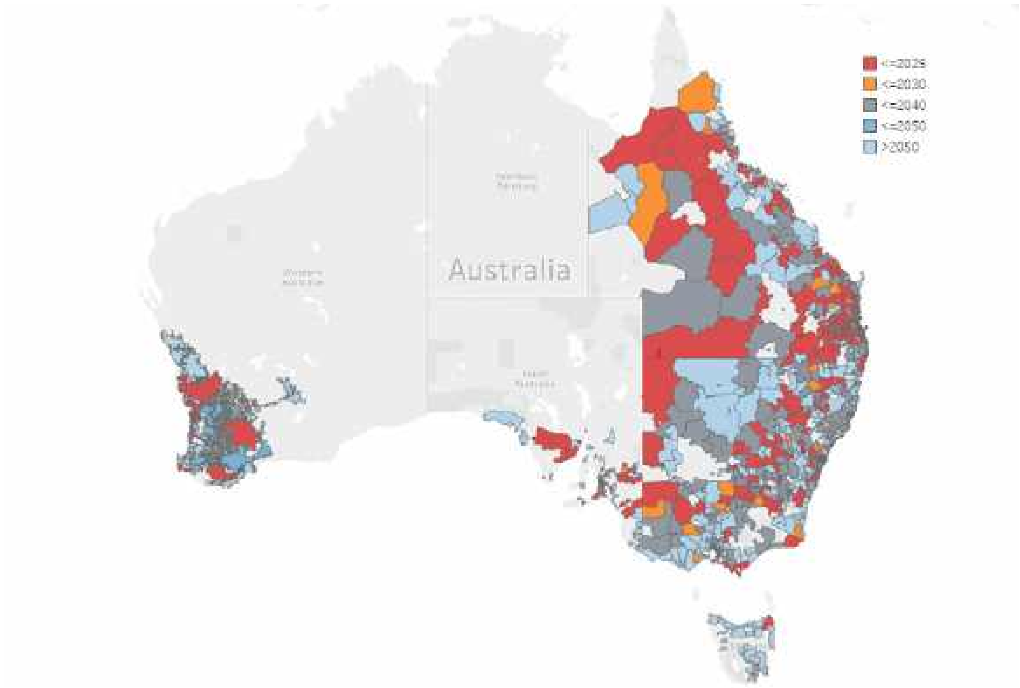
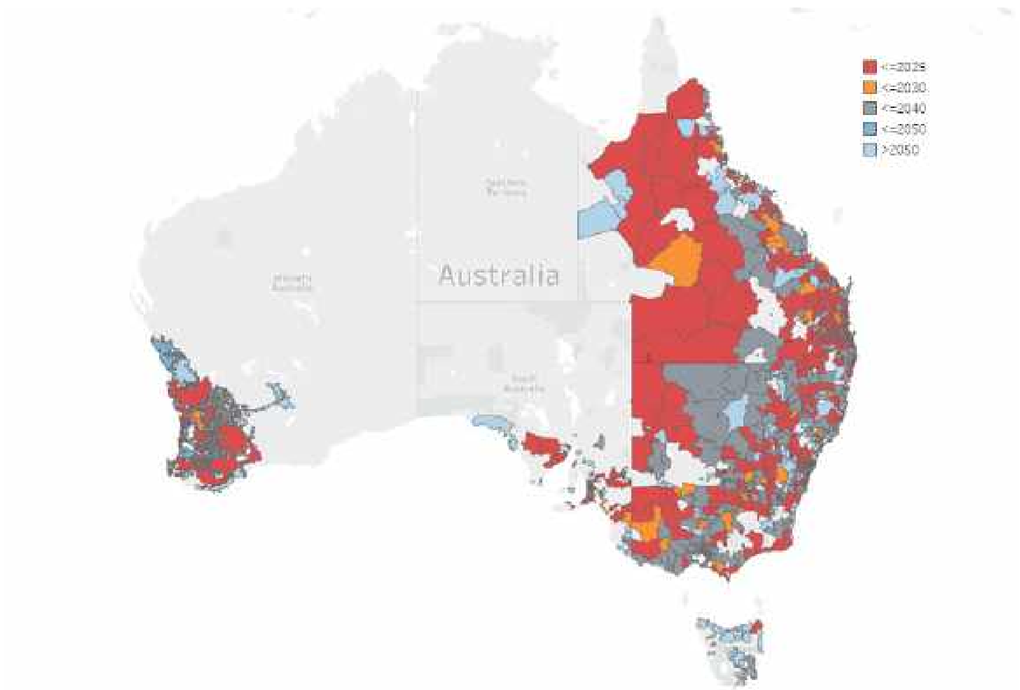


Figure 6. **Projected decade in which the zone substations within each Australian postcode within the NEM and WEM will reach a threshold penetration of rooftop solar adoption (40 percent) indicative of reverse demand/power under the ESOO 'Fast DER uptake' scenario**



4 Australia's current electricity industry

Before describing possible long-term frameworks for a distribution level market to dispatch and optimise DER, it is useful to outline the way things work today. While DER can participate in the wholesale market, it has limited opportunities under the current framework.

4.1 Transmission and distribution networks

In Australia, the electricity transmission and distribution systems are owned and operated by a combination of 18 different publicly and privately owned organisations. These businesses are responsible for the transfer of bulk power from generators in the wholesale market to the distribution of electricity to individual homes and businesses.

Much like arteries, veins and capillaries in the human body there is significantly more complexity in the distribution system (veins and capillaries) than the transmission system (major arteries). For context, there is roughly 50,000kms of transmission and 850,000kms of distribution lines to supply power to 25 million Australians.

Demand side services

DNSPs engage with customers of all sizes to purchase 'demand side' services to help manage constraints. DNSPs can buy services directly from customers through a process known as demand response. This is where the DNSP pays a customer to change the way they use electricity, or through tariffs that give customers benefits for allowing the DNSP to directly control DER such as pool pumps, air conditioning and hot water tanks.

Customers with DER can already be rewarded for providing services to DNSPs and can, in a limited way, be rewarded for providing services to the wholesale market via aggregators and retailers (e.g. SA's Virtual Power Plant and Energy Queensland's PeakSmart – see page 24).

There would be additional compensation for DER if access to the wholesale market were opened up. This could be achieved by developing new services and by extending wholesale demand response to distribution-connected demand or DER. New market participants who can facilitate the participation of DER in the wholesale market (such as aggregators) should be supported. The demand side and DER will continue to play an increasingly important role in providing flexibility to support the electricity system at both the wholesale (transmission) and distribution level.

United Energy's summer saver program

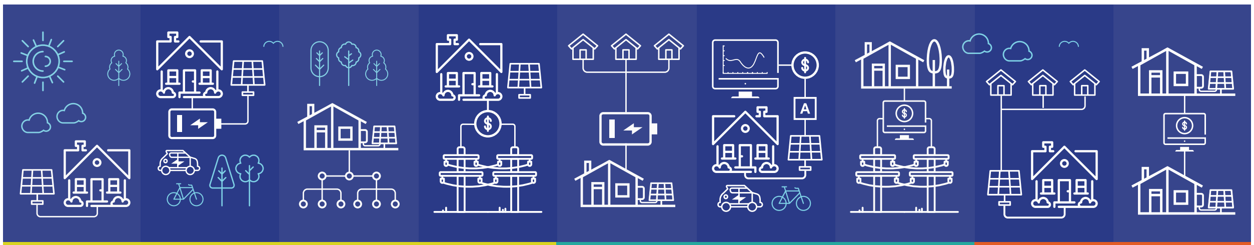
In parts of bayside Melbourne, on extremely hot days United Energy's network struggles to deliver sufficient energy to run air conditioners. The company offered selected customers the chance to participate in a demand side response program, in which they were paid to reduce their electricity use. United Energy made the offer via text message and allowed those with passive DER to manage their electricity use and get rewarded.

Customers could pre-chill their homes, but then had to reduce demand between 4pm and 7pm.

As Victoria has smart meters, customers were able to monitor their electricity use in near real-time and were informed of their earnings shortly after each event.

United Energy estimates that the summer saver program paid customers more than $5.5 million, saving the company from having to invest in more expensive upgrades to wires and helping prevent outages on hot days.

Figure 7. **How DER can operate in Australia**[1]



Things that can be done today				Things that are being trialed today			Things that may happen in the future	
1	2	3	4	5	6	7	8	9
Self-consume	**Self consume with own battery**	**Provide passive network support**	**Provide active network services**	**Self consume with grid connected battery**	**Provide services to the system**	**Participate in the Wholesale Market**	**Provide services and energy via a distribution market**	**Share excess with others**
Consumers use what is generated & export excess energy for Feed in Tariff (FIT) payments	Consumers use what is generated & store excess energy at home for later use	Inverter standards and settings provide automatic network support	Through an aggregator or DNSP smart devices can provide local networks services for compensation	Consume what is generated & export excess energy to a local grid connected battery for later use by the community payments	Through an aggregator/ Retailer provide services to support the operation of the system for compensation	Through an aggregator/ Retailer, customers gain access to selling excess energy and demand mangement to wholesale markets	Consumers provide services that are valued by the market	Consume what is generated and share or trade excess with other consumer via peer-to-peer trading (community markets)

4.2 The wholesale market

The National Electricity Market (NEM) is a wholesale market that operates in New South Wales, the Australian Capital Territory, Queensland, South Australia, Victoria and Tasmania. In Western Australia the Wholesale Electricity Market (WEM) operates over the south-west of Western Australia over the South West Interconnected System (SWIS). AEMO is responsible for operating these wholesale markets and for ensuring that the system (networks) that underpin the market remain secure and stable.

AEMO conducts the market through a centrally coordinated process that pools generation from producers and delivers required quantities of electricity from that pool to wholesale consumers. To participate in the wholesale market, businesses must become Registered Participants.

The wholesale market operates over the transmission system. Transmission network service providers (TNSPs) advise AMEO on constraints in their networks.

1. This figure is based on and developed using Figure 15 (pages 42-43) in the WA DER Roadmap: www.wa.gov.au/government/distributed-energy-resources-roadmap

What is a constraint?

Electricity networks are like roads – sometimes electricity can flow easily and sometimes there are restrictions or congestion that limits the amount of electricity that can pass through a network. These can be converted to “constraint equations” which AEMO uses to operate the transmission system.

Where there are constraints, there may be too much electricity flowing, which can push wires and equipment beyond their safe operating limits. Constraints may be caused by damage to wires, or the work needed to repair them. The traffic analogy is roadworks resulting in speed limits and lane closures.

High temperatures in summer and bushfires make it harder to operate power lines safely and so further constraints may be applied, just like road closures following a storm or fire.

While constraints have traditionally referred to the maximum ability of the transmission system to transport energy, it is now increasingly used in the context of the low voltage (LV) distribution system in managing reliability and quality of supply.

For the bulk system, AEMO manages all the activities that are needed, including understanding constraints, managing the bidding, scheduling and dispatch of generators, determining the spot price, measuring electricity use, and financially settling the market, to ensure that electricity is generated to meet consumer demand. These activities are optimised and actioned over five-minute intervals and instructions provided to generators.

AEMO produces forecasts for the day-to-day operations of the wholesale market covering every five minutes eight days ahead. The forecasts include likely generation from variable renewables, such as wind and solar, conventional fossil fuel generation and the likely electricity demand that consumers of all sizes will require.

Any generator with a capacity greater than 30 MW must participate in the NEM. Generators between 5 MW and 30 MW in size can also participate in the NEM. Generators smaller than 5 MW, which includes consumer DER, can currently only participate in the NEM via an aggregator or retailer.

AEMO uses several services to keep the electricity system stable. These ancillary services are purchased from those who currently participate in the NEM.

