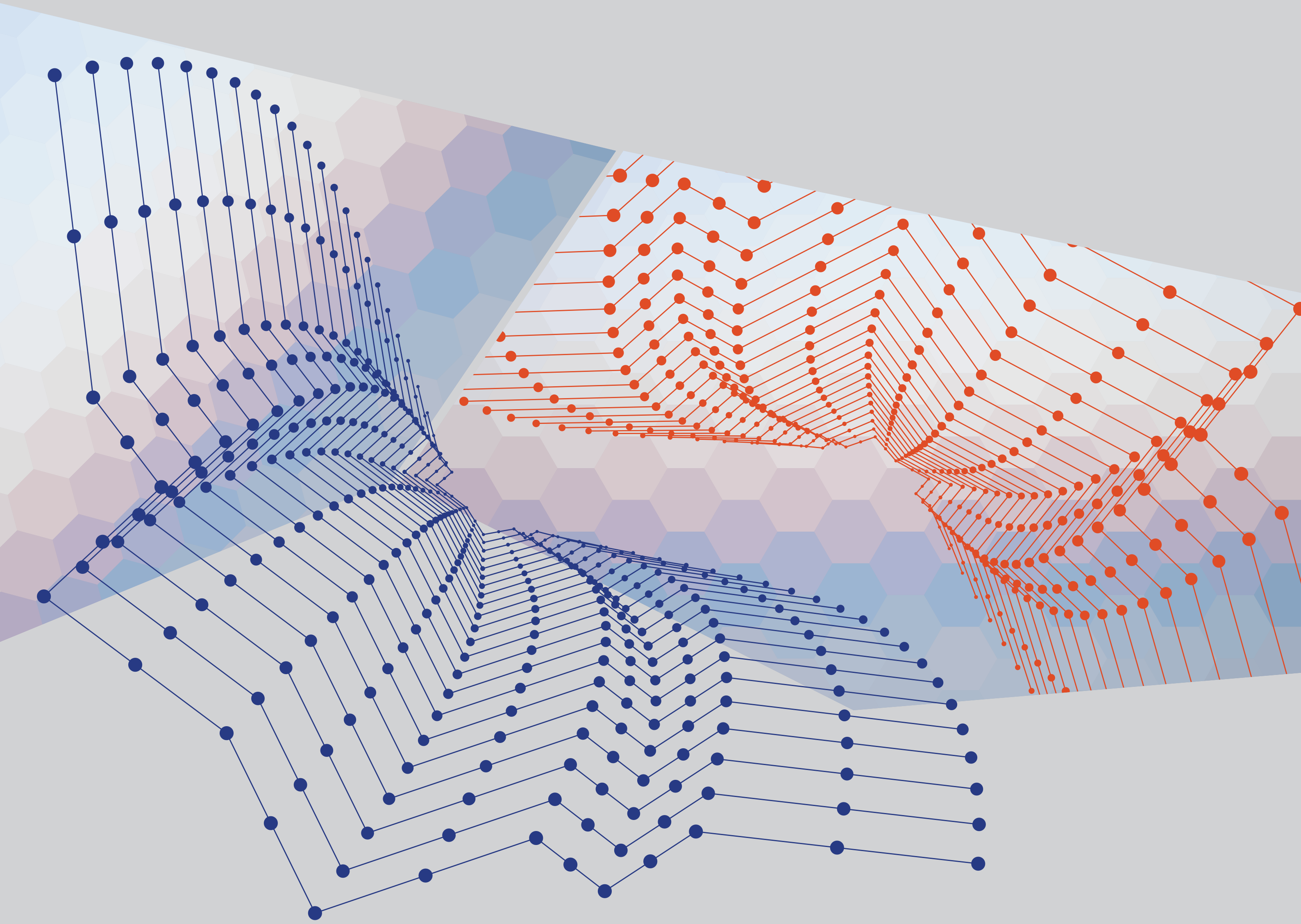
OPEN ENERGY NETWORKS

Interim Report

Required Capabilities and Recommended Actions

A Joint AEMO and Energy Networks Australia Initiative



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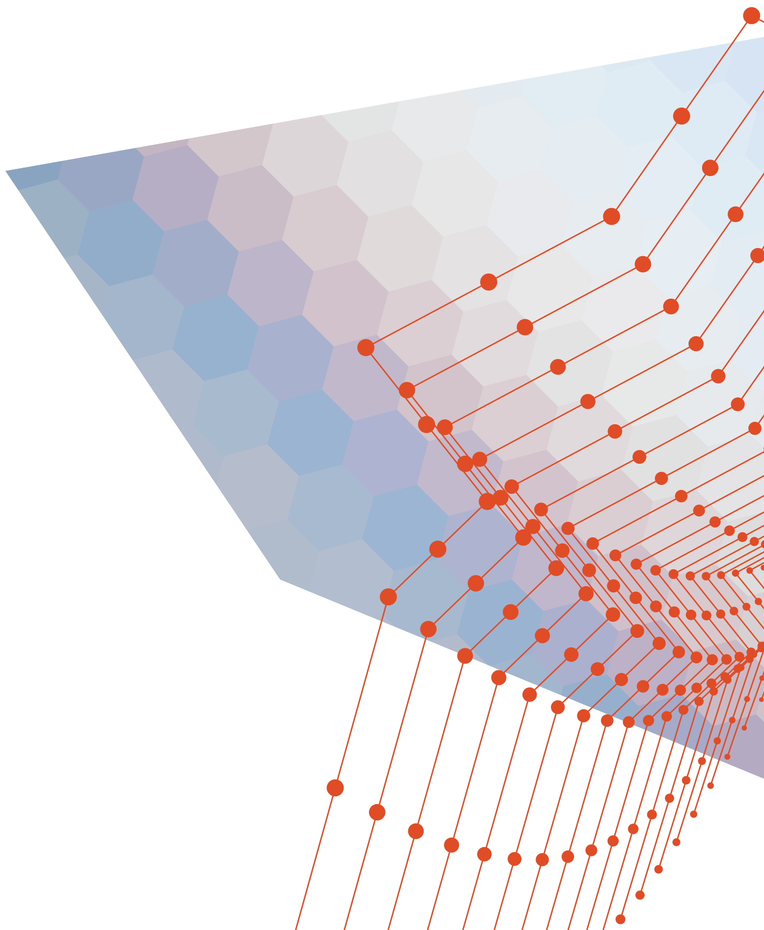

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Glossary of Terms

OpEN – Open Energy Networks project

NEM – National Electricity Market

WEM – Wholesale Electricity Market (Western Australia)

ENTR – Electricity Network Transformation Roadmap

Aggregator – A party which facilitates the grouping of DER to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to the system operator(s).

DER – Distributed energy resources; can refer to distribution level resources which produce electricity or actively manage consumer demand; e.g. PV solar systems, electric vehicles, batteries, and demand response such as hot water systems, pool pumps, smart appliances and air conditioning control.

Optimisation – referred to here as the aggregation and prioritisation of distribution level bids and offers; in global markets also known as “orchestration”.

DMO – Distribution market operator; this term refers to the function of the distribution level market operator, as distinct to the wholesale market operator.

DSO – Distribution system operator; this term refers to an expanded technical capability of a current distribution network services provider to identify and communicate network constraints. Please note this is a revised definition based on improved understanding of this role; the previous definition combined both the DSO and DMO roles.

Executive summary

Making a modern energy system work for all

Household solar and batteries can deliver value for all electricity customers

Our nation's electricity grid was designed more than a century ago to handle one-way distribution of power from large scale generators to customers. It was not engineered to support electricity going from multiple premises back into the grid.

Australia now has more rooftop solar installed per capita than anywhere else in the world. Consequently, as increasing amounts of solar and storage devices (known as distributed energy resources or DER) are installed on and in our homes and businesses, the electricity system faces growing challenges. It also has great opportunities.

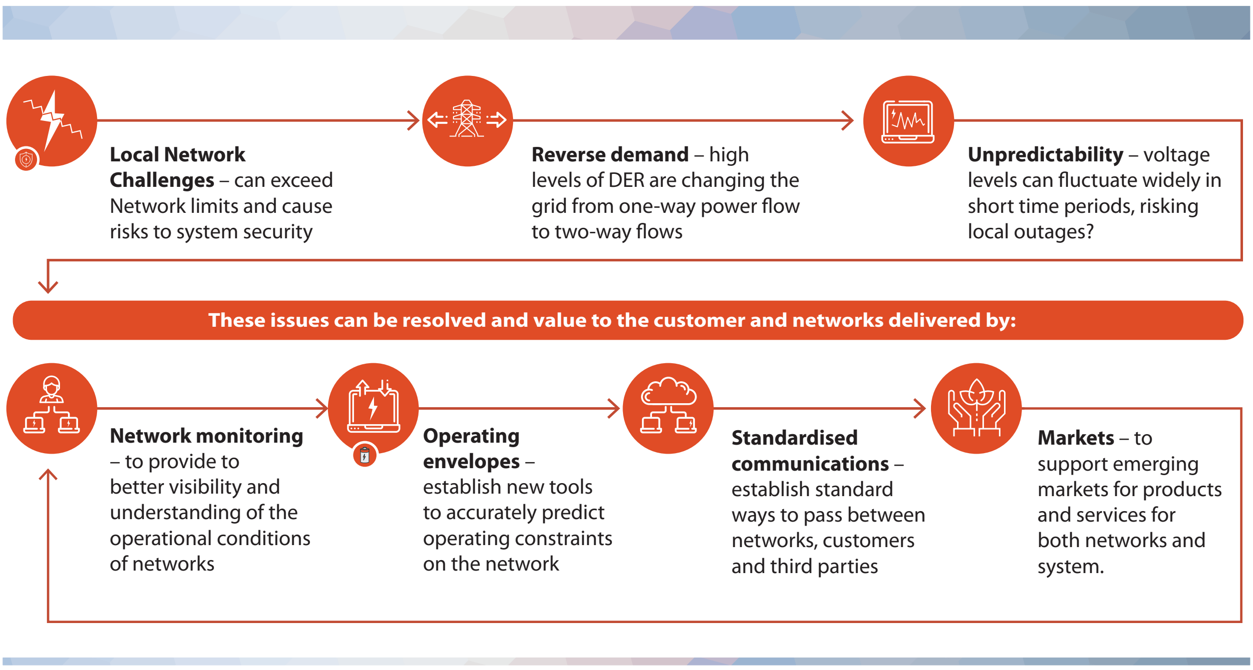
This Required Capabilities Report is part of Open Energy Networks (OpEN), a major joint project of Energy Networks Australia and the Australian Energy Market Operator (AEMO) to address the challenges and take advantage of the opportunities from our nation's embrace of DER.

It outlines the key functions Australia's electricity system must have to ensure it operates safely and reliably, delivering benefits to all customers as it modernises to adapt to an increasingly renewable energy future.

The report provides a comprehensive evidence base to inform this future direction, identifying key milestones and actions to enable the transformation.

> OpEN's primary objective is to ensure the system and market are fit to respond to customer needs into the future.
>
> The CSIRO estimates a transformed energy system could deliver more than $1billion in benefits by 2030 from more efficient use of distribution networks and avoided expenditure on new generation and poles and wires infrastructure.
>
> This means lower costs for customers.

Figure 1. Why the need for change



Required Capabilities

Stakeholder consultation has identified the key functions that distribution network service providers (DNSPs) need to support optimal integration of DER with the electricity system. These 'required capabilities' must be developed as a priority, irrespective of the system to which Australia ultimately transitions. Successful management of DER is an integral feature of any feasible future energy system.