Current system services include, but are not limited to:

Frequency Control Ancillary Services (FCAS)

FCAS are used by AEMO to maintain the frequency on the electrical system, at every moment in time.

ARENA-SA Power Networks Virtual Power Plant

The ARENA-funded **Advanced VPP Grid Integration Trial** with the 1,000-customer Tesla / SA Government virtual power plant (VPP). This trial commenced at the start of 2019 and is ongoing. In this trial SA Power Networks is currently publishing locational and time-varying operating envelopes to the Tesla VPP, enabling Tesla to dynamically maximise access to available network capacity as it bids the VPP into FCAS and wholesale markets. This mode of operation is essentially a precursor to the more advanced market models considered in the OpEN project and provides a means for aggregators to operate within network constraints that can be implemented within current regulations and market structures.

AEMO provided a **report on the early performance** of the VPP in March 2020.

There are two types of FCAS, regulation and contingency. Regulation services are continuously used to correct for minor changes in frequency to ensure that electricity demand always matches electricity generation. Contingency services are used when there is a major event on the system that results in a significant change in frequency. While contingency FCAS is only needed occasionally when an event occurs, it is always ready to be used.

Network Support & Control Ancillary Services (NSCAS)

» Control the voltage at different points of the electrical network to meet required standards.

» Control the flow of power over the transmission network to ensure that the assets (conductors and wires) do not operate beyond their physical and safe limits.

» Maintain the stability of the power system following major power system events.

System Restart Ancillary Services (SRAS)

SRAS are reserved for situations when there has been a complete or partial system blackout and the electrical system must be restarted. The electricity system needs electricity to operate. Following a major blackout, electricity to restart the system is delivered via SRAS providers.

Reliability and Emergency Reserve Trader (RERT)

The Reliability and Emergency Reserve Trader is a role that AEMO undertakes to maintain power system reliability and system security using contracts with reserve providers.

Typically, each RERT reserve provider can provide capacity for at least 30 minutes. Examples of reserve that can be procured for RERT include:

» Customer demand that can be curtailed and restored easily, this can be large industrial load or a group of aggregated smaller loads

» Generation capacity that is not normally available in the NEM

RERT reserve is used by AEMO in summer to support increase electricity demand caused by air conditioners on extremely hot days.

Changes to the wholesale market framework

There are a number of proposed rule changes and reviews that will affect the current market framework already underway, these include:

» 5 Minute Settlement

» Wholesale Demand Response (WDR)

» Aggregator Definition

» Storage Market Participant

» Post-2025 Market Design

5 National and international transformation programs

OpEN explores approaches to maximise the benefits of DER by considering options for the development of distribution market platforms (Figure 8).

There are other approaches, such as demand management and dynamic connection arrangements that unlock the value of DER before the need for a distribution market. These approaches are already being used by DNSPs to better integrate and manage DER.

Identifying the best pathway for the integration and optimisation of DER into the electricity system cannot be achieved by one segment of the energy industry alone. There are a number of important work programs being undertaken across Australia and internationally. The following is a summary of the main initiatives exploring DER integration.

5.1 Australian experiences

5.1.1 ARENA Distributed Energy Integration Program

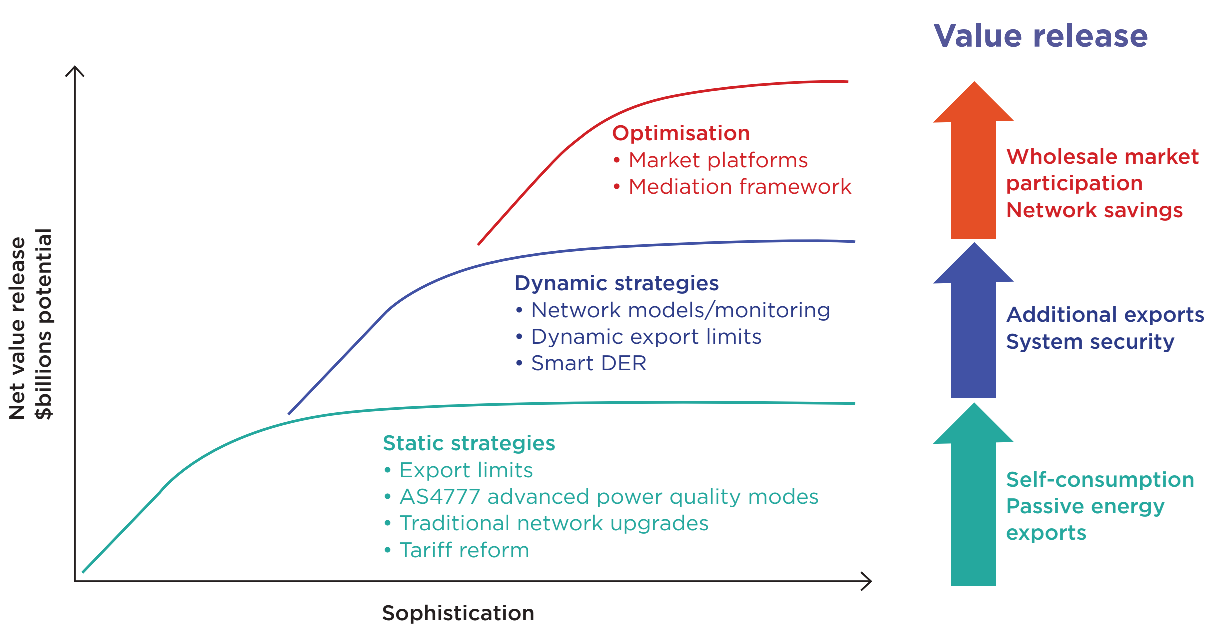
The distributed energy integration program (DEIP) is a collaboration between government agencies, market authorities, industry and consumer groups. The program objective is to maximise the value of DER for all energy users by funding research and demonstration projects on their integration.

The aim is to help market participants, networks, the system operator and governments understand and overcome the technical and commercial challenges of managing an electricity system that includes high levels of DER.

OpEN incorporated information from a number of DEIP projects, including:

» SA Power Networks' advanced VPP grid integration. This project aims to maximise the export of DER by establishing an interface to exchange real-time and locational data on distribution network constraints between SA Power Networks and the Tesla VPP.

Figure 8. **Additional value release enabled by optimisation of active DER**



- DEIP access and pricing. The aim is to develop pricing and access arrangements that support investment and operation of distributed energy services to provide more equitable, sustainable and efficient outcomes for all energy users.
- CSIRO national low voltage feeder taxonomy study. CSIRO is working with DNSPs to develop a low voltage distribution network taxonomy that will enable the establishment of more accurate low voltage network models that will enable more effective DER hosting analysis.
- Australian National University consumer energy systems providing cost-effective grid support (CONSORT). The project will develop an automated control platform and new payment structures that will enable consumers with solar PV and battery systems to provide support services to a constrained electricity network.

ARENA's projects are listed **here.**

5.1.2 AEMO Distributed Energy Resources Program

AEMO is **working with stakeholders** across the NEM and the WEM to explore innovative ways to develop and embed new capabilities and services into Australia's energy system and markets.

This work program comprises three key areas:

a. AEMO/ARENA demand response trials

These trials have been developed to investigate how best to integrate DER while maintaining system reliability and security. The trials have been designed to demonstrate that demand response is an effective source of reserve capacity for maintaining reliability of the electricity grid during contingency events, and to provide evidence to inform the merits and design of a new market or other mechanism for demand response to assist with grid reliability and security, allowing for greater uptake of renewable energy.

b. VPP demonstration trials

A number of **marketplace trials** are underway to test how DER can be aggregated to enhance power generation and provide network services, as well as trading or selling power on the electricity market. These include the SA home battery scheme, Victorian solar homes scheme, the NSW empowering homes project, and the SA VPP.

c. DER marketplace trials (e.g. DER-Max)

In collaboration with state and territory governments, DNSPs, retailers and aggregators, trials are being developed to test the consumer value of different distributed energy market designs, based on the OpEN frameworks.

OpEN findings along with those from these pilots and trials will support changes to the regulatory framework and operational processes in order to effectively operate the electricity grid and markets with increasing levels of DER penetration.

5.1.3 Distribution network service provider trials

DNSPs are implementing their own suite of research and development projects to achieve more responsive and dynamic grids. Each DNSP operates in different environments and each approach reflects this.

a. Peaksmart air-conditioning program (QLD)

In Queensland, over 83 per cent of households have one or more air conditioners. In the **Ergon and Energex program**, customers receive up to $400 for each demand response enabled device enrolled AC. There are now over 110,000 participating units in the state providing over 109MVA of controllable load during a heatwave or emergency event, making it one of the largest demand response programs in Australia. Approximately 3 events are called during summer every year, with a strong positive response where over 80 per cent of survey respondents (n=617) would recommend the program.

b. **Mooroolbark Community Mini-grid Project (Vic)**

Ausnet Services explored what distributed energy and microgrids might look like in the real world by installing solar PV and residential batteries at 14 premises (out of 18) in a street on the same low voltage circuit. There was also a device that balances the load amongst the circuit. After the trial, customers overwhelmingly supported the technology (88 per cent, up from 19 per cent) due to the direct financial benefits, increased network reliability and lower carbon emissions. The project highlighted benefits that networks received in increased reliability and customer engagement. It demonstrates what is possible when both customers and networks work together towards a common goal.

c. **Visibility trials (NSW)**

Essential Energy predicts that DER will match network demand in the late 2020s. With contestable smart meters only reaching full penetration by 2041, alternative solutions must be found to safely and efficiently plan DER networks. They are working with partners (Origin Energy, Redback Technologies, NBN and others) on numerous trials to monitor, analyse and plan their network. This will enable the generation of more accurate and dynamic system modelling, known as operating envelopes.

5.1.4 AEMO Renewable Integration Study

The AEMO **Renewable Integration Study** is the first of a multi-year project aimed at helping the market operator maintain system security in a future wholesale market with a high share of renewable resources. It makes some initial recommendations on actions and reforms whilst also noting that it is purely a technical assessment of the DER challenge and does not incorporate customer expectations and perspectives, nor does it undertake a cost-benefit analysis.

It also appendices three reports on distributed photovoltaic, frequency control and variability and uncertainty. Of specific interest to OpEN is Appendix A – Distributed Solar PV where it explores some of the technical challenges that the market operator and distribution networks are experiencing at increasing frequencies.

5.1.5 WA DER roadmap

In 2019, the WA government established an energy transformation taskforce to develop a DER roadmap that would establish a set of actions and solutions to better integrate and use DER in the WEM. The roadmap objective was to:

» allow customers to continue to use DER to manage their energy costs

» provide for greater use of DER to help reduce supply costs for all customers

» integrate increasing volumes of DER into the South-West Interconnected System without adversely affecting it.

The roadmap was published in April 2020 and is significant piece of work that will complement other reforms being considered and implemented in the South-West Interconnected System, with the objective of enabling effective DER integration to help manage the transition towards high renewables, low carbon and improved market efficiency in Western Australia.

The OpEN team has worked closely with the taskforce's DER working group to ensure alignment between the work programs and the actions identified in the roadmap, while acknowledging the differences in the WEM.

5.2 International experience

Australia is not the only country trying to establish how best to integrate DER into its electricity systems. Substantial work has been undertaken internationally on network transformation and optimisation.

5.2.1 AEMO international report

AEMO commissioned **a report** that summarises international experiences and provides analysis to assist the OpEN team in exploring future system architectures for the optimisation of DER. The international review of DER coordination architectures found that they are still at an early stage of development, and that except for projects in the UK and Japan, most are yet to obtain multi-stakeholder consensus on how the DER coordination architecture may develop.

The report concludes that there is a general acknowledgement of the need for transmission-distribution coordination, rather than purely transmission level coordination of DER. DNSPs are key to coordinating DER and will need to transition to a more “system operator” like role, analogous to that at the transmission level. The report also concludes that developing approaches to integrating DER require many years of design and engagement and that this is best supported by policymakers and the regulator.

The international review found that the UK is undertaking the world’s most comprehensive evaluation of various DER and TSO-DSO coordination architectures. The OpEN team has established a knowledge sharing arrangement with the UK’s Energy Networks Association, who are leading the project in the UK.

5.2.2 Energy Networks Association (UK) Open Networks Project

The precursor to the Australian OpEN is the **UK Open Networks Project**. The two projects both seek to optimally transition from a traditional centralised energy system to a smarter decentralised one.

Open Networks brings together the nine British and Irish electricity grid operators, the British Government, the energy regulator Ofgem, academics, and NGOs.

One important difference between the UK Open Networks Project and OpEN is that the UK has predominantly initiated change to decrease net carbon emissions, whereas in Australia the change is being driven more by grid instability caused by the high uptake of many decentralised renewable resources such as solar PV. Simply put, both projects are examining the same problem from slightly different drivers.

A core concept for the UK Open Networks Project is the idea of flexibility services. These are effectively services that third parties may offer the local distribution network operator to resolve system issues at a lower price than traditional augmentation of the network. This means that distribution network operators must take a more active role in procuring services through flexibility markets with third parties to achieve stable operation of their networks.

The UK transmission system operator, National Grid Electricity System Operator (ESO) uses demand side services, including services from providers connected to the distribution network, to balance the transmission system in real-time. These services from the demand side have been used for many decades and National Grid ESO has been strengthening the role for the demand side through its **Power Responsive program** and envisages that more than 60 per cent of system operation ancillary service will come from the demand side.

Because of the maturity of the demand side response market in the UK, the new markets for flexibility services to support the distribution networks are much more advanced than in Australia not only in the number of participants, but also in regulations and contractual agreements adhered to by all parties.

5.2.3 Local Energy Markets (UK)

Centrica, a UK and European gentailer, is leading a pioneering trial in Cornwall that **will test** the use of flexible demand, generation and storage across both the domestic and business sectors in a **local energy market**.

Centrica is developing a virtual marketplace with the support of the local DNSP (Western Power Distribution) that will provide consumers with a platform to buy and sell energy and flexibility both to the transmission system operator and the wholesale energy market.

6 The consumer perspective

Note: this chapter has been prepared by the Customer Forum, a group that attended workshops in October and December 2019 to help establish a more technical consumer understanding of OpEN and to understand consumer needs more directly. The customer Forum members are listed at the end of this chapter

Australia is experiencing an unprecedented transition from an energy system involving central large-scale, synchronous power plants and passive consumption, to one that includes many energy resources and technologies.

The change is being led primarily by people seeking to reduce electricity bills, achieve energy independence and reduce greenhouse gas emissions (Energy Consumers Australia & UMR Strategic Research, 2016). Feed-in-tariffs, renewable energy subsidies and grant schemes have made changes more affordable and helped accelerate the growth.

Trends in roof-top solar installation are expected to continue, with other complementary DER, such as battery storage, EV chargers and home automation systems, likely to be installed as the costs of these technologies continue to fall.

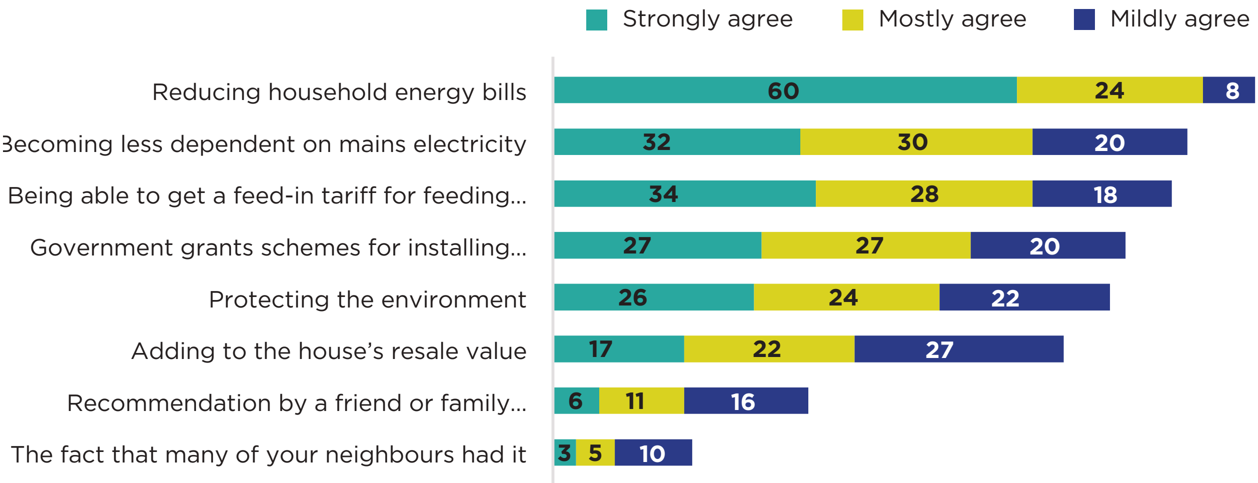
As people increasingly invest in DER, they are also looking to participate in energy and system security and reliability markets to earn a return on their investment by:

- supporting local network security and reliability by providing paid services via their DER, directly to the DNSP
- engaging in peer-to-peer trading
- participating in the wholesale market via retailers, aggregators and other third parties.

As the importance of the demand-side is fully realised, in exporting *and* importing electricity, opportunities for consumer participation will increase. However, the current patterns of investment (and associated business models) are not technically or economically designed to reduce risk and maximise the benefits for all. Reforms and education will be required to improve consumer decisions, consumer protection and product choice and access, ensuring consumers can receive value from their distributed energy assets.

To ensure that integration of DER is optimised to meet consumer needs, their preferences and priorities should be reflected in future energy system reforms. Accordingly, the OpEN team convened a working group of consumer advocacy representatives to examine the principles that should guide future work, consumer objectives, and the next steps.

Figure 9. **How much have following factors contributed to your decision to install a solar electricity system?**



Principles to guide future work

The Australian Council of Social Service and the Total Environment Centre in collaboration with Energy Consumers Australia have developed people-centred principles to guide the reform of the energy system. The draft *New Energy Compact* (ACOSS & TEC, 2020) identifies principles that require decision makers to put people at the centre, think long-term and be flexible, be just and fair, ensure it works, and deliver clean and healthy energy.

The principles are underpinned by regarding energy as an essential service, with everyone having the right to access clean, affordable, dependable energy.

The *New Energy Compact* guides the approach taken by OpEN, which has adopted the following principles:

» Energy is an essential service

» Think long-term and be responsive

» Put the needs of people at the centre

» Be just and fair

» Drive efficiency and reduce waste

» The energy system must be secure, reliable and resilient

» Achieve zero emissions and be environmentally responsible.

While these principles were developed towards the later stage of OpEN, some of them are reflected in the project's initial aims:

1. OpEN focuses on a framework that will be progressively rolled out across the networks in the 2020s and 2030s, thereby representing long term and responsive thinking
2. A framework that successfully coordinates and optimises DER in the distribution network should provide extra value to consumers with DER and a lower cost of energy for all
3. Reducing waste associated with DER: maximising DER installations and minimising solar curtailment
4. While ensuring network and system security, encouraging a higher uptake of renewable energy and flexible demand and storage that will accommodate more renewable generation.

These principles will be important as the industry moves from the idea and initial design stage into regulatory actions that ensure that changes do not compromise the essential nature of the provision of energy to all, and that the changes are just and fair. A careful balance between DER owners and non-DER owners will need to be struck to ensure that the interest of all consumers are safeguarded and opportunities are realised.

Table 2. Consumer working group issues to be addressed in a future market framework

Equity	Coordination	Protections	Reliability
» Variability of experience for consumers depending on their location in the network » Maximising individual and collective value from DER » There is no **coherent framework** for determining who are the winners and losers with DER dispatch / constraint » There is no clear approach for allocating costs, system benefits and payments to consumers	» There should be a **consistent principles-based approach** to DER export » Consumer incentives **don't align** with system incentives » There is a lack of shared vision between stakeholders and Industry responses to increasing DER aren't coordinated or coherent » Lack of **visibility** of network constraints contribute to inefficient decisions » A platform may be required	» Protection of consumer data will evolve over time » Consumers will need to be educated to **make better decisions** » Who will educate consumers and how? » **No transparency** for consumers (and their agents) make decisions? » What kind of protections do consumers need? (financial/legal)	» More information is needed to **improve decision-making** » Security of the system is paramount (Reliability and Cyber concerns) » Location of issues on the network will change over time

Consumer working group insights

The consumer working group determined the following objective for OpEN: 'Coordinate and leverage individual choice and decision-making for optimal social outcome to deliver energy at lowest cost, ensure cyber security and maintain a secure operating state'.

However, the group determined that to deliver this objective, any future system must be designed to work for all consumers. Table 2 presents the consumer working group's list of issues that will need to be addressed in designing an electricity market.

The working group explored whether existing services, markets, tools such as appropriate pricing instruments, and updates to regulations could potentially achieve the objective without establishment of a new market framework.

The group argued that while additional functionalities may ultimately be required to leverage these tools and coordinate DER optimisation within distribution network limits, it was not yet clear whether, and when, implementation of a new market framework should occur.

The group concluded that the OpEN process had not demonstrated conclusively that the early implementation of any distribution system operator/distribution market operator (DSO/DMO) model is necessary to leverage these tools and to coordinate DER optimisation within distribution network limits. This is particularly the case given the number of other current reform processes, including two-sided market, the DEIP access and pricing process, the post-2025 market structure, and AEMC consumer protections in an evolving market, which may influence the need for, and design of, any DSO/DMO model.

The group also agreed that any market framework to optimise DER should aspire to achieving consumer objectives or outcomes. These include:

» responsive, just and fair services for consumers

» an alignment of consumer incentives with system requirements

» the availability of information and tools to assist consumers to make informed decisions

» reliable and secure transactions

» positive environmental and social outcomes

» costs being borne by the beneficiaries.

It is clear there will be a need to increase consumers' level of understanding of energy, and their roles and rights. With such unprecedented changes taking place in the energy system and markets, the consumer working group emphasised that both government and industry have crucial parts to play in educating consumers now, during, and after, the distributed energy transition.

Next steps

Consumers must be at the centre of any new design of the energy system and markets. To ensure that this occurs, we suggest the following actions:

» OpEN should halt until completion of other current and future work, including two-sided market, the DEIP access and pricing process, the post-2025 market structure, and AEMC development of consumer protections in an evolving market

» continue incorporating the consumer voice by consulting the consumer working group as any outcomes of OpEN are explored and developed through trial projects

» ensure that consumers contribute to the co-design, trial and ultimate establishment of any new market frameworks using the principles in the *New Energy Compact* and OpEN consumer objectives

» explore innovative strategies to engage with consumers and test the ideas with the public through forums and trial projects

» facilitate discussion with networks' consumer consultative panels to help raise awareness of OpEN, its goals and the recommendations detailed in Chapter 11.

The Customer Forum comprised Chris Alexander, Energy Consumers Australia; Mark Byrne, Total Environment Centre; Kellie Caught, Australian Council of Social Service; Gavin Dufty, St Vincent de Paul Society Victoria; Dean Lombard, Renew; and Craig Memery, Public Interest Advocacy Centre.

7 Modelled frameworks for OpEN

OpEN created four potential new market frameworks and examined how well each one allows DER to operate efficiently with other elements of the network and system.

Frameworks represent a rigorous way of testing various options for integrating DER into wholesale markets and the response of DER to distribution network constraints.