These required capabilities are:

- Enabling DNSPs to improve network visibility – i.e. know where DER are installed and how they are capable of behaving in real-time so the local distribution network and the wider system can be managed. For example, the export capacity of a solar and storage system needs to be known, as well as how fast the battery can respond to a signal to switch from charging to discharging.
- Defining network constraints or 'operating envelopes' so customers can be advised 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.
- Establishing standards to communicate these 'operating envelopes' to aggregators, retailers, owners of DER and AEMO to help ensure the safe and secure operation of the network.

Required capabilities have been grouped into three key milestones.

Figure 2. Required capabilities and milestones

MILESTONE 1:
DNSPs defining network visibility requirements and network export constraints

- Define DNSP requirements for increased network visibility to maintain network operations within required parameters
- Define how to achieve increased network visibility to maintain network operations within required parameters (operating envelopes)
- Establish an iterative and targeted approach for the timing of investments required to provide network visibility to maintain network operations within required parameters

MILESTONE 2:
Defining communication requirements for operating envelopes

- Define protocols for operating envelope communication
- Establish a Australian standards and/or guidelines to support the establishment of operating envelopes
- Define data access permissions

MILESTONE 3:
Establishing an industry guideline for operating envelopes for export limits

- Develop an Industry guideline that outlines the requirements and use of operating envelopes

If these required capabilities are delivered, a number of key benefits will be unlocked, irrespective of which market framework is ultimately pursued. Benefits include:

- Better accommodation and integration of all generation and energy storage options into the grid, enabling more DER connections;
- Improved power quality and reliability at lowest cost to customers;
- Optimisation of existing assets to increase utilisation and efficiency, further reducing costs for customers;
- An electricity system that is better placed to respond to system disturbances;
- Creation of a platform that will enable new products, services and markets for customers.

Distributed energy resources are integral to Australia's energy mix

One in five Australian households today have connected solar energy. Commercial solar installations have been growing at unprecedented rates. Forecasting suggests that by 2050, almost half of households and businesses in Australia will have solar PV installed, many accompanied by a storage device, an electric vehicle charger and other smart appliances of the future.

If managed correctly, these customer-DER assets can play a significant role as part of Australia's future energy mix. The rooftop solar panels and customer batteries in Australian homes and businesses could be harnessed to partially replace ageing grid scale power generation – at much lower cost. This can be achieved with the right planning – what is technically called "aggregation and coordination" - of individual DER assets so that combined, they can provide dispatchable power or network services. This is similar to how generators in the National Electricity Market (NEM) or Western Electricity Market (WEM) work today.

Findings in this report have been informed by extensive engagement and consultation with a wide range of domestic and international experts. Timely decisions and actions are required to deliver a market framework that secures our energy mix now and into the future. This report details the required capabilities that must be established and deployed if networks and AEMO are to facilitate DER integration that can support the reliability and security of energy at a lower cost, releasing value to the DER owner.

Key analysis and findings supporting the recommendations made in this report include:

1. International Review of DER Coordination – Newport consulting.
2. Open Energy Network Project Report and Smart Grid Architecture (SGAM) models – EA Technology.
3. Cost Benefit Framework – CSIRO.

These supporting documents have been published in conjunction with this report.

Four system operator models

Energy Networks Australia and AEMO launched OpEN in June 2018, seeking submissions to an industry-wide consultation paper.

A key objective of the project is to establish a comprehensive understanding of the roles a future distribution system operator (DSO) might play in the modern energy system and make recommendations based on the value return for all customers, irrespective of whether they possess DER assets.

OpEN is investigating four frameworks that facilitate market access for all stakeholders, including DER owners, aggregators, third parties, network operators and retailers, while ensuring uncompromised system integrity and security.

The initial consultation paper identified three potential market frameworks (a detailed description can be found in this report's appendices) however, a key outcome of the extensive consultation workshops has been the development and inclusion of a fourth 'hybrid' model.

The fourth model addresses specific stakeholder concerns associated with the three original models, which were:

- » The independent DSO model was seen to be overly complex.
- » The two-step tiered platform model highlighted potential conflict of interest in the DNSP maintaining a technical operation role in addition to a market clearing function.
- » Managing the market and the system at both transmission and distribution level was considered potentially problematic for one organisation in a single integrated platform.

Recommended actions

In addition to the required capabilities, the report makes the following recommendations that underscore the urgent need for testing new approaches to the way our electricity system and market are managed:

1. All customers (with and without DER) must be at the centre of decision making.
2. The role of the aggregator needs to be defined.
3. Industry must collaborate to improve network and demand forecasting.
4. Integration of DER into the wholesale market must be strategically managed.
5. A market for network services must be facilitated.
6. Pricing signals for DER customers must be established.

Integrating DER in the right way is important for many reasons. We must be sure of the benefits for all consumers when we design our future energy system, putting the customer at the heart of all our decision making.

We must make sure our energy system remains dependable and reliable, with steady supply, minimised interruptions and no compromises of safety or security.

This report considers what needs to be done so obligations of customer value, reliability and safety can be met as increasing amounts of DER are integrated into the energy system.

Next steps

The Open Energy Networks process is working towards making final recommendations. To reach a conclusion we will:

- » Complete a cost-benefit analysis on each of the four models;
- » Undertake further stakeholder engagement to test the outcomes of the cost benefit analysis and the potential model frameworks;
- » Release the draft report on the distributed market framework recommendations for public consultation (Q3, 2019);
- » Publication of the final OpEN report (Q4, 2019).

Further engagement will be undertaken with the Australian Energy Regulator and the Australian Energy Market Commission to explore regulatory changes that may be required to facilitate this work.

Energy Networks Australia and AEMO acknowledge all participants of the OpEN project and are grateful for the engagement and constructive input to-date. The continuous engagement and high-quality feedback have been invaluable in helping the OpEN team identify the required capabilities and recommended actions outlined in this report. Stakeholder responsiveness has informed the program and co-designed the proposed market frameworks. We look forward to engaging further as we conclude the OpEN project and take forward these important reforms.

For more information, go to Energy Networks Australia - www.energynetworks.com.au/joint-energy-networks-australia-and-australian-energy-market-operator-aemo-project or AEMO - www.aemo.com.au/Electricity/National-Electricity-Market-NEM/DER-program/Open-Energy-Networks-joint-consultation-with-Energy-Networks-Australia.

The OpEN team may be contacted via email info@energynetworks.com.au or DERProgram@aemo.com.au.

1. Introduction

In the not too distant future, it is easy to envisage an Australian energy system with millions of homes and businesses with rooftop solar, a battery system, a charging station for an electric vehicle and a household energy management system.

One in five Australian households already have solar. Commercial solar installations have been growing at unprecedented rates and by 2050, forecasts from the CSIRO and Bloomberg New Energy Finance suggest almost 50 percent of households and businesses in Australia will have solar PV installed. A significant portion of these will likely be accompanied by a storage device, EV charger or other controllable load.

If managed correctly, these customer assets could be utilised to replace ageing grid-scale power stations and provide system and network services. This can be managed through the aggregation and coordination of individual rooftop solar, batteries and other assets so they can be combined to provide dispatchable power or network services like generators in the National Electricity Market (NEM) or Western Australia's Wholesale Electricity Market (WEM) today.

Australians would have a more affordable and better optimised electricity system that delivers increasingly customised services.

The Energy Networks Australia and CSIRO Electricity Network Transformation Roadmap (ENTR) identified the importance of maximising the return value from the significant investment in distributed energy resources (DER). It estimated potential savings of more than $100 billion by 2050, predominantly from deferring network investment through efficient use of DER as an alternative.

As an outcome of the ENTR, key recommendations were identified to enable utilisation of DER in the NEM and WEM. This finding was also identified and validated by AEMO's 2018 Integrated System Plan (ISP). Highlighted in the ISP was the need for coordination and optimisation of DER under its group 2 projects. The ISP projected a 'high DER' scenario with potential to lower total supply costs and net present value wholesale resource costs by almost $4 billion, compared with a neutral case. In mid-2018, Energy Networks Australia and the Australian Energy Market Operator (AEMO) partnered to start a conversation with the wider industry through the Open Energy Networks Project (OpEN).

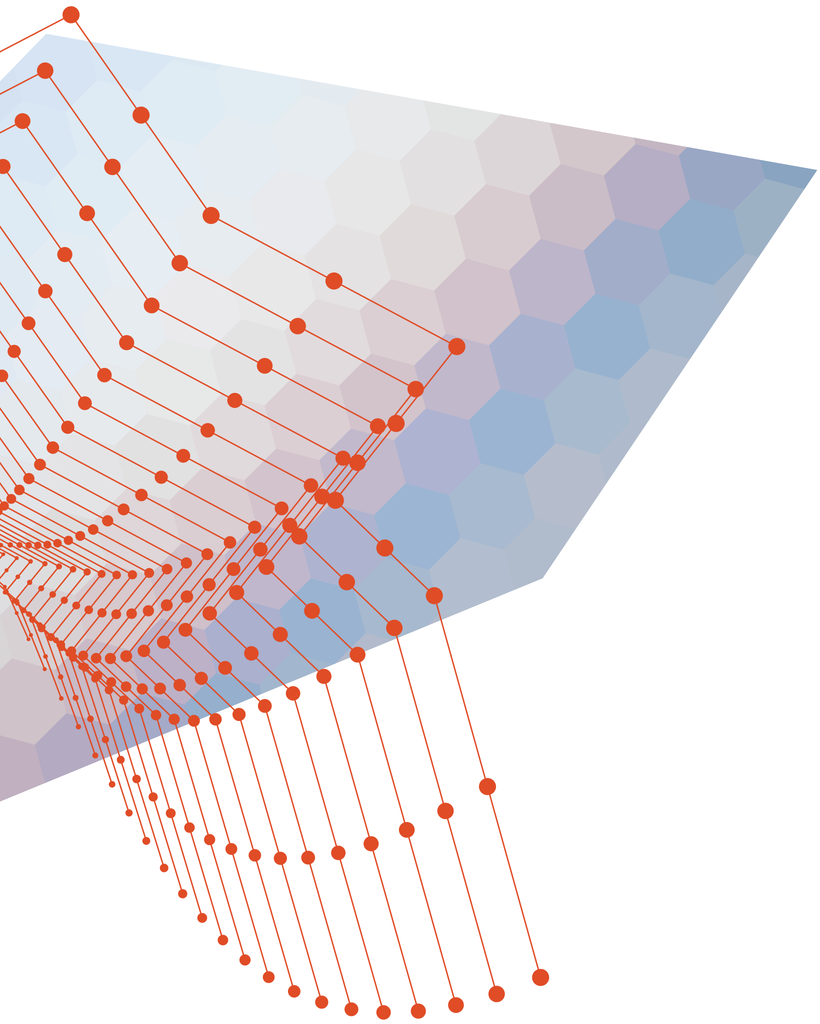
OpEN was designed to be a collaborative platform for all stakeholders to scope how best to integrate and manage DER within Australia's electricity grid. Ensuring that the best value can be achieved for customer-owned DER is central to decision making, as are system security and reliability obligations at the wholesale level. An additional consideration is the requirement to operate within the distribution network constraints that are emerging with increasing DER penetration in local networks.

DER assets could be used to ensure the networks and the system as a whole can operate safely and securely in a transmission network increasingly reliant on large-scale wind and solar generation.