The frameworks assume that all DER in the future will be dispatchable. That is, they can be used on demand and provide electricity (or absorb electricity) at the request of operators, according to market and system needs. The assumption is that dispatch will be undertaken by an agent acting on behalf of a customer, ensuring that consumers have been fully engaged in making and understanding the decision to be involved in any market.

While emerging approaches, such as blockchain and artificial intelligence, may provide ways of delivering dispatchable DER, these technologies are not yet mature for widespread deployment. Consequently, OpEN has adopted a more centralised approach in the creation of frameworks.

OpEN adopted the following principles for framework design:

1. Simplicity, transparency and adaptability of the system to new technologies
2. Supporting affordability whilst maintaining security and reliability of the energy system
3. Ensuring the optimal customer outcomes and value across the short, medium and long-term, for both those with and without DER
4. Minimising duplication of functionality where practicable and using existing governance structures without limiting innovation
5. Promoting competition in the provision and aggregation of DER, technology neutrality and reducing barriers to entry across the NEM and WEM
6. Promoting information transparency and price signals that encourage efficient investment and operational decisions
7. Lowest cost

Initially, OpEN created three frameworks:

» Single integrated platform (broadly, AEMO does everything)

» Two-step tiered platform (broadly, the DNSP does everything)

» Independent distribution system operator (envisages the creation of a new participant to manage the integration and dispatch of DER in a distribution market).

OpEN developed the third framework to address any of perceived conflicts of interest that AEMO and DNSPs might exhibit. Information on each of of the potential market frameworks is presented below.

Following discussions internally and with stakeholders, a fourth framework was developed. The Hybrid allocates the market operation functions to AEMO, while leaving the DNSP to optimise the network. Further details on the OpEN project methodology and results of stakeholder engagement can be found in the Interim Report (AEMO and ENA, 2019).

All four frameworks envisage the creation of two new entities to deliver a distribution market: the distribution system operator (DSO) and the distribution market operator (DMO).

Distribution System Operator (DSO)

A Distribution System Operator (DSO), with visibility of power flows and DER on the network, will be required to manage the network within the technical constraints of the assets (otherwise known as “operating envelopes”), 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 obtain services to support the operation of the network from DER directly, or via aggregators, retailers and third parties and such services would be compensated.

The DSO provides inputs to the DMO to ensure DER participation in markets does not compromise system security at the distribution level.

The DSO will plan and actively operate distribution assets to support the optimal use of DER for the benefits of all consumers. Given current DNSP experience in maintaining and operating safe and reliable networks, they are best placed to evolve to take on the expanded DSO role.

Distribution Market Operator (DMO)

The Distribution Marker Operator (DMO) manages the distribution market, optimising the provision of services and energy from DER within operating envelopes provided by the DSO. The DMO also provides information to AEMO to support the participation of DER in the wholesale market and ancillary service provision.

At the distribution level, a DMO administers, operates and manages platforms for aggregators, the DSO and AEMO to access flexibility services. The DMO might also administer, operate and manage platforms to support local market trading for energy and capacity.

A number of parties could take on the DMO function, such as aggregators, retailers and new third parties. However, AEMO, as the current wholesale market operator, is likely to be best placed to be the DMO.

7.1 Single integrated platform

The single integrated platform framework most closely resembles the current system, with AEMO acting as the single market operator.

AEMO would operate a single centralised platform to optimise the dispatch of DER and manage all distribution and transmission-connected generation and storage. The platform would link with aggregators for the provision of DER services, providing direct access to the market. Aggregators would provide bids and offers directly to AEMO via the platform.

Each DNSP would need to provide AEMO with constraint information, in the form of operating envelopes, to indicate any limits to providing services.

Aggregators and energy retailers would develop portfolios of DER customers to provide system services offerings to AEMO's central market platform. AEMO would assess all bids and offers and optimises the dispatch of energy resources considering both transmission and distribution network constraints. AEMO would have the commercial relationship with DER via aggregators/retailers and would be responsible for financial settlements to market participants.

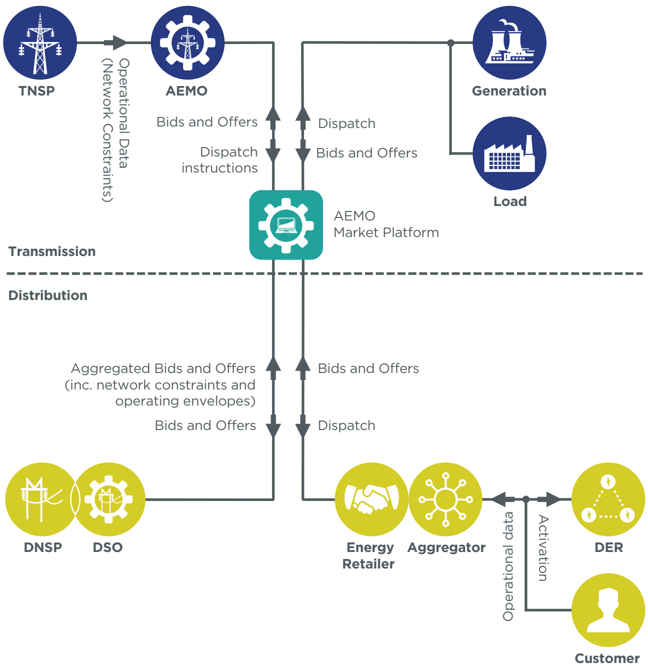
The aggregator/retailer would activate DER based on dispatch instructions from AEMO via the platform. In this way, AEMO would be responsible for maintaining system security and reliability.

Figure 10 summarises the relationships involved in a single integrated platform framework and Table 4 presents some advantages and disadvantages of the framework.

Table 3. **Roles and responsibilities as defined in the OpEN distribution market frameworks**

Frameworks	Distribution Market Operator	Distribution System Operator
Single Integrate Platform (SIP)	AEMO	AEMO DNSP maintain assets
Two-Step Tier (TST)	DNSP *Could be third party	DNSP
Independent Distribution System Operator (IDSO)	Third party	Third party DNSP maintains assets
Hybrid	AEMO *Could be third party	DNSP

Figure 10. Model 1: Single Integrated Platform



Key characteristics	
Market arrangments	» There is a single central market comprised of wholesale and ancillary services markets (i.e. FCAS, NSCAS and SRAR) that is operated via a central market platform » Market participants, including DER via aggregators/retailers, submit bids and offers for system services to the central market platform which in turn makes them available to AEMO for whole system optimisation
AEMO	» AEMO organises the operates the market » AEMO assesses all bids and offers and optimises the dispatch of energy resources considering T-network and D-network constraints » AEMO sends out dispatch instructions to energy resources, including DER via their respective Aggregator/Retailer
DSO	» The DSO receives DER bids and offers from the central market, prequalifies them into aggregated bids based on D-network and DER operating envelopes and passes them to AEMO for whole system optimisation » The DSO prequalifies, procures and settles the DER from aggregators/retailers for D-network constraint managment via central market platform
Aggregator / Retailer	» Aggregator/Retailer combines different DER and offer their aggregated output as system services to the market platform

Table 4. The advantages and disadvantages of a single integrated platform

Advantages	Disadvantages
» All market participants interact with a single entity (AEMO) via a central platform that acts as an independent, neutral and transparent market facilitator	» The expanded role for AEMO, requiring a wider range of resources, may have implications for AEMO's funding model as it may need to be adapted to fit this expanded role
» A central market allows for standardisation of processes and procedures	» Unclear control: The DNSP/DSO does not have direct control over DER connected to the distribution network because they are procured and dispatched by AEMO, which may result in "dueling"
» More moderate regulatory change required (compared to other frameworks) as AEMO already performs this type of role for wholesale and frequency, and it can be seen as an extension of the wholesale and frequency control ancillary services markets	» AEMO has no experience of operating distribution networks
» Procurement, dispatch and settlement of DER for provision of system services are organised and operated by a single entity (AEMO)	» The complexity of a single party undertaking whole of system planning cannot be understated and will incur significant cost which passes through to all customers

For more detail on this OpEN Framework please visit: www.energynetworks.com.au/sgam/sip/index.htm

7.2 Two-step tiered platform

This framework involves DNSPs taking responsibility for optimisation of DER dispatch within their own networks.

The framework derives its name from its two types of market platform: the central wholesale market platform operated by AEMO, and distribution level market platforms operated by DSOs. The distribution level platforms have responsibility for the organisation and operation of the local market for DER and for the development and operation of the distribution network.

Aggregators would provide bids to the DNSP, representing their dispatch preferences. The DNSPs would aggregate bids from all DER in their networks and provide them to AEMO. AEMO would include these aggregated bids in wholesale market dispatch optimisation. This would represent 'co-optimisation' of both distribution and wholesale markets.

Figure 11 summarises the relationships involved in a two-step tiered framework. Table 5 presents some advantages and disadvantages.

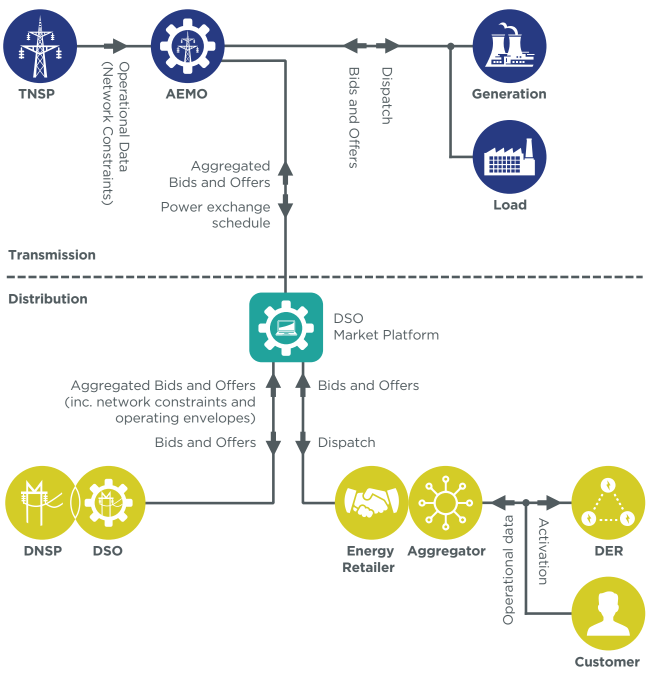
Table 5. The advantages and disadvantages of a two-step tiered platform

Advantages
» DSOs take full responsibility for management of DER in their own networks, facilitating a more decentralised and active operation and management of distribution networks
» DSOs prequalify, procure, dispatch and settle DER from aggregators/retailers to resolve constraints on the network
» DSOs have priority over the procurement and dispatch of DERs from the distribution network to resolve local constraints
» A local market may create fewer barriers to entry for DERs and provide more seamless participation in wholesale markets

Disadvantages
» DSOs do not have any experience with real-time dispatch processes, and would need to establish such capability
» Requires a seamless and coordinated dispatch process between DSOs and AEMO
» DSOs may not be perceived as adequately independent
» DSOs will incur costs for the operation of a local market

For more detail on this OpEN Framework please visit:
https://www.energynetworks.com.au/sgam/tst/index.htm

Figure 11. Model 2: Two step tiered platform



Key characteristics	
Market arrangments	» There is a single central market comprised of wholesale and ancillary services markets that is operated by AEMO » There is a local market(s) for regional and national system service provision from DER that is operated via a local market platform
AEMO	» AEMO organises the operates the market » AEMO assesses all bids and offers and optimises the dispatch of energy resources considering T-network and D-network constraints » AEMO sends out dispatch instructions directly to T-network energy resources and indirectly to D-network schedule at D-network boundary
DSO	» DSO(s) organise and operate the local market(s) » The DSO receives DER bids and offers from the central market, prequalifies them into an aggregated bid stack per transmission connection point based on D-network and DER operating envelopes and passes them to AEMO for whole system optimisation » The DSO allocates the dispatch to individual DER based on the power exchange schedule » The DSO prequalifies, procures, dispatches and settles the DER from aggregators/ retailers for D-network constraint management via the local platform

7.3 Independent distribution system operator

This framework involves independent distribution system operators (IDSOs) optimising DER dispatch within distribution network technical limits. A separate IDSO would be needed for each distribution network, or a single IDSO for the NEM and WEM.