The frameworks that are explored in OpEN should all enable DER to integrate into the NEM and WEM. Successful integration will enable a truly two-way system and marketplace, decentralising and democratising energy as it is implemented. While these frameworks are required to integrate and incentivise DER participation in the system, they will not operate without certain network capabilities, new categories for market participation and a review of network regulation more broadly. This includes how networks invest and recover costs, access arrangements for customer DER and tariffs.

We must solve the technical issues associated with DER integration and optimisation. We need to incentivise customers to share access to their solar and battery storage devices and appliances. We also need new business models to drive this innovation. Updated or new market rules will be required to facilitate the integration of these unregulated assets as part of the energy mix.

It is critical to develop systems that are capable of checks and controls, real-time data collection and communication. The integration of distributed energy presents technical, commercial and regulatory challenges that require resolution.



2. Why the need for a new operating approach?

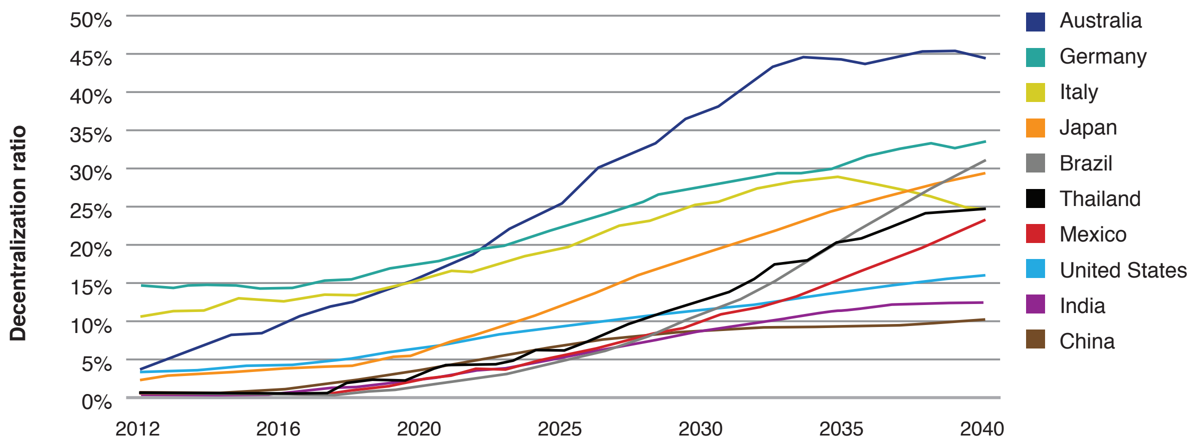
Australia has the highest ratio of rooftop photovoltaic (PV) generation to operational consumption in the world and this trend is forecast to continue into the foreseeable future as highlighted in Figure 3.

According to AEMO's Quarterly Energy Dynamics Report[1], the average daily peak generation of rooftop PV increased 25 percent from 3110 MW to 3878 MW between Q4 2017 and Q4 2018, which can be attributed to a record amount of installed rooftop solar capacity over 2018. As highlighted in Figure 4, rooftop solar provided most solar generation across the NEM, comprising 74 percent of total solar generation in Q4 2018.

The Clean Energy Regulator estimated that installed rooftop PV capacity reached 1GW in 2018 and continues to grow, driven in part by strong growth in the mid-sized (30 - 200kW) commercial sector as businesses respond to high energy prices. The rate of applications for new rooftop PV systems in this market sector tripled from 2016 to 2017. While not highlighted here, this trend is similar for the WEM. The speed and magnitude of solar PV uptake is skyrocketing across Australia.

The market for battery storage is accelerating, along with the adoption of other new energy technologies driven by falling costs and global carbon abatement measures. This provides a limited window of opportunity to reposition our electricity system to deliver efficient outcomes to customers.

Figure 3. Australia is leading the world in moving to a hyper-decentralised future[2]



1 AEMO. Q1 2018 Quarterly Energy Dynamics. May 2018. Available at www.aemo.com.au/Media-Centre/AEMO-publishes-Quarter-Energy-Dynamics---Q1-2018

2 Bloomberg New Energy Finance. 2017 New Energy Outlook. 2017. Available at https://data.bloomberglp.com/bnef/sites/14/2017/06/NEO-2017_CSIS_2017-06-20.pdf

Figure 4. Average NEM hourly large-scale solar and rooftop PV generation profile across Q4 2017 and Q4 2018[3]

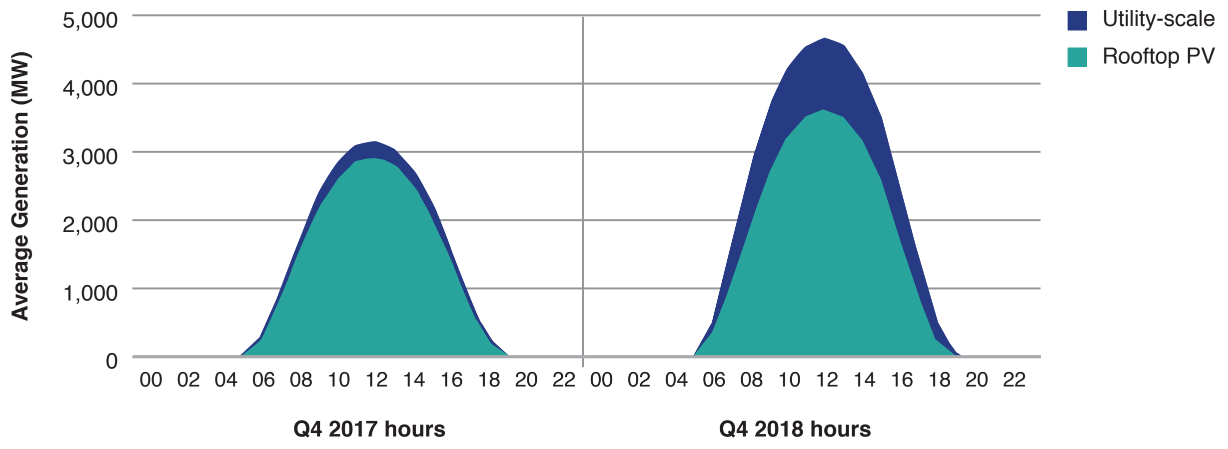


Figure 5. Scenarios for installation of DER devices - CSIRO

Timeline		Residential rooftop solar	Commercial rooftop solar	Residential battery storage	Commercial battery storage	Electric vehicles	Electric vehicle p.a. electricity demand
		MW	MW	MWh	MWh	No.	GWh
2020	Slow	7842	2094	647	27	3966	31
	Moderate	9795	3257	1100	69	10688	55
	Fast	10183	3840	1161	82	18342	84
2030	Slow	9981	4009	1622	72	456318	1506
	Moderate	13869	6104	3362	243	1716214	5761
	Fast	15199	7861	5424	456	3242170	12056
2040	Slow	12661	5651	3127	193	4973668	15745
	Moderate	21300	9053	8794	868	7164739	24225
	Fast	28344	13397	16444	1833	10019327	39218
2050	Slow	19581	9301	5586	414	9199969	29318
	Moderate	26009	12978	17877	2138	11032809	37947
	Fast	38426	20801	29778	4083	15015551	59953

3 Ibid.

Customer expectations and benefits

There are varied motivations for customers to invest in DER. This includes reducing the cost of their energy supplies, but there are many other factors, including a response to environmental issues and a desire for more control and independence. Irrespective of the specific motivation, customers expect affordability, security and safety.

There is also increasing expectation from customers that additional value can be derived from their investment in DER if they are able to trade excess energy or capacity with other users or participate in evolving markets. This potential has been recognised by emerging competitive service providers. These new service offerings allow individual DER owners additional value from their investment. This includes aggregation of DER to provide a service to the wholesale market and/or the provision of services to networks which, during times of supply shortfall, may have very significant value.

Customer expectations are also shifting as online and mobile retail experiences are becoming the new normal. This raises the expectations for a utility's operations. Combined with developments in device and building automation as well as energy management, this is creating new opportunities for customer service, benefits and new business streams. Ultimately, these lead to greater empowerment of customers, both business and residential.

The need to focus on end users and customers during this dynamic time is crucial. The ongoing value of the grid in supporting and delivering improved customer choice, value and personalisation of electricity products and services is essential.

The transformation of the system must be undertaken in a fair manner that provides better outcomes for all, not just those who can afford to invest in DER. When considering proposed future DER models, there will be a range of new players in the mix, with multiple parties developing and offering customers a suite of products and services.

These scenarios must not only consider added complexity for customers, but also consumer protections. To provide equitable access to the benefits of DER, a strong holistic market design, backed by a strong regulatory framework, will be imperative.

If we do not adapt and change the electricity system, we risk not being able to affordably provide what customers with and without DER want and need. A customer-oriented transition must balance key customer outcomes without jeopardising the underlying future electricity system.

Distribution network role and impact

Distribution networks and connected DER are part of an integrated system that must synchronise and operate effectively to maximise the potential benefits. Networks enable sharing of the diversity of DER investment by allowing system access to facilitate trading of energy and other services. The most efficient outcomes will be achieved through the effective integration and operation of the system. Achieving maximum benefits for customers relies on the value provided by networks.

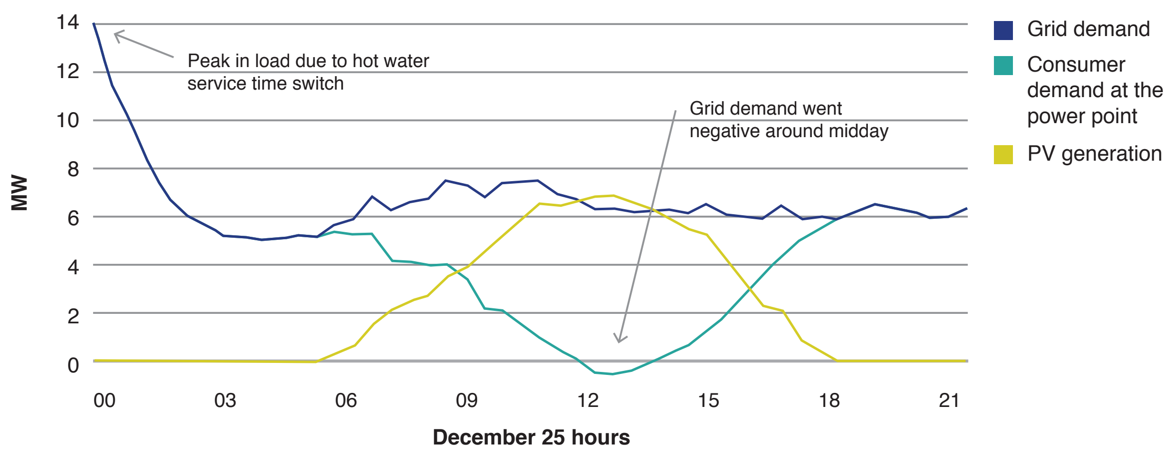
Distribution networks were not originally built to cater for grid-connected DER. They were developed to provide a connection for commercial and residential properties to large scale centrally-generated electricity. They were established on a set and forget basis and had minimal need for monitoring or control. The design of the distribution network was based on ensuring capacity to meet customer demand along their specific feeder and by the connection equipment. In addition, the technical performance requirements (such as quality of supply and voltage levels) were maintained within the required technical envelope, with demand requirements being relatively predictable based on standard usage patterns.