This is the most complex of the frameworks considered. It is similar to the two-step tiered platform, with aggregators providing bids to the IDSO, and the IDSO aggregating those bids to each transmission connection point, taking into account distribution network limits. The IDSO would pass these aggregated bids to AEMO to include in the national electricity market dispatch process.

The model allows some decentralisation. Independent organisations would need to be established in each distribution network area.

Figure 12 summarises the relationships involved in an independent distribution system operator framework. Table 6 presents some advantages and disadvantages.

Table 6. The advantages and disadvantages of an independent distribution system operator framework

Advantages

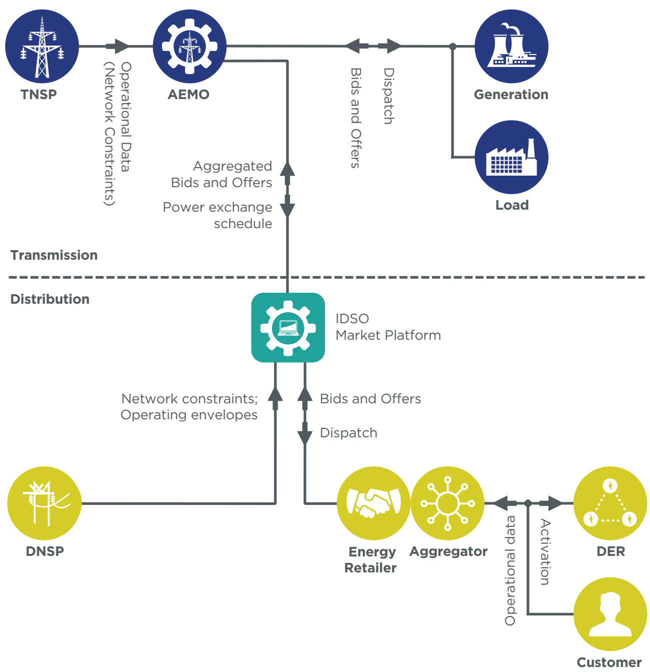
- The IDSOs act as independent, neutral and transparent market facilitators, removing concerns around conflicts of interest

Disadvantages

- Seamless interfaces between the IDSO and DNSP for exchanging network status and distribution network constraints, and between the IDSO and AEMO for co-optimisation of resources can be complex and costly to achieve
- New independent IDSOs would need to be established in each distribution network area, adding an additional layer
- IDSOs would need to develop extensive capabilities on power networks and systems

For more detail on this OpEN Framework please visit:
www.energynetworks.com.au/sgam/idso/index.htm

Figure 12. Model 3: Independent distribution system operator



Key characteristics

Market arrangments	» There is a central market comprised of wholesale and ancillary services that is operated by AEMO » There is local market(s) for regional and national system service provision from DER that is operated via a local market platform
AEMO	» AEMO organises the operates the market » AEMO assesses all bids and offers and optimises the dispatch of energy resources considering T-network and D-network constraints » AEMO sends out dispatch instructions to energy resources directly or via a power exchange schedule at the D-network boundary
DSO	» IDSO(s) organises and operates the local market(s) » The IDSO(s) receives DER bids and offers from the local market, prequalifies them into and aggregated bid stack per transmission connection point based on D-network and DER operating envelopes and passes them to AEMO for whole system optimisation » The IDSO(s) allocates the dispatch to individual DER based on the power exchange schedule across the D-network boundary
Aggregator / Retailer	» The DNSP actively exchanges dynamic DER operating envelopes with the IDSO(s) to account for D-network constraints in AEMO's dispatch Process » The DNSP procures and settles the DER from aggregators/retailers for D-network constraint managment via the local market platform

7.4 Hybrid model

In examining the three frameworks, stakeholders created a fourth, hybrid framework that addresses some of the problems with the others.

Some stakeholders felt that while the independent distribution system operator framework resolved some of the issues presented by either AEMO operating the single integrated platform or DNSPs operating the two-step tiered platform, the framework was too complex and unwieldy.

In the hybrid framework, the DNSP would manage and communicate distribution network constraints (operating envelopes) to DER participants, via aggregators and retailers, and AEMO. AEMO would manage a market platform that optimises all DER bids for wholesale electricity and system support services.

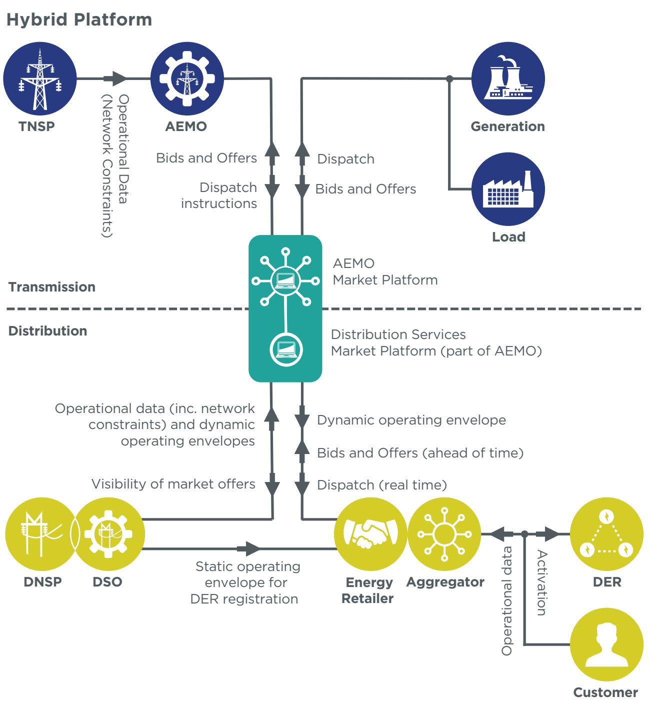
Figure 13 summarises the relationships involved in the hybrid model framework and Table 7 presents some of the advantages and disadvantages of the Hybrid Framework.

Table 7. The advantages and disadvantages of the hybrid framework

Advantages
» All market participants interact with a single entity (AEMO) via the two-sided platform that acts as an independent, neutral and transparent market facilitator
» Procurement, dispatch and settlement of DER for provision of system services is organised and operated by a single entity (AEMO)
» DSO calculates the dynamic operating envelopes based on understanding and direct access to network operation data and constraints
Disadvantages
» The expanded role for AEMO, requiring a wider range of resources, may necessitate changes to AEMO's funding model
» The DSO does not have direct control over the DER connected to the distribution network because they are procured and dispatched by AEMO, which may result in "dueling"
» Seamless interface required between the DSO and AEMO for exchanging real-time network status and distribution network constraints and operating envelopes

For more detail on this OpEN Framework please visit:
www.energynetworks.com.au/sgam/hybrid/index.htm

Figure 13. The Hybrid Model



Key characteristics	
Market arrangments	» There is a two-sided market platform, comprised of wholesale and ancillary services that is organised and operated by AEMO » Market participants, including DER via aggregators/retailers, submit bids and offers for system services to the market platform which in turn makes them available to AEMO for whole system optimisation
AEMO	» AEMO organises the operates the market » AEMO assesses all bids and offers and optimises the dispatch of energy resources considering T-network and D-network constraints » AEMO sends out dispatch instructions to energy resources, including DER via their respective Aggregator/Retailer
DSO	» DSO provided DER with static operating envelopes based upon the technical capability forecast of the D-network to accommodate DER dispatch » The DSO assesses market bids and D-network constraints to generate dynamic operating envelopes for DER which respect distribution network constraints and inform their technical and commercial offering to the markets
Aggregator / Retailer	» Aggregator/Retailer combines different DER and offer their aggregated output as system services to the market platform

8 Frameworks: cost-benefit

Baringa Partners was engaged to deliver a cost-benefit analyses of the four OpEN frameworks for a distribution market.

The Cost Benefit Analysis assessed the costs and benefits for two different DER deployment forecasts, with the two scenarios taken from the planning and forecasting work for AEMO's Integrated System Plan (AEMO 2019).

The cost benefit analysis focuses on the NEM because scenarios for the WEM had not been developed. However, an assessment of the costs and benefits of the OpEN frameworks for distribution markets in the WEM is being developed.

The Central scenario

AEMO's central scenario reflects a future energy system based on current government policies and best estimates of all key drivers. This scenario represents the transition of the energy industry under current policy settings and technology trajectories, where the transition from fossil fuels to renewable generation is led mainly by market forces.

The Step-change scenario

This scenario includes a step change in response to climate change, supported by technology advancements and a coordinated cross-sector plan that tackles adaptation challenges. Domestic and international action rapidly increases to achieve the objectives of the Paris Agreement.

The scenario incorporates advances that increase the capacity of consumer technologies to manage energy use, with technology improvements and complementary manufacturing and infrastructure developments that enable greater adoption of alternative fuelled vehicles, electrifying much of the transport sector. Sustainability has a strong focus, with consumers, developers and government supporting the need to adopt greater energy efficiency.

The step-change scenario differs from the central scenario in ways including:

- higher population and economic growth
- most aggressive decarbonisation goals
- technology innovation and increased DER uptake
- greater EV uptake and stronger role for energy management solutions
- stronger role for energy efficiency measures.

The impact of COVID-19

2019 was a record year for the deployment of rooftop solar PV, with over **2.2 GW deployed**.

In some locations, particularly Western Australia and South Australia, rooftop solar PV represents a significant proportion of overall generation and in some places the deployment rate has aligned more with the step-change than the central projection.

However, the COVID-19 pandemic in 2020 has had a significant impact on the renewable generation sector. While it is too early to fully understand the economic impacts of the pandemic, the predictions for large- and small- scale renewable generation deployment indicate a significant downturn of 25 per cent to 50 per cent (GEM, 2020).

It is not yet certain how the Australian economy will respond to the pandemic but, the loss of jobs and widespread reduction in household incomes resulting from the contraction of the economy and reduction in GDP are likely to impact on the deployment of DER.