The introduction of high levels of DER connected to distribution networks has changed this paradigm. Distribution network flows have become much more variable and unpredictable and impose a much wider range of operating conditions on the networks than they were originally designed for. The expansion of solar and other distributed energy resources has changed the grid from one-way power flow to a system that now requires multi-directional flows that can fluctuate significantly within relatively short time periods. An example of how this alters the characteristics of the power system is illustrated in Figure 6 below, which shows reverse demand in South Australia at a transmission connection point during a low demand period due to high levels of DER penetration.

This has led to increasing difficulties in ensuring that the operation of the network is maintained within the technical envelope. Without monitoring or control, such deviations are not known and cannot be actively managed by the network operators.

In managing traditional distribution networks with one-way flow, there was limited need for control of the feeder as it was typically designed so that the range of anticipated voltage excursions did not exceed the allowable voltage limits. However, with increased distributed energy resources penetration, this is in many cases no longer possible without dramatic excursions outside the allowed voltage limits (with subsequent rooftop solar inverter tripping), unless dynamic control is implemented. A study by the Institute of Sustainable Futures in 2017 identified customer complaints of inverter trips due to voltage excursions on feeders in Victoria and rural NSW were due to voltage excursions correlated to a significant amount of connected domestic solar systems in the region[5].

Figure 6. Kadina East transmission connection point, Christmas Day 2014[4]



4 AEMO. 2018 Inquiry into Modernising Australia's Electricity Grid, submission 47. 2018. Available at www.aph.gov.au/Parliamentary_Business/Committees/House/Environment_and_Energy/modernelectricitygrid/Submissions

5 UTS: Institute of sustainable futures. 2017 Networks Renewed Technical Analysis. January, 2017. Available at www.uts.edu.au/sites/default/files/NetworksRenewedTechnicalAnalysis.pdf

This represents a significant impediment to the operation of DER and its ability to deliver the anticipated benefits from its investment. The connected DER is unable to operate effectively if the network operates outside its designed parameters. One consequence, for example, is that PV inverters may shut down in response to an abnormal local network condition and may not be able to restart.

Given the low level of monitoring and control implemented to cope with a relatively predictable operating regime, significant enhancement of these functions is required for the robust connection of distributed energy resources. This is needed for the safe technical range of the network's capacity and to allow for performance optimisation of the integrated network with its connected devices.

High levels of DER penetration can result in distribution networks becoming constrained. Given distribution networks' limited visibility, they are equally limited in capacity to manage constraints, so restrictions of DER output become necessary. In extreme cases, DER export ability may be limited as part of their connection agreement or connection could be rejected altogether to ensure that network performance is maintained.

Restrictions can significantly reduce the value of customer DER investments. This can result from the DER generation being unable to meet the customer's energy needs and/or unable to transfer excess energy to achieve value in other markets. For example, it may not be able to contribute to a demand response signal at the wholesale market level. At the extreme, if the DER is not managed to stay within the network's technical envelope, there is potential for widespread outages or even damage to distribution network and connected equipment. These constraints must be addressed to avoid restrictions on DER generation into the networks, loss of value to the DER owner and inefficiency for customers.

If the capability to monitor and actively manage DER is installed, it has the capacity to contribute to remedying these constraints. As a highly distributed resource it is possible for a DER system to modify power output or provide reactive power services that can address these technical issues. If this response is coordinated across a local network, relatively small manipulation of customers' DER can dramatically increase the hosting capacity of the network. This is known as DER optimisation.

Managing these distribution network constraints and the development of an improved operating framework is central to OpEN. This involves identification and management of the constraints over their entire life cycle and the framework must consider these components.

Risk of reverse demand

The risk of reverse demand/power flows associated with high rooftop solar adoption has been a growing national issue and was identified as a clear priority in the ENTR[6].

These findings were based on a review of the relationship between rooftop solar's share of total annual load at the zone substation and reverse power flows as a general indicator of other power quality issues. It was found that some reverse power flows occurred at 30 percent rooftop solar load but were common from about 40 percent of load. CSIRO then examined when each substation would potentially meet that threshold (during the period 2017 to 2050).

The modelling indicated that while South Australia was most at risk of reverse power flows, other states, or particular substations within a state (i.e. South East Queensland) were anticipated to increasingly face similar issues.

These findings have been updated as part of OpEN based on the latest NEM and WEM 2018 Electricity Statement of Opportunities (ESOO) data, with the results outlined in Figures 7, 8 and 9.

6 CSIRO and Energy Networks Australia. 2017 Electricity Network Transformation Roadmap: Final Report. April 2017. Available at www.energynetworks.com.au/sites/default/files/entr_final_report_web.pdf

The analysis has been considered under all three ESOO scenarios (i.e. slow, neutral and fast DER uptake). It indicates that zone substations in some areas of Australia, such as Adelaide and south east Queensland, have already met the threshold or will do so before 2025.

The speed of solar PV uptake will have a major impact on how quickly significant challenges emerge. Under the low uptake scenario, the remainder of the WEM and NEM will not have a significant share of substations over the threshold until around 2040. This aligns with the ENTR analysis.

Under the slow uptake scenario, 15 percent of zone substations hit 40 percent penetration by 2025; about one in every seven. However, under the fast uptake scenario this figure rises to 23 percent, almost a quarter of all zone substations.

This is slightly more pronounced in populated areas of the coast, but not exclusively so. Much of Queensland is red in the fast DER uptake scenario.

Figure 7. Updated 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'

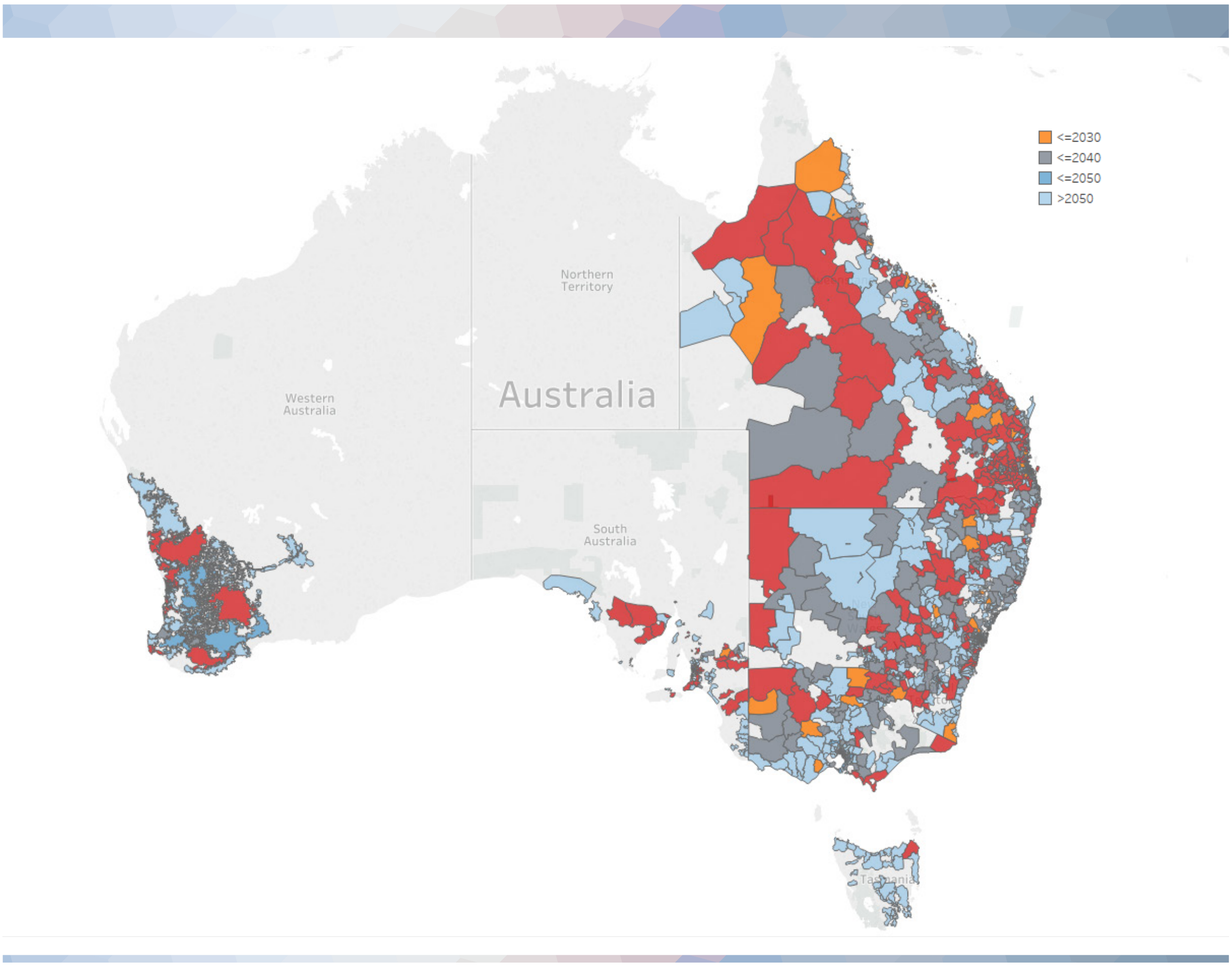


Figure 8. Updated projected decade in which the zone substations within each Australian postcode within the NEM and WEM will reach a threshold penetration of rooftop solar adoption (40 percent) indicative of reverse demand/power under the ESOO 'Neutral DER uptake scenario'

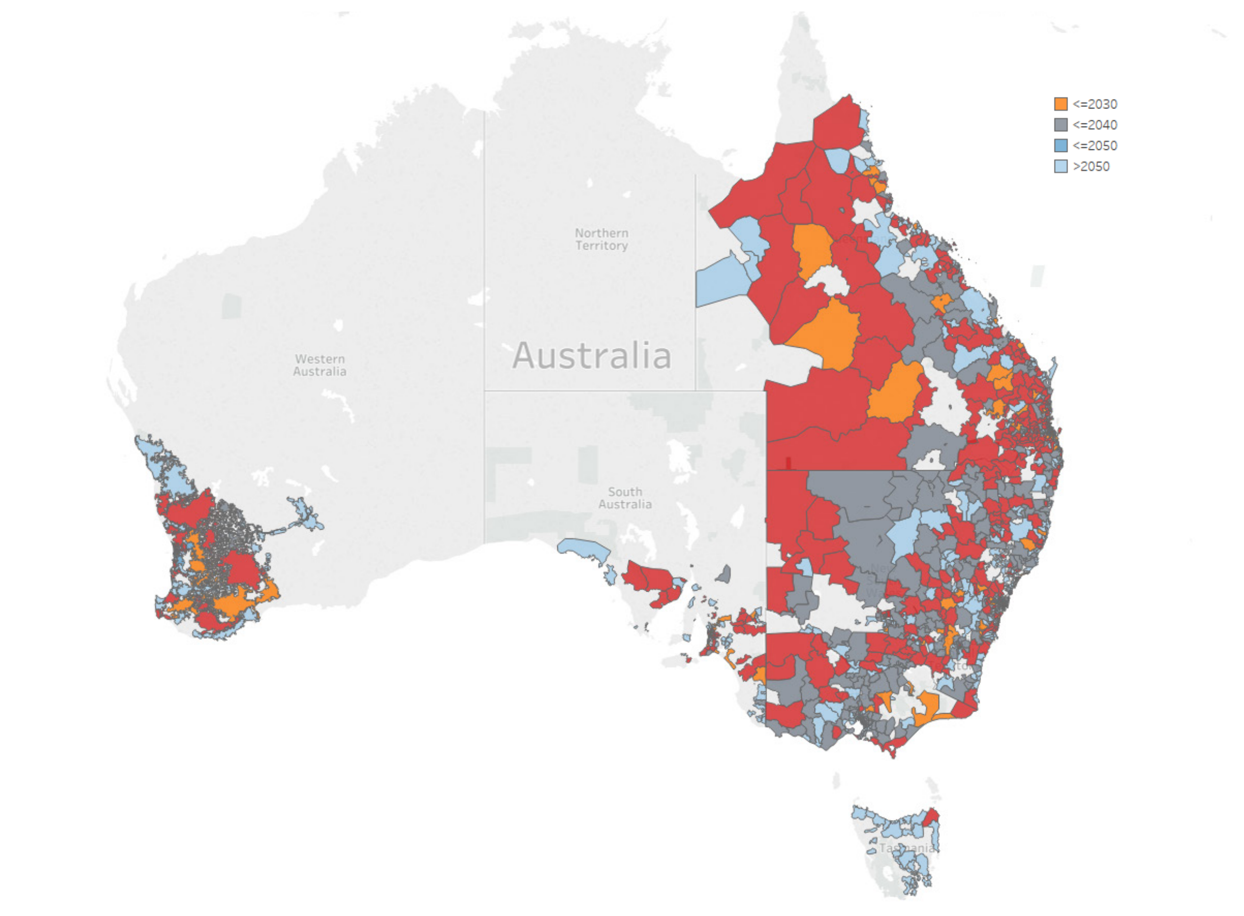
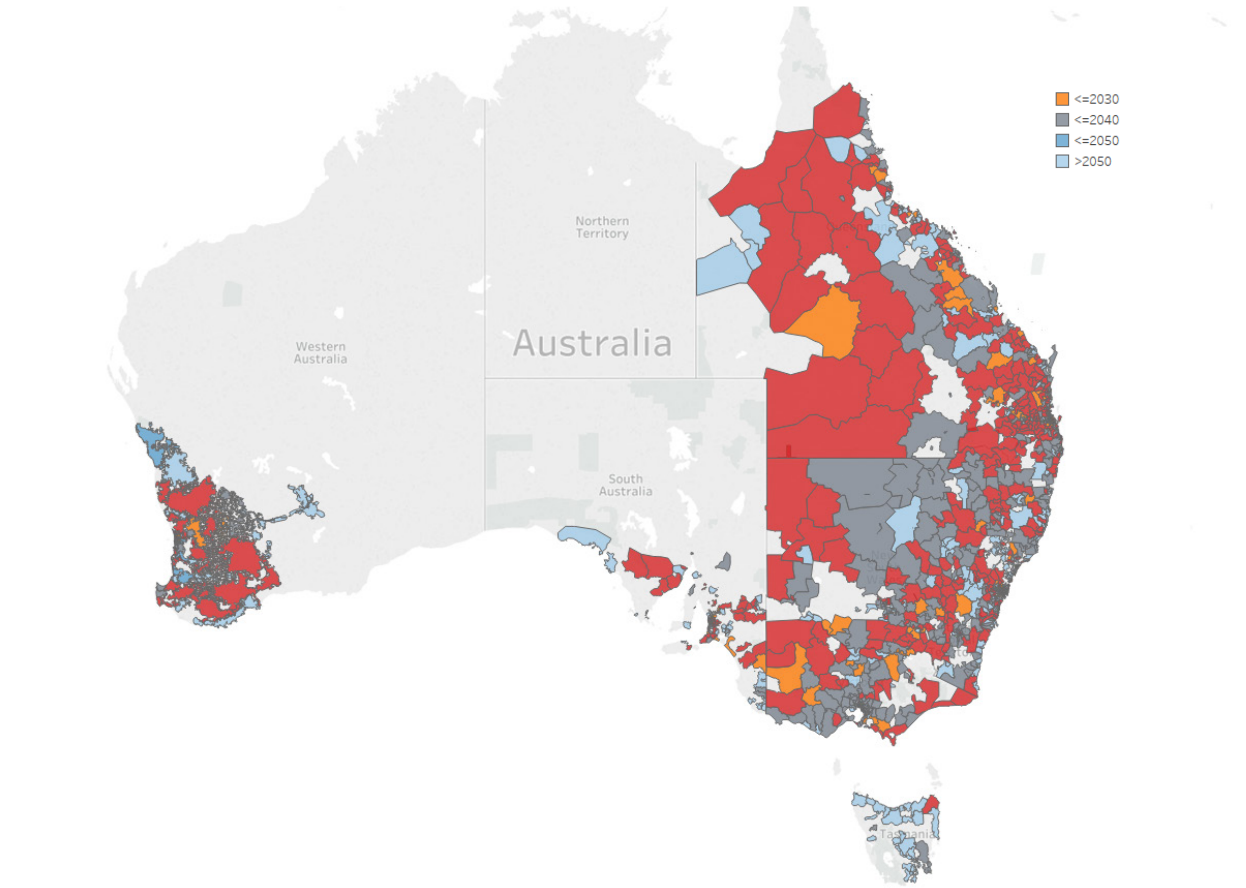


Figure 9. Updated projected decade in which the zone substations within each Australian postcode within the NEM and WEM will reach a threshold penetration of rooftop solar adoption (40 percent) indicative of reverse demand/power under the ESOO 'Fast DER uptake' scenario



System wide issues with DER

AEMO has published several reports on the wide-reaching implications for utilisation of DER. These reports have highlighted the opportunities and challenges associated with the continued integration of DER into the NEM and/or WEM. Real-world analysis demonstrating that system wide issues are already occurring can be found in AEMO's report[7] of August 2018 on the Queensland and South Australia system separation and AEMO's Integrating Utility-scale Renewables and Distributed Energy Resources in the SWIS report[8] published in March 2019.

These reports highlight that system security risks are emerging. This is because the increase in large-scale renewable generation and DER displaces the dispatchable thermal generators that provide system security services such as inertia, frequency control, system strength and voltage control. However, it was also noted in the most recent Technical Integration of DER report[9] that modern distributed PV and other DER such as energy storage are typically capable of advanced functionality which would better support system security. Some benefits of this advanced capability have been observed during system events and greater benefits could be realised via improved clarity and expanded capabilities defined in technical performance standards.

Ensuring access for DER

A primary objective of OpEN is to as far as possible, remove restrictions on the operation of DER. These restrictions limit the ability for DER to maximise value for its owner.

The distribution network constraints are depicted conceptually in Figure 10. These circumstances will differ based on the network, location (even within a small network area) and time.

Circumstantial differences are important when proposing a framework for DER operations in the NEM or the WEM.

The importance of well-coordinated DER

To access DER's full benefits, it must be well coordinated and resources properly optimised. Optimisation refers to the management of the real-time operation of DER, so that each customer's assets respond in a coordinated way to meet various system needs. This supports the essential power system needs for visibility, predictability and controllability.

While well-coordinated DER can bring significant benefits and reduce system costs, poorly coordinated DER growth could significantly increase system costs. For example:

» "Virtual Power Plants" of aggregated distribution connected resources could operate without regard for distribution network limitations, exceeding local technical limits and trigger a need for local network augmentation. The increased costs of network augmentation would be borne by all consumers.

» Managing large rapid ramps by aggregated price-responsive DER (in response to time of use tariff periods, for example) could require significant expansion of the frequency control reserves enabled by AEMO, increasing costs paid by market participants, including customers.

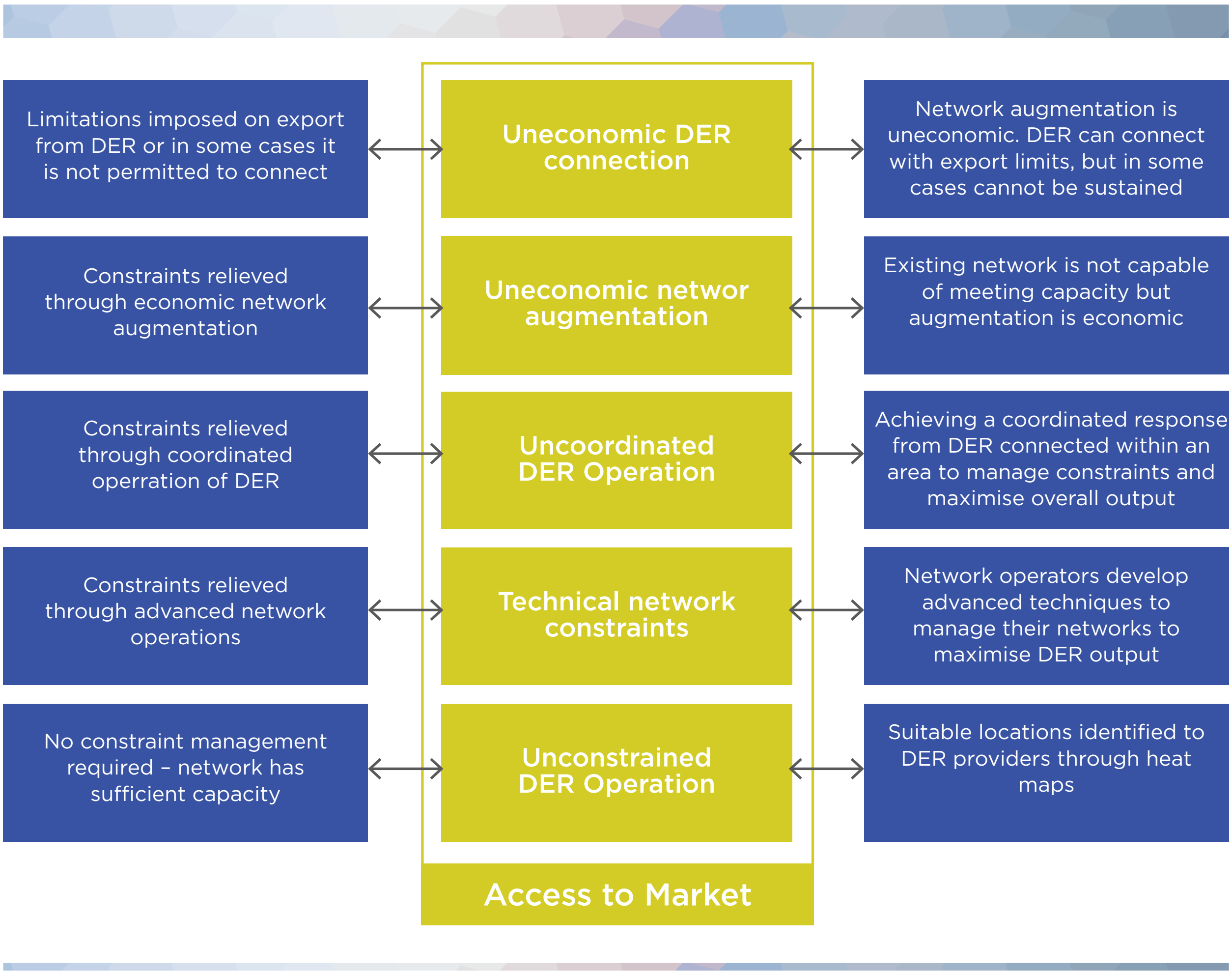
» In the absence of mitigation measures, ongoing growth in passive rooftop photovoltaics will progressively reduce AEMO's ability to maintain transmission network flows within secure limits. From the period 2025 to 2030, AEMO will no longer be able to maintain network flows from South Australia to Victoria within secure limits during emergency periods (such as following an unexpected network outage, severe weather, or bushfires). From 2030 to 2035, exports from South Australia will exceed secure network limits even under normal conditions. Growth in rooftop PV in other regions is likely to cause similar issues in the following decade.