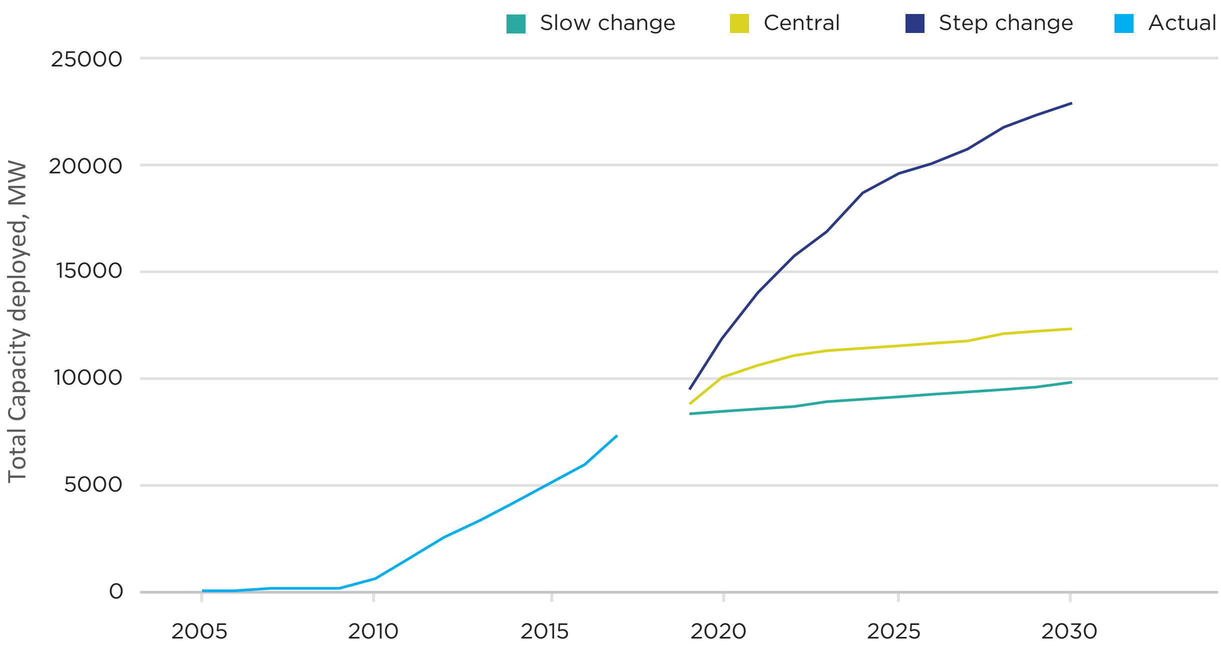
These conditions are closer to the Slow change scenario than to either the Central or Step Change scenario:

> "economic conditions are challenging, leading to a slowdown in investment and hence slower transformation of the electricity industry. Consumers and governments concentrate more on protecting standards of living than on structural reform to the energy sector and, with less capital available, investors are slow in developing large-scale technology projects to replace existing resources." (AEMO, 2019)

The costs and benefits of developing a distribution market are highly sensitive to the DER deployment rate, with benefits demonstrated only at the very high deployment rates of the step change scenario.

Under the central DER deployment scenario, the costs outweigh the benefits for all four OpEN frameworks, leaving consumers to face material costs in developing a distribution market, without any concomitant benefits. If, as a result of the COVID-19 pandemic, Australia follows the slow change scenario, the risks of consumers incurring negative net benefits from the development of a distribution market are high.

Figure 14. **Actual and projected rooftop solar PV deployment**



Potential benefits from better DER integration

The cost-benefit analysis summarised in Figure 15 (Baringa, 2020) illustrates that under the step change scenario there are significant potential gross benefits from better DER integration of up to $6.5 billion by the end of 2039. However, if the uptake of DER follows a lower trajectory, the corresponding benefits are also materially lower ($2.5b) (Baringa, 2020).

The analysis also indicates that the majority of benefits are realised just before 2039. This is because a key driver for benefits comes from avoiding network investment associated with the electrification of transport, while also harnessing this new EV demand to resolve export constraints at residential level.

These results are based on DER uptake across the NEM. It is important to note that some regions are already experiencing high DER penetration now and that the profile of available benefits over time will look quite different in those regions.

Cost of the frameworks

The cost assessment (Baringa, 2020) is based on forecasts from AEMO and DNSPs of the expenditure needed to build the full functionality envisioned in the frameworks. There is uncertainty regarding the nature and scale of systems needed and the subsequent costs, but the methodology is able to highlight the main comparative differences in the costs associated with implementing each framework, given a common baseline.

Figure 16 shows that the total cost of the frameworks ranges between $2.5 billion and $3.5 billion on a present value basis. In the high DER uptake step change scenario, this leads to net benefits of approximately $3 billion to 2039. However, under the lower DER uptake central scenario, implementing full functionality of any of the four frameworks would lead to negative net benefits. This suggests that while there remains uncertainty about the scale of DER uptake, the new functionality (and its associated cost) required to integrate DER should be implemented in an incremental way.

Figure 15. **Potential benefits available from greater DER integration ($m, NPV 2019/2020 prices)**

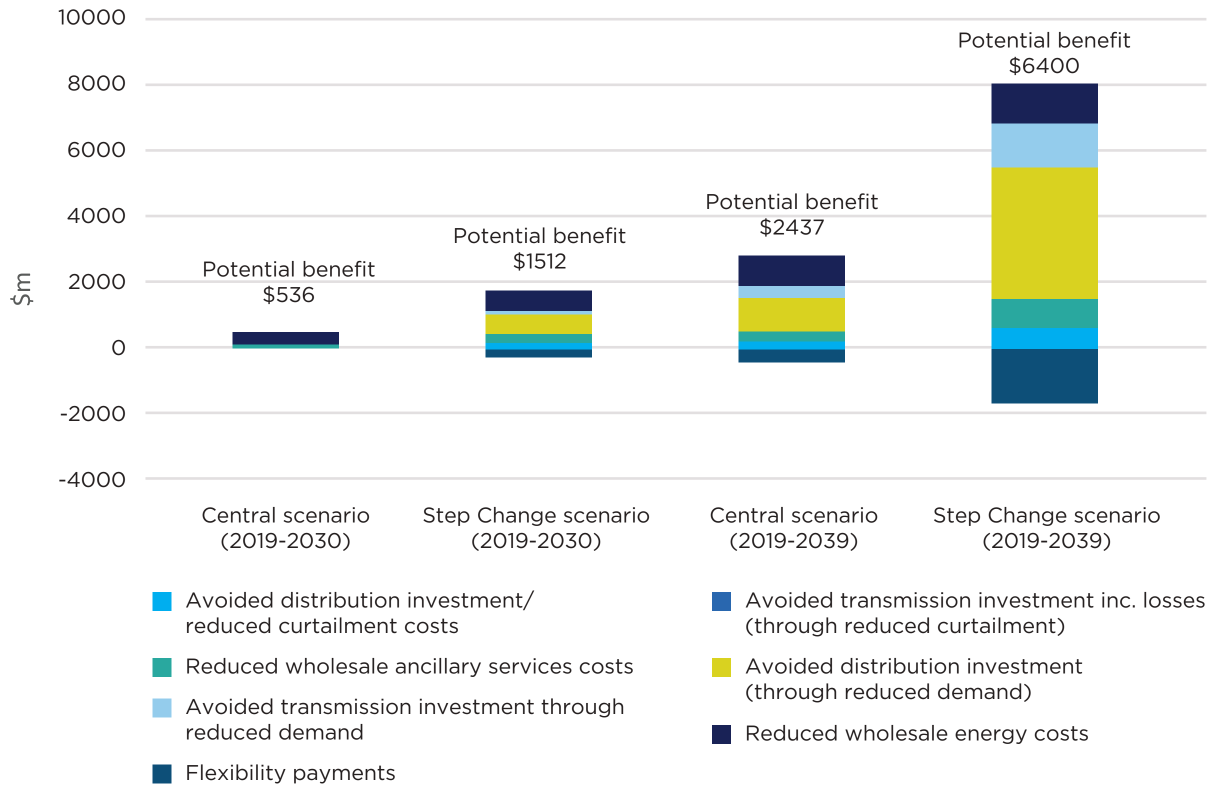
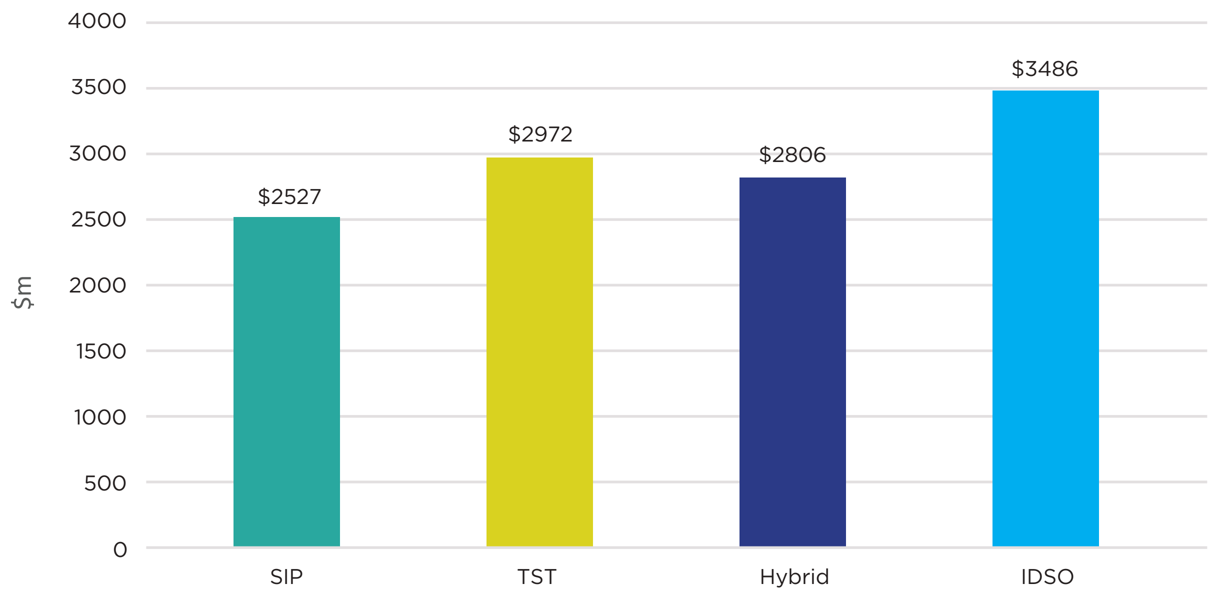


Figure 16. **Comparative costs associated with implementing each of the four frameworks ($m, 2019-20 prices)**



Network visibility

None of the proposed OpEN project distribution market frameworks can be delivered without increased monitoring of the distribution network. This is needed to improve visibility to the DNSPs of how their networks, the assets and potentially consumer assets, are operating on a moment-to-moment real-time basis.

Investing in improved network visibility represents a significant cost for all of the OpEN distribution market frameworks. However, DNSPs would not plan to implement monitoring over their entire networks at one time. Rather, as we are already seeing, they would deploy additional monitoring in parts of the network where DER deployment is reaching a critical peak.

Moreover, the costs for monitoring vary significantly between networks, reflecting the different approaches and availability of data for each DNSP. For instance, costs for Victorian DNSPs would be lower, as smart meters are mandatory, whereas other networks have limited numbers of smart meters.

Improved monitoring of distribution networks and access to real-time data will be required in the near term to deliver on other policy imperatives, such as dynamic connection arrangements.

The speed at which the potential benefits can be delivered

There are a number of assumptions or judgements that can be made regarding the ability of frameworks to deliver the available benefits.