7 AEMO. 2018 Queensland and South Australia System Separation Report. January 2019. Available at www.aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2018/Qld---SA-Separation-25-August-2018-Incident-Report.pdf

8 AEMO. 2019 Integrating Utility-scale Renewables and Distributed Energy Resources in the SWIS. March 2019. Available at www.aemo.com.au/-/media/Files/Electricity/WEM/Security_and_Reliability/2019/Integrating-Utility-scale-Renewables-and-DER-in-the-SWIS.pdf

9 AEMO. 2019 Technical Integration of Distributed Energy Resources. April 2019. Available at www.aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/Technical-Integration/Technical-Integration-of-DER-Report.pdf

Figure 10. Potential constraints for DER



These challenges, if addressed, can be avoided. Substantial benefits can be unlocked if DER is well coordinated and properly optimised. Growth in DER offers significant opportunity for the NEM and WEM by facilitating reduced system costs.

DER's growth also offers cost savings and value for customers, as well as enhancing system security and reliability. Alternatively, DER can become a significant burden increasing system costs.

Outcomes will be determined by the degree to which DER is coordinated and properly optimised in a well-designed framework.

3. Open Energy Networks models

Purpose of Open Energy Networks

The purpose of the Open Energy Networks project has been to engage with stakeholders and obtain general agreement that action is required to facilitate and manage the ever-increasing levels of DER within the distribution system. This consultation has focused on how best to transition to a multi-directional grid that allows better integration of DER for the benefit of all customers, including possible new market frameworks that will be needed to facilitate the future energy system.

The OpEN consultation process has worked with stakeholders to identify the required capabilities and actions to facilitate increased DER integration and provide the building blocks for any future market framework.

Consultation process

For this project to deliver the right outcomes, it has been essential to take into account considerations of all parts of the sector. Many stakeholders have remarked on the value of audience diversity, sector-wide representation and the unique tone of each workshop.

With the launch of the OpEN consultation paper in mid-2018, collaboration and feedback opportunities were invited through a comprehensive nation-wide series of workshops. These events informed the progressive building of the frameworks in response to industry feedback.

The consultation process to date has been designed to ensure stakeholder collaboration and alignment with the projects findings. Stakeholder feedback has been extensive since the project's inception, including 62 submissions in response to the initial paper. Consultation has continued to test components of the work program. This included co-design with stakeholders of key materials that underpin the recommendations of this report and these collaborative findings will inform the final OpEN report.

An example of our extensive collaboration with stakeholders is the OpEN issues register. At the 'functional specification' workshops, the OpEN team compiled a register of stakeholder concerns regarding the smart grid architecture models (SGAM) for each of the frameworks (see appendices for more detail). EA Technology extracted key issues from the register considered to be in scope of the future framework design and consolidated these in its report that accompanies this document. The SGAM models were published in March 2019 and these are key elements of the full framework cost benefit analysis currently being undertaken.

Discussion and testing of proposed actions that must be undertaken to help manage current integration of DER was another area in which we sought wide collaboration. Focusing on the required capabilities needed to underpin a future market platform, we considered network visibility requirements and export constraints and defined communication and data requirements for establishing and utilising operating envelopes to manage constraints and export limits. The development of the required capabilities and actions followed extensive consultation and the analysis undertaken by EA Technology.

A summary of the key outputs established from the OpEN stakeholder consultation to-date includes:

- Allowing for more DER integration into the grid, some level of intervention and optimisation of the system is required;
- Optimisation can occur at multiple levels including local microgrid all the way through to the transmission connection point, frameworks must allow for this;
- Consensus that better network visibility and hosting capacity information is of value to all stakeholders across the value chain (including household customers);
- Networks need basic requirements to have visibility and actively manage network constraints recognised within their network pricing reviews;
- Customer frameworks for incentive and benefit must be weighed against the need to supply all customers with energy at the same or lower cost.

International engagement

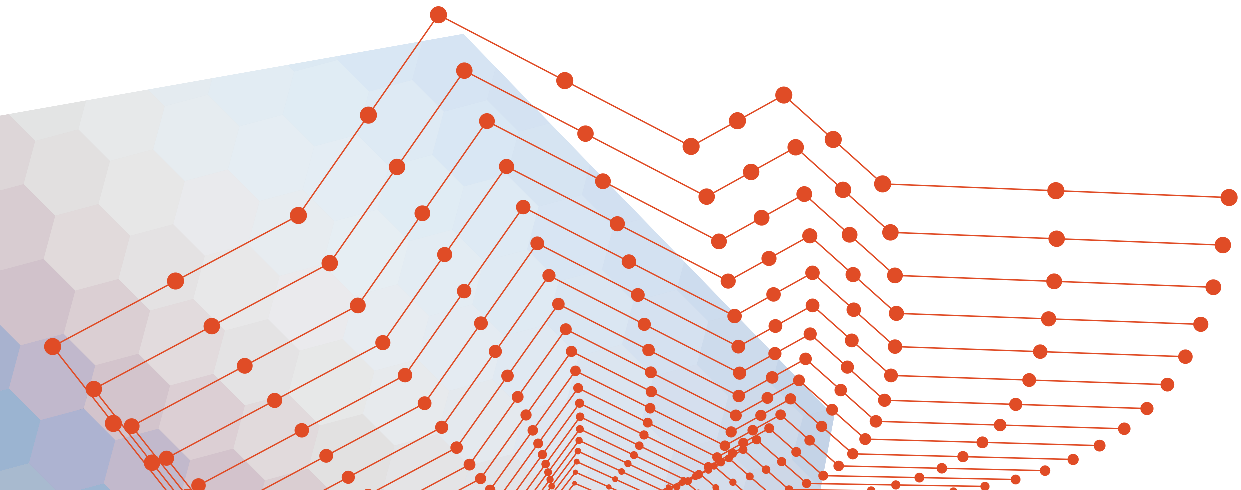
OpEN reviewed the design architecture for distribution system and transmission system operators (TSO) already occurring in other parts of the world and incorporated learnings into the design of our frameworks. A key example of this has been the establishment of a knowledge sharing arrangement between the OpEN project team and the UK's Energy Networks Association which is currently undertaking a similar project focused on a more flexible energy system. The Open Networks Project UK aims to give households, businesses and communities the ability to take advantage of a new range of energy technologies and services, including renewable generation, battery storage and electric vehicles. The UK's project will help customers take control of their energy and lower their costs.

Another key design element included in all the frameworks is the need to aggregate distribution level market bids for all services. This was revealed in a paper AEMO commissioned to support OpEN titled Coordination of Distributed Energy Resources; International System Architecture Insights for Future Market Design. This report synthesised current thinking on TSO-DSO market design and introduced three key concepts for the framework design of distributed optimisation for DER – see the table below.

Aggregation at the distribution level for all services follows from the first concept of layered decomposition, breaking problems down into sub-problems. This approach can solve the issue of tier bypass. Typically, distribution connected assets focus on the wholesale market without considering distribution level constraints or hidden coupling. An example of this is DER assets simultaneously bid to provide wholesale market and distribution network services.

Figure 11. Summary of international models

Principal	Description
Layered decomposition	Layered decomposition solves large-scale optimisation problems by decomposing the problem multiple times into sub-problems that work in combination to solve the original problem.
Tier bypassing	Creation of information flow or instruction/dispatch/control paths that skip around a tier of the power systems hierarchy, thus opening the possibility for creating operational problems. To be avoided.
Hidden coupling	Two or more controls with partial views of grid state operating seperately according to individual goals and constraints to be avoided. Such as simultaneous, but conflicting signals from both the Do and TO.



The Hybrid Model

The initial consultation paper detailed three frameworks (descriptions of the other three models can be found in the appendices)[10]. These were the subject of a number of workshops culminating in detailed smart grid architecture (SGAM) models which have been published.

A key outcome from the workshops was the development and inclusion of a fourth or hybrid model. This model evolved from stakeholder feedback throughout the consultation period and from the workshops of late 2018.

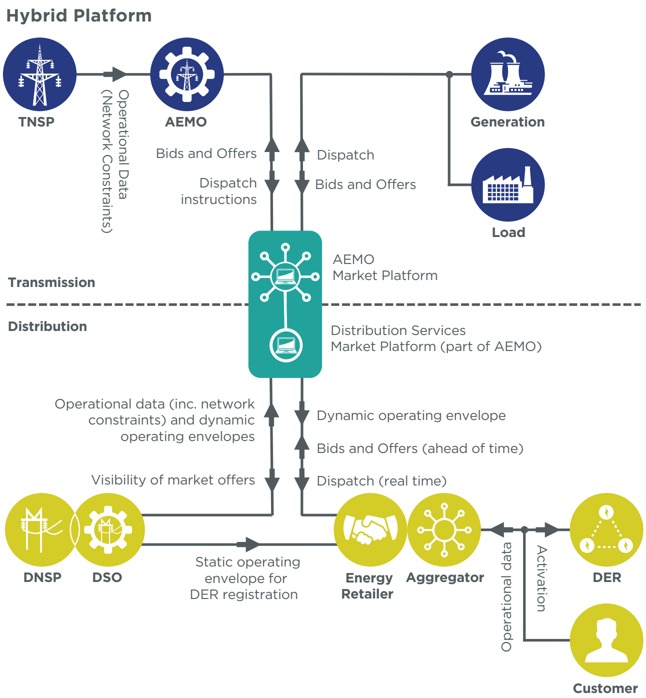
Feedback on the three models uncovered issues that could be potentially addressed with the inclusion of a new framework. The independent DSO was seen to be overly complex. The two-step tiered platform highlighted a perceived conflict of interest in the DNSP maintaining a technical operation role as well as a market clearing function.

Managing the market and the system at the transmission and distribution level was considered a lot to manage for one organisation in the single integrated platform.

In the hybrid model, the DNSP maintains a technical DSO function – managing and communicating distribution network constraints. AEMO manages a market platform that optimises all DER bids for wholesale, Frequency Control Ancillary Services (FCAS), network services and other identified market services.

This model will be assessed alongside the three identified in the initial OpEN consultation paper in a cost benefit analysis to be undertaken by Baringa consulting group – the consulting team associated with the UK's Open Networks process.

Figure 12. The Hybrid Model[11]



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

10 Energy Networks Australia and AEMO. 2018 Open Energy Networks, Consultation Paper. June 2018. Available at www.energynetworks.com.au/sites/default/files/open_energy_networks_consultation_paper.pdf

11 Ibid.

Cost benefit analysis

The CSIRO was engaged to complete a high-level cost benefit analysis of the need for distributed optimisation. This report builds on work undertaken as part of the 2017 Energy Transformation Roadmap. This work also considers UK-led projects and the SA Power Networks regulatory submission based on investment in distribution network monitoring and DER integration.

The report finds that while broader approaches may offer a variety of potential gains, a key benefit is avoiding costs in generation, transmission and distribution. The direct costs will be information technology, administration (labour) and various transaction costs. Baringa Consulting will undertake further work on costings to be delivered in the next phase of the cost benefit analysis. The project will estimate when these costs and benefits occur over time for each DER integration model to determine the optimal one to implement.

The CSIRO report concluded that based on studies to-date, a reasonable estimate of the cost of DER integration for an Australia-sized electricity generation system may be $600 million to 2030 and $1 billion to 2050 (on a net present value basis). After taking into account the avoided costs, the overall net benefits estimated by existing Australian studies are about $1 billion by 2030.