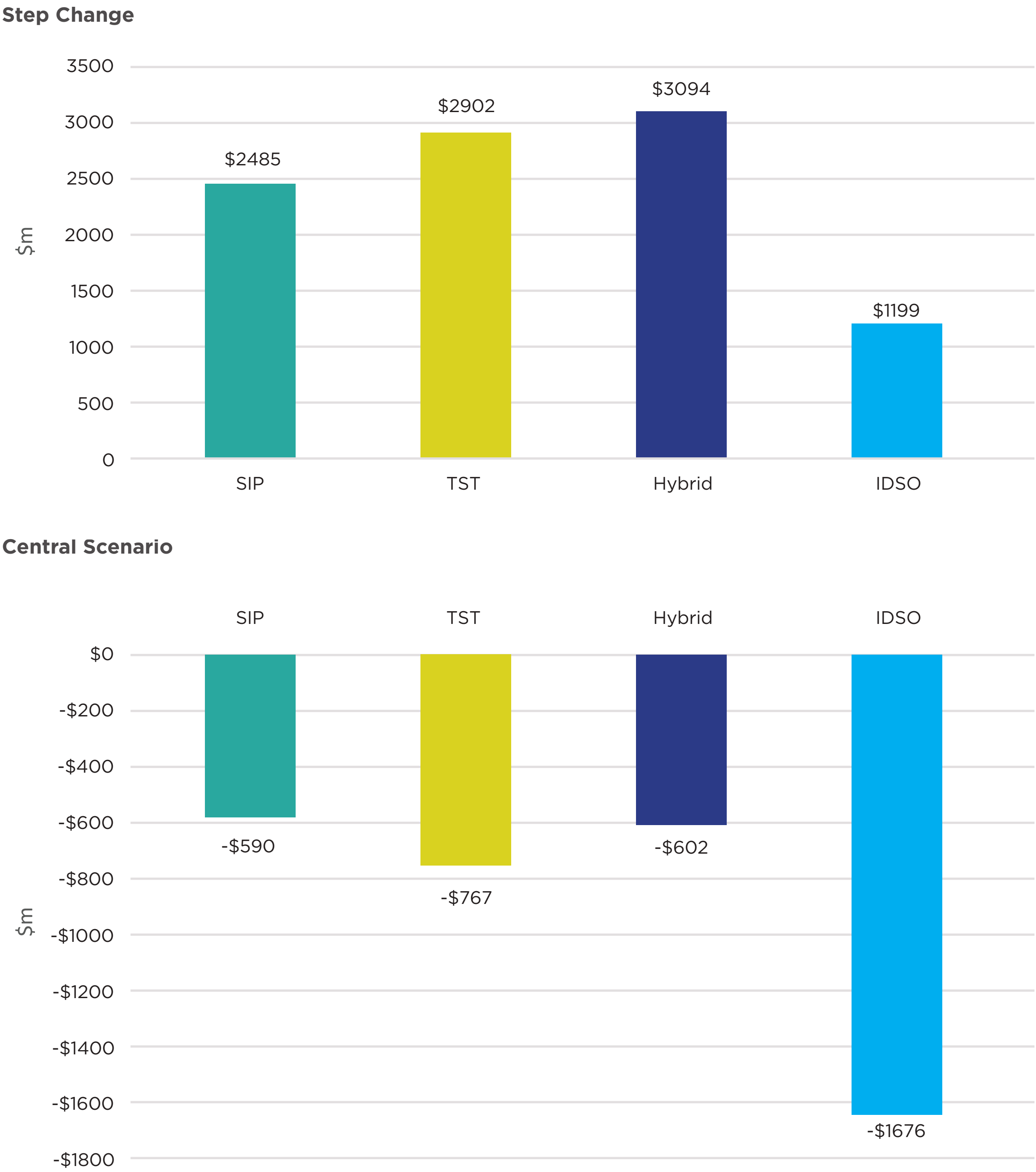
Various distribution market framework features influence the speed at which benefits can be delivered. For example, if DNSPs capabilities in distribution network planning, connections and operations mean that they can deliver network access sooner than a third-party system operator (IDSO) or AEMO (SIP), then the two-step tiered (TST) distribution market framework will appear more attractive. However, if a single route to market can deliver faster DER access into wholesale markets and AEMO and DSOs can coordinate planning and operations effectively under split responsibilities for market and system operations, then the hybrid distribution market framework appears most attractive.

As an illustration, for the Hybrid framework these assumptions produce the following results for when network and wholesale market access will be maximised (Table 8) and results in benefits under the Step Change scenario, but costs under the Central scenario (Figure 17)

Table 8. **Projected year for maximising network and wholesale market access under each of the four frameworks. (Baringa, 2020)**

Factor assessment	SIP	TST	IDSO	Hybrid
Year when network access maximised	2033	2028	2034	2029
Year when wholesale market access maximised	2025	2028	2031	2025

Figure 17. Overall net benefits under the Step Change and Central Scenario ($m, NPV 2019/20 prices)



Conclusions and recommendations

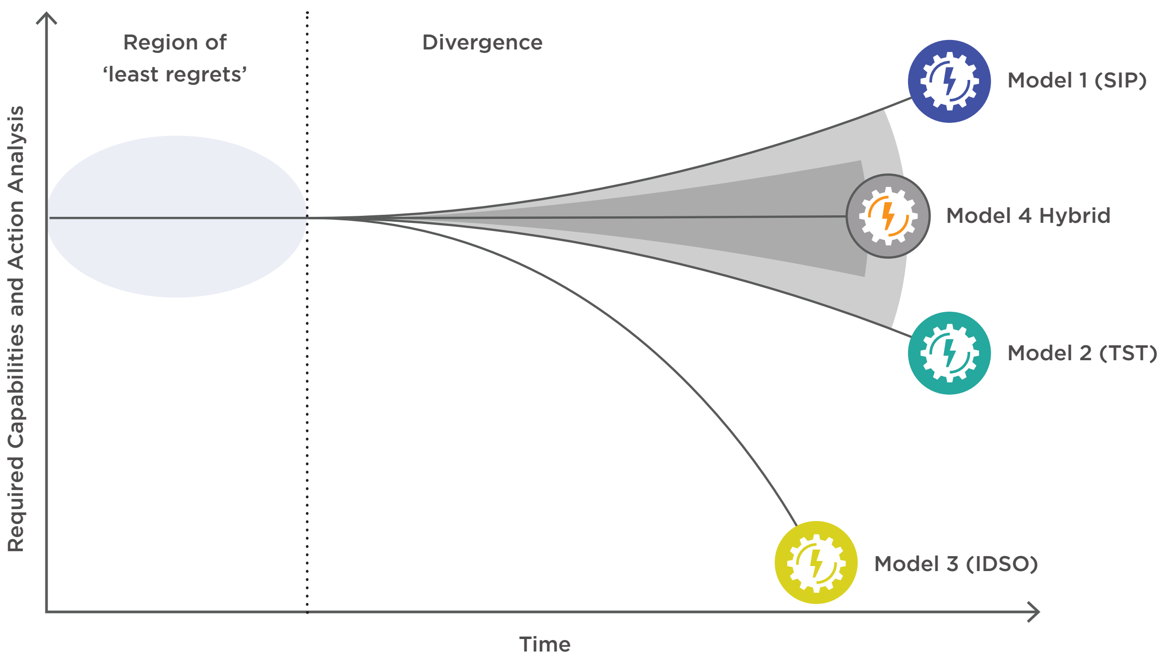
The Baringa Partners (2020) cost-benefit analysis indicates that at the high DER deployment rates used in the step change scenario there are significant benefits to consumers of developing a distribution level market for integrating DER. However, the benefits of a distribution market are highly dependent on the rate of deployment of DER. The central DER deployment scenario would not result in net benefits from developing a distribution market.

Slower deployment rates of DER favour approaches to better integrated DER that are led by the DNSPs, while very high deployment rates of DER favour a more centralised approach.

While there is uncertainty regarding the performance of the distribution market frameworks, the assessment suggests that the independent distribution system operator framework is likely to be the least attractive, due to its high implementation and operating costs. While it can provide greater transparency by separating market and system operations, the qualitative assessment shows that this may also be achieved under a hybrid framework. Consequently, the independent distribution system operator framework is the least preferred option.

The remaining three frameworks could all be viable options to suit different circumstances (Figure 18). They have significant positive net benefits under high DER uptake scenarios, but significant costs under slower DER uptake scenarios. However, the differences in quantified net benefits and costs between the three distribution market frameworks are all within the margin of error and are not significant.

Figure 18. Illustrative example of required capabilities and actions analysis



There are already substantial regional variations in DER uptake and the resulting potential for network constraints, this means that scalable and proportionate approaches are required to deliver optionality value and to minimise the risk to consumers of high costs in investing heavily in distribution markets now. DNSPs are already taking action to facilitate the increased uptake of DER and to utilise that DER to provide network support.

The cost benefit analysis does not provide strong evidence to support significant steps towards the deployment of any of the OpEN distribution market frameworks NEM-wide today.

Rather, a variety of measures, some already underway, should be tested and implemented to effectively integrate DER within the current market framework.

When there is greater certainty concerning the uptake of DER, a decision should be made on whether a distribution market framework could deliver better outcomes for all consumers.

The two-step tiered and single integrated platform frameworks represent contrasting end points of market design. Consequently, a logical conclusion is that a hybrid is a pragmatic solution that might represent the best of both frameworks, while minimising the weaknesses.

However, a hybrid framework would benefit from more detailed definition to ensure that roles and responsibilities are clear. The original Hybrid distribution market framework was developed late in the project and was not as clearly articulated or tested with stakeholders as the initial three frameworks. A hybrid framework could take various forms, with some closer to the two-step tiered and others closer to the single integrated platform framework. It would be valuable to trial these different hybrids to help design the optimum configuration.

Currently, there are differences in the abilities of DNSPs to use new approaches to better integrate DER. The frameworks deployed in different locations may need to adapt to local requirements. This further indicates that trialling a range of hybrid frameworks, reflecting various balances of the two-step tiered and single integrated platform frameworks, may be beneficial in determining which best suits specific circumstances.

Trials could also help assess the performance of stakeholders in developing and operating the new functionality required to integrate DER.

9 Energy market rules and network regulation

The Interim OpEN Report (2019) made recommendations regarding the need to address rules and regulations associated with integration of DER into the wholesale market, the role of an aggregator for DER and related services, and the key required capabilities, specifically the best practice method for distribution networks to monitor their networks, define hosting capacity and constraints and communicate these to market participants. The report also recommended the need for a review of network pricing and tariffs for DER.

In each of these areas, trials and stakeholder consultation have helped advance the understanding of options for regulatory change through:

- the wholesale demand response rule change, due for a further draft determination in March 2020, has introduced the new roles of a demand response service provider, which will aggregate provision of frequency control ancillary services and demand response on behalf of customers
- required capabilities being actioned via the distribution networks regulatory reset process, with, for example the SA Power Networks draft regulatory plan including significant investment into DER hosting capacity monitoring and management. There are ARENA-funded projects being run by ANU, CSIRO, AEMO and DNSPs that are looking to define best practice in defining and communicating operating envelopes, which incorporate network hosting capacity constraints and communication.
- AEMC's **electricity network economic regulatory framework review** and ARENA's distributed energy integration program's access and pricing stream investigating network pricing and tariffs with rule change proposals likely in 2020.

This chapter explores five possible regulatory changes regarding networks that might better enable a smoother energy transition for all market participants and stakeholders.

Strengthen incentive-based network regulation for better outcomes

The regulatory framework could allow for better incentive schemes that target a wider range of outcomes that customers and society value outside the scope of current regulation.

Current network regulation primarily seeks to minimise traditional categories such as capital and operating costs, and incentivise serviceability and reliability outcomes. However, network regulation lacks the flexibility to reflect several key aspects that customers and society will strongly value in the future including:

1. modern customer service and satisfaction measures
2. facilitating improved network access for owners and operators of DER
3. transparency of network constraints and opportunities

Failure to properly incentivise these aspects of service may result in inaccurate signals to networks when they make future investment decisions on behalf of all customers connected to their network.

The perfect answer is yet to be found and any solution will need to respond to customers, as well as stakeholders in government, industry and society.

Some options may include

1. Reform and expansion of regulatory incentive schemes: updating existing incentives or adding new forms of incentives relevant to all customers. This could include incentives targeted at optimising hosting capacity using DER where efficient, providing greater network visibility, or network reinforcement where this enables realisation of customer and market value through additional capacity.
2. Negotiated schemes: network businesses could negotiate more specific and relevant incentive schemes with their customers to address unique needs, customer-valued outcomes or network circumstances.
3. Promote greater output-based revenues: an evolutionary shift away from a 'cost recovery' based approach where delivery of defined outputs is linked to a larger part of a network businesses' revenue.

Current incentives focus heavily on the need for network businesses to lower costs. Further changes should value new or required aspects of service which will produce more positive outcomes for customers.

Integrating DER into the network regulatory determination process

The potential greater role of customers in the future energy system is likely to require a greater focus on enabling DER in future determinations.

This is evident in the current regulatory framework's fragmented and iterative processes that affect the issue, including distribution annual planning reports, regulatory investment tests and distribution Australian Energy Regulator guidelines on justifying DER expenditure. A more fundamental change to how DER is integrated into the determination process may be warranted.