Stakeholder feedback demonstrates a lack of consensus on the trajectory of DER uptake and network investment. To address this, a further piece of work on the analysis of a base or reference case will be published by the CSIRO. This will ensure we capture all stakeholder views and have an agreed position to anchor the cost benefit analysis. With this information, final recommendations will be made regarding the OpEN model market frameworks.

Functions and activities

The OpEN project identifies and defines 13 high-level functions for developing the key capabilities to progress distributed level optimisation. These functions were introduced in the consultation paper and were updated to incorporate stakeholder feedback.

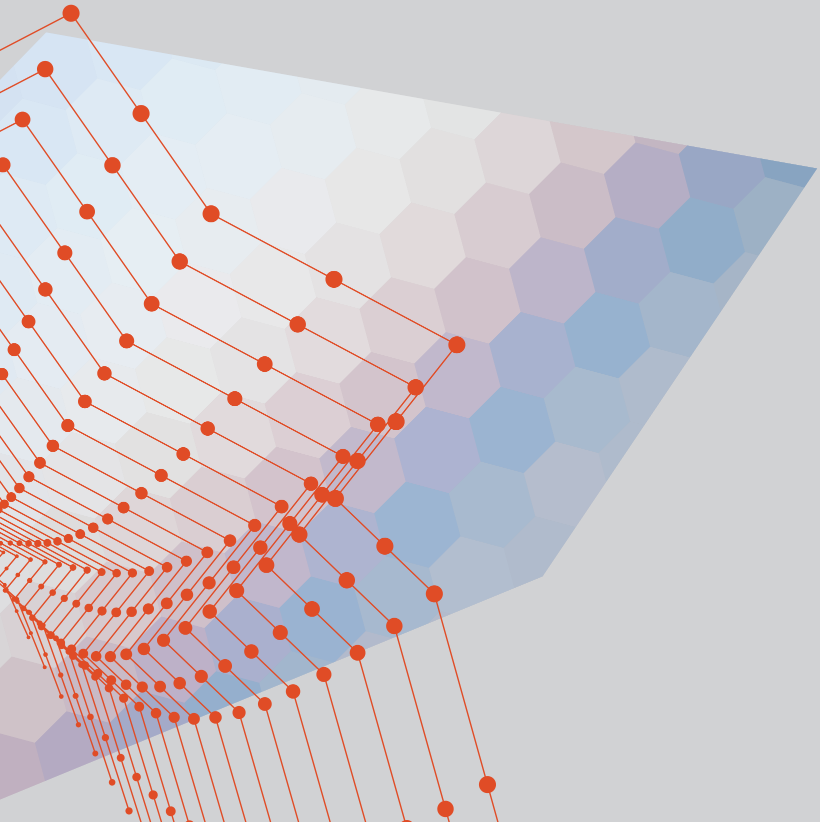
At the industry workshops, the four DSO frameworks were explored and defined within the context of the 13 functions. We considered the requirements for improvements of DER integration irrespective of which model framework was ultimately pursued. Figure 13 summarises these DER optimisation functions.

Figure 13. Summary of DER optimisation functions and associated activities

Function	Activities
1. Distribution system monitoring and planning	Gather network data
	Network planning and investment
2. Distribution constraints development	DER engagement
3. Forecasting systems	Forecast short-term network state
4. Aggregator DER bid and dispatch	Engage with DER to create aggregator portfolio
	Aggregator bilateral reserve contracts
	Aggregator market engagement
5. Retailer DER bid and dispatch	Engage with DER to create retailer portfolio
	Retailer bilateral reserve contracts
	Retailer market engagement
6. DER optimisation at the distribution network level	Optimise operating envelopes of distribution network end-customers
	Aggregation of wholesale and FCAS market bids
7. Wholesale - distributed optimisation	Update market dispatch engine
	Determine dispatch schedules for bilateral Reliability and Emergency Reserve Trading (RERT) contracts
	Receive transmission network requirements and market offers
	Receive distribution network market offers and run dispatch engine
8. Distribution network services	Smart grid network solutions
	Bilateral reserve contracts for D-network support and control ancillary services
	D-network market engagement for network support and control ancillary services
9. Data and settlement (network services)	Settlement of bilateral contracts for network services
	Settlement of NSCAS market
	Dispute resolution (network services)
10. Data and settlement (wholesale, RERT, FCAS and SRAS)	Settlement of bilateral contracts for Reliability and Emergency Reserve Trading (RERT)
	Settlement of wholesale, FCAS and SRAS markets
	Dispute resolution (wholesale, RERT, FCAS and SRAS)
11. DER register	Establish, maintain and publish or share DER register data
12. Connecting DER	Determine the regulatory framework for connections
	Connect DER assets
	Manage DER connections
	Contribute to DER register
13. Network and system security with DER	Asset security
	Distribution network security for high impact events
	Distribution network security under localised market failure
	Whole system security
	System restart

Full descriptions of the functions and their associated activities can be found in the EA Technology Open Energy Networks Report[12].

12 EA Technology. 2019 Open Energy Networks Report. July 2019. Available at www.energynetworks.com.au/reports-and-publications



4. The required capabilities

Establishing the required capabilities for Open Energy Networks

OpEN is investigating the high-level functionality required in a world of increasing levels of DER. Consultation with stakeholders to-date has identified required capabilities across all frameworks. These requirements are key enablers for whichever path is taken in facilitating a high DER future.

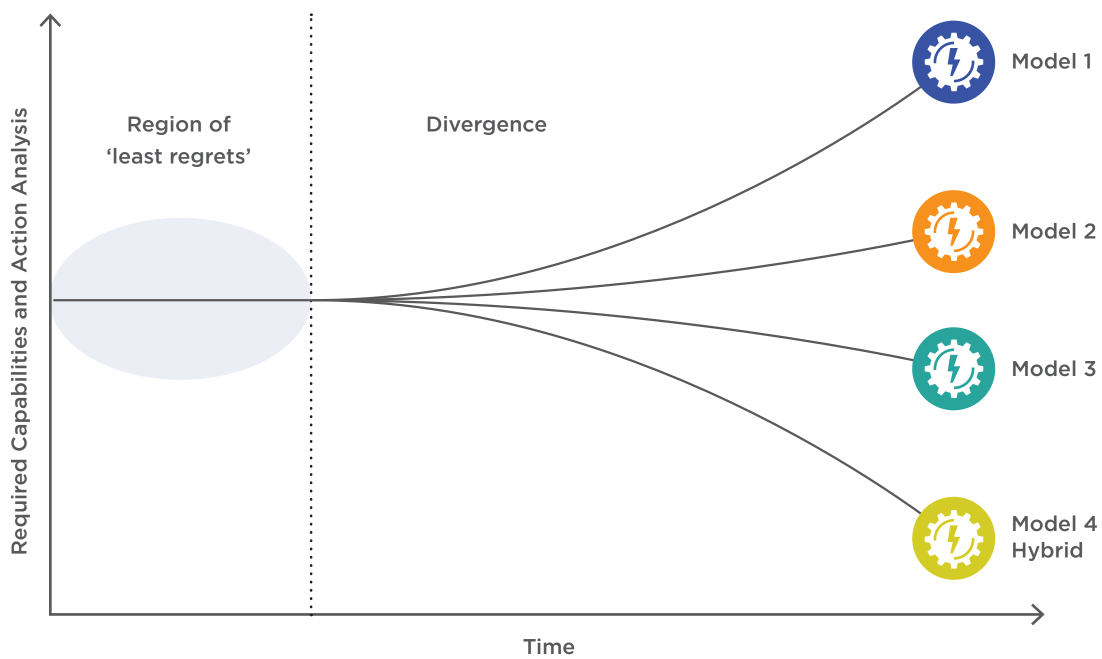
Required capabilities must be developed as a priority to clear the way for wider DER optimisation. By laying the foundations of a framework, the industry will be well positioned to progress towards a DER optimisation network-market model.

The identification of required capabilities and actions is an opportunity to be strategic about the development and implementation of the transition to a smart, flexible energy system.

In developing this report, we have considered a number of areas of work including the analysis undertaken and outlined in the EA Technology Open Energy Networks Project report and all feedback received from stakeholders to-date. Our work is informed by evidence and analysis undertaken by the CSIRO.

Given the scale of potential areas for development, we have had to prioritise work areas aligned with stakeholders' identified preferences. This report details the approach that has been applied to program modelling and evaluation.

Figure 14. Illustrative example of required capabilities and actions analysis



Required capabilities to enable Open Energy Networks

Required capabilities are the ability of a DNSP to improve network visibility, define network constraints or operating envelopes and communicate these to aggregators, retailers, owners of DER and AEMO.

Three areas of required capabilities are key to the industry's transition from its current capacities to those of any future optimised DER world. They are:

1. DNSPs defining network visibility requirements and network export constraints.
2. Defining communication requirements for operating envelopes.
3. Establishing an industry guideline for operating envelopes for export limits.

In order for the required capabilities to optimise DER while minimising negative impacts for the grid and delivering maximum benefit to customers, each of the capabilities listed above have a series of enabling actions.

An underlying premise of Energy Networks Australia's and AEMO's future vision for DER optimisation is the use of operating envelopes. Operating envelopes indicate to customers the export and/or import limits that they must operate within for the safe and secure running of the network. To do so, data needs to be collected in real time. Algorithms are then defined on the network state, based on the data. Constraints as determined by these algorithms should be communicable, based on standard protocols.

Initially, operating envelopes may be static and determined through an examination of the long-term network constraints. However, as network visibility is enhanced, operating envelopes may be calculated at shorter timescales, becoming dynamic.

Figure 15. Required capabilities and associated milestones

MILESTONE 1: DNSPs defining network visibility requirements and network export constraints

- Define DNSP requirements for increased network visibility to maintain network operations within required parameters
- Define how to achieve increased network visibility to maintain network operations within required parameters (operating envelopes)
- Establish an iterative and targeted approach for the timing of investments required to provide network visibility to maintain network operations within required parameters

MILESTONE 2: Defining communication requirements for operating envelopes

- Define protocols for operating envelope communication
- Establish a Australian standards and/or guidelines to support the establishment of operating envelopes
- Define data access permissions

MILESTONE 3: Establishing an industry guideline for operating envelopes for export limits

- Develop an Industry guideline that outlines the requirements and use of operating envelopes

MILESTONE 1:
DNSPs defining network visibility requirements and network export constraints

Network visibility: All future scenarios indicate the involvement of third parties in a variety of roles interacting with the grid in real time, responding to price signals or operational incentives. This functionality requires real time access to monitoring data, giving rise to the requirement for a cheap, reliable and open data, monitoring and communications platform.

This platform can be used to provide various information, including operational data, that may assist in providing more transparent information to AEMO on the real time and forecast operation of the distribution network interface.

The data required to build a picture of the network first must be defined and a source identified. Where AMI meters are abundant, (i.e. Victoria), the data may already be available. However, a picture of the network state may be combined with a disparate data set depending on the level of granularity required by the network operator, the relative strength of the network and the activity of DER and customer load profiles. However, increasing amounts of data may be needed when making accurate predictions about connection level operating envelopes in something approximating real time.

Networks are already focused on network visibility improvements, collecting data from a variety of sources. Two ARENA funded projects are focused on improving data use to help understand the network and increase its hosting capacity. The first project, Increasing Visibility of Distribution Networks to Maximise PV Penetration Levels, led by The University of Queensland, aims to provide a better understanding of the operational conditions of networks. This work considers the application of a proven state estimation technique (SEA) that generates an estimate of networks' operational conditions.