Reforms could include:

1. DER integration plan: encourage network businesses to present plans focusing on DER management investments, decisions on hosting capacity and measures to improve visibility of constraints and opportunities
2. Revised capital and operating expenditure criteria: the current criteria were drafted more than 10 years ago in different circumstances and do not reflect the goal of allowing customers to benefit from their DER assets
3. Exploring moving to alternative revenue assessment models (for example, assessing TOTEX): this could ensure that incentives are unambiguously neutral between capital-intensive investment and short-lived operating solutions, and promote a more holistic assessment of cost trade-offs.

Each of these potential options could improve the regulatory assessment process for DER-related expenditure by producing a more fit for purpose treatment of DER issues aligned with customer preferences.

Review ring-fencing

Examining ring-fencing arrangements is a logical step in a review of market frameworks, especially if changes to the arrangements could better enable network businesses to deploy and utilise DER in a wider variety of network services.

Energy Networks Australia believes that a refresh of ring-fencing obligations could allow for greater participation of DER regardless of its position in the grid. Changes would also allow network businesses to provide more efficient solutions day to day without heavy regulatory burden and complexity. This could then begin to form the basis of more mature procurement platforms for network services in the future and provide a roadmap of future regulatory changes for all participants.

Some possible reforms in this area could include a thresholds permission approach, which would allow networks to invest in providing access to DER up to a maximum cap or per project threshold, to address concerns about networks 'crowding out' prospective market participants. Wider class exemptions, applying a standing 'class exemption' for specific DER investment for fixed periods, would streamline access to market for customer DER.

The aim of any reform should be to improve the experience of current and future DER owners by reducing the regulatory burden and complexity associated with the existing framework. One example of this is the trialling and investment in innovative projects such as community batteries. These trials are being undertaken in Western Power and United Energy networks, with the results helping inform any changes to ring fencing arrangements.

Trials that are exploring the market frameworks should also investigate how DER is operating in LV networks and investigate the cost and operational barriers to utilising customer DER compared with network-owned assets.

Energy Networks Australia believes that changes to ring-fencing arrangements would allow network businesses to leverage their relatively low cost of capital to invest in solutions that would create greater economic and social value for consumers on a whole of system basis.

The Australian Energy Regulator and the AEMC have run an important regulatory sandbox project allowing participants to explore innovative concepts under more relaxed regulatory rules at a smaller scale and with appropriate safeguards (**AEMC, August 2019**, **www.aemc.gov.au/news-centre/media-releases/aemc-recommends-regulatory-sandbox-toolkit-support-innovative-trials**).

Regulations for distribution level markets

Current regulations do not allow the emergence and management of distribution level markets that may be critical in providing the right economic signals for customers with DER and other participants in the future.

Work being done by the ESB and DEIP should focus the industry on these changes.

Energy Networks Australia believes that it is too early to implement institutional reform at the distribution level and that maintaining a flexible and iterative approach will yield optimal results. This is globally consistent with the regulatory work happening in the UK and **noted by Ofgem**.

Creating a legal foundation will be pivotal in ensuring efficient distribution-level markets and allowing DER owners to fully realise the benefits of their investments. Over time distribution markets might promote lower whole of system costs such as deferred wholesale generation and deferred distribution investment.

Network tariffs

Network tariffs should have the ability to signal to households and businesses that have DER the cost of using the network and the benefits of changing their behaviour. There are numerous variations of how this might look like in practice. For example, customers could be incentivised via low network tariffs to charge storage devices such as EVs or batteries at times when there is low network usage. High tariffs could apply during times of high network usage.

This approach would help limit the need for networks to over-invest in infrastructure to respond to rare peak conditions, ultimately lowering costs for customers.

As previously mentioned, work in this area is already progressing through the AEMC-DEIP distribution access and pricing work program in conjunction with customer advocates (reference needed).

The benefits of pricing reform have been quantified and outlined in a range of reports from parties such as the ACCC and Energy Networks Australia and there is wide acceptance of this need. The *Electricity Network Transformation Roadmap* (CSIRO and Energy Networks Australia, 2017) identified network tariff reform as potentially enabling more than $16 billion of avoided infrastructure costs for customers.

10 Conclusion

The Open Energy Networks project (OpEN) was designed to explore whether distribution markets offered a cost-effective approach to integrating distributed energy resources (DER), while delivering benefits to all consumers, with and without DER.

Australians are installing DER with enthusiasm and while solar PV dominates it is likely that batteries and controllable loads will be increasingly deployed as costs reduce and the ability to save money or make money increases. Electric vehicles (EVs) are expected in significant number in the 2030s and will have additional impacts on the operation of distribution networks.

Consumers invest in DER for their own reasons, often to manage their own costs. To provide extra value to consumers, DER can also be aggregated and used to provide services to the wholesale market. Any future market framework must allow for DER to access and participate in markets for these services in an economically efficient way, and for all consumers to benefit from the additional value that this creates.

No rush on distribution markets

The OpEN cost benefits assessment concluded that all four OpEN framework models could deliver net benefits under a very high DER uptake scenario. However, under a lower DER scenario, the net benefits were negative, that is, distribution level markets delivered less benefits than costs for consumers.

Given that the benefits and costs to consumers of a distribution market are highly dependent on DER deployment rates being high, there is no strong case to adopt any of the frameworks for distribution markets in the near term.

While the economic impacts and the impacts on DER deployment of the pandemic are not certain, it is highly likely that Australia will experience a severe recession and reduction in the demand side due to the significant increase in unemployment and income reductions for millions of households. This is likely to result in slowdown in the deployment of DER, further reducing the benefits of a distribution market.

Optionality to balance costs and benefits

The optimum approach to DER integration is an incremental approach that supports optionality and allows all participants to learn by doing. There are approaches that can be used now, such as pricing and tariffs, that will help facilitate the cost-effective integration and management of DER without the need for significant near-term investment in new IT platforms for delivering distribution markets.

Incremental approaches ensure that decisions do not need to be made today that commit consumers to bearing the risk of significant investment costs, for uncertain benefits well into the future.

There has been a huge transformation in the electricity system already. This transformation is not complete, and it is not possible to predict the final system model. There may never be a fixed end to the transformation, taking telecommunications as an example. By taking incremental actions now to support DER integration where it is required, rather than throughout the whole system, there is flexibility to take alternative approaches and to explore alternative models.

The distribution market frameworks

Qualitative and quantitative findings indicated that one of four proposed frameworks had significantly lower net benefits relative to others and that it was not compelling to progress this framework:

» **The independent Distribution System Operator (IDSO)** – Identified as too expensive and inefficient.

The three remaining models demonstrated comparable net benefits:

» **Single Integrated Platform (SIP)** – When DER deployment is uniform and widespread, the SIP can provide an efficient way to maximise access to the wholesale market. However, the SIP risks centralising all capability to manage all DER down to the small scale/household level in one organisation, leading to complexity and inefficiencies.

- **Two-step Tiered (TST)** – Across regions of varying network constraints and DER deployment, the TST Framework can provide an effective way to quickly maximise network access to facilitate DER participation in markets at local/regional levels. However, as the TST envisages that each DNSP invests in both DSO and DMO functions, it becomes costly to implement if DNSPs do not collaborate.
- **Hybrid model** – a combination of the SIP and the TST was added for consideration as it can combine the existing strengths of industry parties; DNSPs can maximise network access and operate their local systems while AEMO acts as market operator to provide a single route to markets. This could be a natural evolution for both parties. But there are questions over how it will operate in practice, which may make it complex, and this requires further examination.

It is proposed that a range of hybrids be tested, in a series of trials which AEMO and DNSPs with the support of ARENA and the DEIP are in the process of establishing. The hybrid models tested should explore versions that are more "TST-like" and versions that are potentially more "SIP-like".

Any trial should be co-developed with consumers to place them at the heart of policy and technical developments in this area.

Things that must happen now

DNSPs will need to have a better understanding of their own network assets in real-time and the ability to manage those assets in real-time to integrate higher levels of DER. Better visibility, through monitoring assets and DER, will support all participants to better understand and manage DER. This increased visibility is required now regardless of whether distribution markets are developed, since the data from DER and network assets facilitates forecasting of the need for network services, the delivery of dynamic connection arrangements and active network management to support increased hosting capacity.

Access to consumer data needs to be carefully managed in consultation with consumers, so that they understand the benefits and risks of sharing their data to support the operation of a lower cost system.

Consumer considerations

OpEN was a very technical project and was criticised by consumers for not exploring the social issues related to utilising consumer-owned assets and to supporting the engagement of those consumers without DER. Any approach taken to optimise DER must deliver benefits to consumers with and without DER.

Consumers have clearly stated a desire to participate in the co-design of any new energy future. This must be a focus of any trials or new market proposals, such as the ESB's Post-2025 Market design project.

Energy Networks Australia is committed to working with consumers to help them understand the options and implications of approaches to integrating DER for the benefit of all, including the costs of improving network visibility and monitoring.

While the Open Energy Networks project has focused on the technical capabilities for successful DER integration, there will also be a need to review access and pricing (tariff) arrangements to determine the best way to recover the cost of the network and encourage positive retailer, aggregator and consumer behaviour.

In addition, we believe that the Open Energy Networks project has delivered a key piece of analytical work that will help the considerations of the ESB, AEMC, AEMO and the AER in the NEM 2025 Market Design process. Consumers and their DER will be increasingly important in Australia's energy markets so DER integration must be considered a key part of the market design process.

References

ACOSS & TEC (2020) *New Energy Compact: People centred vision for the Australian energy system*. Australian Council of Social Services & Total Environment Centre. Available at www.acoss.org.au/wp-content/uploads/2020/02/NEC_Consultation-Draft-V.4-19022020-002-1.pdf

AEMO (2019) *2019 forecasting and planning scenarios, inputs, and assumptions.* Available at https://aemo.com.au/-/media/Files/Electricity/NEM/Planning_and_Forecasting/Inputs-Assumptions-Methodologies/2019/2019-20-Forecasting-and-Planning-Scenarios-Inputs-and-Assumptions-Report.pdf

AEMO, (2020), *Renewable Integration Study*. Available at https://aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integra-tion-study-stage-1.pdf

AEMO and Energy Networks Australia (2019) *Interim Report: Required Capabilities and Recommended Actions*. Available at www.energynetworks.com.au/assets/uploads/open_energy_networks_-_re-quired_capabilities_and_recommended_actions_report_22_july_2019.pdf

Baringa (2020), *Assessment of Open Energy Networks Frameworks*, p77, London (unpublished)

Clean Energy Council (2020) *Clean Energy Australia Report 2020*. Available at https://assets.cleanenergy- council.org.au/documents/resources/reports/clean-energy-australia/clean-energy-australia-report-2020. pdf

CSIRO and Energy Networks Australia (2017) *Electricity Network Transformation Roadmap: Final Report*. Available at www.energynetworks.com.au/resources/reports/electricity-network-transforma- tion-roadmap-final-report/

Energy Consumers Australia & UMR Strategic Research (2016) *Usage of solar electricity in the nation- al energy market: A quantitative study – November 2016*. Sydney, UMR Strategic Research. Available at https://energyconsumersaustralia.com.au/wp-content/uploads/UMR-Usage-of-solar-electrici-ty-in-the-national-energy-market.pdf

Energy Security Board (ESB), (May 2020), *ESB cover note on the UNSW Voltage Report*, presented at ESB/AER/UNSW Webinar on new Voltage report, 6 May 2020.

Green Energy Markets (GEM), (April 2020), *DER Projection Results*, presented at the AEMO Forecasting Reference Group meeting on 29 April 2020.

Please contact Energy Networks Australia for further information.

Energy
Networks
Australia