An ARENA funded initiative called the "EVOLVE" project is run by the Australian National University and ZepBen working alongside utilities in Queensland and NSW. This project looks to use data from a variety of sources (including the DER installations themselves) to calculate the operating envelopes for DER assets and understand how they may be constrained under different circumstances. This involves:

- Development of a live (and forecast) reference model for the low voltage (LV) segment of the grid. This will include the as-switched network model and the current and forecast operating state of connected DER and virtual power plant (VPP) assets.
- Development of a live (and forecast) reference model for the medium voltage (MV)segment of the grid. This will include the as-switched network model and thecurrent and forecast operating state of any connected assets.
- Applying the LV and MV references models to calculate the operating envelopes for each NMI endpoint using a combination of techniques drawn from mathematical optimisation, optimal power flow analysis and power systems analysis domains.

The ability of operating envelopes and application programming interfaces (APIs) to share information is the Evolve project's ultimate aim. This is also one of the key outputs of a third ARENA funded project, the SAPN VPP project, and work is underway to ensure that these processes are aligned.

In addition, in order to provide contingency FCAS, AEMO with the AER and AEMC, has launched the VPP Demonstrations Program.

This includes an API for VPP proponents to provide operational forecasts and work is underway to ensure that this API is commonly defined to allow for multiple uses. A common data set will be required for any participant in a future set of distributed markets, as well as the NEM. More information on the VPP Demonstrations is included later in this paper.

Figure 16: The actions required to deliver Milestone 1

MILESTONE 1:
DNSPs define network visibility requirements and network export constraints

Define DNSP requirements for increased network visibility to maintain network operations within required parameters

- Establish what information is required
- Establish what time frames data is required
- Establish where the data needs to come from

Define how to achieve increased network visibility to maintain network operations within required parameters (operating envelopes)

- Define minimum technical requirements and system specifications for enhanced visibility, communication and co-ordination between the DER and DNSP/DSO
- Define new operating envelopes for export limits stablish new minimum technical requirements for information, data and communication architecture

Establish an iterative and targeted approach for the timing of investments required to provide network visibility to maintain network operations within required parameters

- Evaluate if customer losses are likely to outweigh network costs and therefore scope the case for a future network project
- Define methodology of obtaining operating envelopes for network data
- Review current methodology for calculation operating envelopes for export limits
- Establish the methodology to calculate network constraints and develop the operating envelope from the technical network data.

MILESTONE 2:
Defining communication requirements for operating envelopes

Active network management: Far greater levels of monitoring and control will be required to allow active management of the distribution network to meet its increasingly complex operational needs.

There is a significant amount of preparatory work and support needed to develop the optimisation methodology and for distributed monitoring and control devices. This will require consistent, open and flexible systems, with suitable communications and open standards to permit participation of new market entrants. This decentralised intelligence should be developed to operate as a key part of a hierarchical scheme that facilitates effective control at higher voltage levels. The system must provide additional flexibility and control at the interface with the transmission network and the wholesale market.

To enable this, approaches and protocols to manage and exchange information between networks, distributed energy resources participants, aggregators and AEMO must be established. Effective coordination of the system in real time and full interoperability needs to be built, as outlined in Figure 17.

To support these approaches, minimum technical standards are required. The development and adoption of open standards and protocols aligned to international standards (where possible) is necessary. Information, data and communication systems or electric vehicle integration require the highest levels of security maintenance.

An accelerated timeframe is critical, due to the ever-increasing levels of DER connecting to the system.

Figure 17: The actions required to deliver Milestone 2

Milestone 2: Defining communication requirements for operating envelopes

Define protocols for operating envelope communication

- Determine the appropriate format (e.g. syntax, semantics) of the data and its transmission method
- Establish agreement across all industry stakeholders regarding the form of data and systems

Establish a Australian standards and/or guidelines to support the establishment of operating envelopes

- Develop or adopt an Australian Standard on data management frameworks/ protocols
- Develop or adopt an Australian Standard on communication protocols/frameworks
- Develop or adopt an Australian Standard on cyber security
- Develop or adopt an Australian Standard on control system protocols
- Develop or adopt an Australian Standard on interoperability

Define data access permissions

- Establish agreement across all industry stakeholders regarding access arrangements to data and systems

MILESTONE 3: Establishing an industry guideline for operating envelopes for export limits

Consistency of approach - The final milestone (Figure 18) focuses on the development of an industry guideline. A nationally consistent approach to how networks establish and communicate the operating envelopes to other relevant parties is vital. This must include a review and compliance program as the ability to move to real-time calculation and use of operating envelopes is established.

The rules and regulatory approach to the use of operational envelopes must be considered, likely by the AEMC in its annual review of the network regulatory framework.

Figure 18: The actions required to deliver Milestone 3

MILESTONE 3: Establishing an industry guideline for operating envelopes for export limits

Develop an Industry guideline that outlines the requirements and use of operating envelopes

- Establish an agreed framework and principles for Australian Network Service Providers to for identification of network constraints, the establishment and communication of operating envelopes
- Establish an industry guideline for operating envelopes based on the agreed framework and principles and the technical requirements identified in Milestones 1 and 2.

Key benefits from delivering required capabilities

The benefits associated with the delivery of the required capabilities system include:

Accommodating all generation and storage options. By establishing the required capabilities and optimising how Australia's power system is integrated and functions, the full value of all generation (including distributed energy resources) and storage options at the grid and household scale can be unlocked. This may include system aggregators with an array of generation systems.

Providing power quality and reliability. By fulfilling the required capabilities, a platform for reliable electricity supply with fewer and briefer outages, cleaner power and self-healing systems can be established. This will be accomplished with the use of digital information, automated control, and autonomous systems, with distributed generation sources changing the traditional network reliability paradigms.

Optimised asset utilisation and provision of operational efficiency. The required capabilities will enable network assets to operate and integrate well with other assets, maximising end to end efficiency and reducing costs.

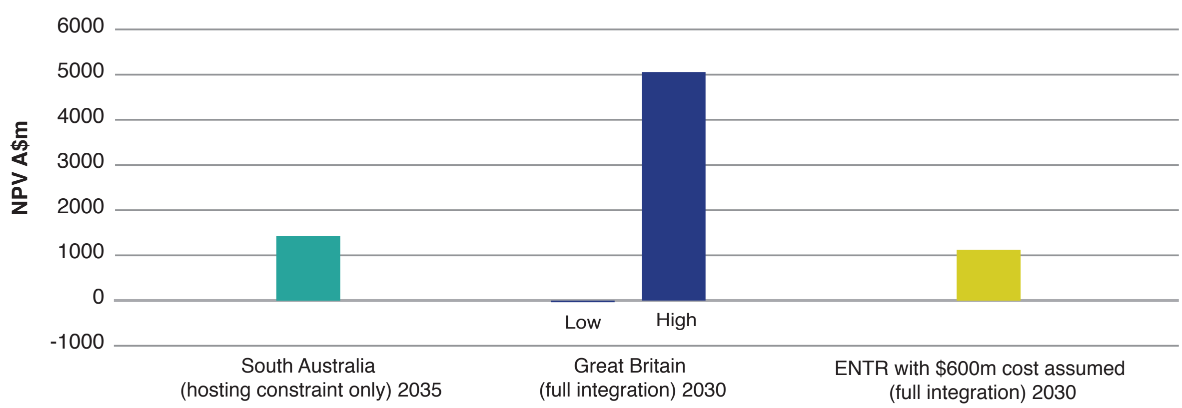
Anticipating and respond to system disturbances. By establishing the required capabilities, the grid is better placed to independently identify and respond to system disturbances with mitigation. Further, network operators will be able to establish predictive analysis to identify issues, initiate corrective actions, react quickly to electricity losses, and optimise restoration times and costs.

Enabling new products, services, and markets for customers. The required capabilities are the first step in building a platform that enables market systems to provide cost benefit trade-offs to third party participants and customers by creating opportunities to bid for competing services.

Net benefits of the required capabilities

As part of the Open Energy Networks program, the CSIRO was engaged to undertake cost-benefit analysis to estimate the potential net benefits if the required capabilities were implemented. The figure below (extrapolated from detailed work undertaken by SAPN) indicates how much value can be released if just these capabilities were enabled.

Figure 19: Estimates of the net benefit of DER integration (partial or full) in 2030 or 2035 normalised to an Australian-sized electricity generation system[13]



13 CSIRO. 2019 Review of cost-benefit analysis frameworks and results for DER integration: Input to AEMO and ENA Open Energy Networks project. April 2019.

This modelling was extrapolated from three primary sources of existing cost-benefit analysis data; the SAPN business case for LV management, the ENTR and the UK Energy Networks Association's (ENA) Open Networks. Although there are different features of these studies which make the data challenging to directly compare, with some adjustment CSIRO was able to model potential benefits for the Australian market.

This modelling indicates that by providing the required capabilities (network visibility and communications etc.) more than $1 billion dollars in benefits could be delivered by 2035. The full integration outlined in the 2017 Electricity Network Transformation Roadmap also identified about $1 billion dollars in benefits.

The CSIRO analysis considered that the UK ENA's Open Networks estimates were in higher range of slightly negative to $5 billion in 2030 NPV terms. This is due to many of the benefits of DER integration bound to the pace of that country's greenhouse gas emissions reduction program and associated increasing shares of variable renewable electricity.

The CSIRO's framework for the calculation of costs and benefits was tested with stakeholders to develop models to qualify the cost and benefit of each of the frameworks identified in OpEN.

The value proposition for integrating DER focuses on four separate areas of benefit:

» System and market – reduced need for duplication of balancing services and network support services (SA FAC market outcomes from HPR);

» Transmission infrastructure (offset further investment or greater utilisation of the infrastructure);

» Distribution network – less augmentation required if DER can be optimised;

» Generation – reduced need for generation investment, especially in storage assets where customer DER can be utilised.

Feedback throughout the engagement process has shown significant support for these recommendations of required capabilities.

Implementation of required capabilities - an iterative and targeted approach

Establishment of the required capabilities is critical in enabling the integration of DER into the grid and will be required whichever OpEN framework is ultimately pursued. However, the required capabilities can be delivered incrementally.

A key theme of the workshops backed up by the analysis by EA Technology is that the roll out of DER across Australia is not homogenous. The roll out of the capabilities required for optimisation does not need to be undertaken in a single deployment but could be scheduled on a needs basis as thresholds are met.

The table below details a recommended approach. In strong networks with low penetration of DER there is a case for continued operation. However, in networks with high and medium penetration, the minimum monitoring requirements should be put in place. Optimisation should be considered where networks may already be showing signs of stress – i.e. operating at voltage limits from time to time. (See Chapter 2 'Risk of Reverse Demand') With the introduction of VPPs as well as to assist in the deployment of EV charge infrastructure, network limits may be met even at low to medium levels of penetration of DER. These installations may be optimised to operate at economically opportune times.

Figure 20. An iterative and targeted approach to the rollout of the required capabilities

DER penetration	Low Hosting Capacity (< 20%)	Medium Hosting Capacity (20% - 40%)	High Hosting Capacity (> 40%)
DER Low < 20%	Monitor	Operate (as today)	Operate (as today)
DER Medium 20% - 40%	Optimise	Monitor	Operate (as today)
DER High > 40%	Optimise	Optimise	Monitor

5. Recommended actions

The OpEN consultation paper (2018) detailed potential pathways which could be pursued to develop a market framework for DER and the distribution network.

These pathways highlight the differences between each of the frameworks. However, as outlined, there are common elements that will be required irrespective of which pathway is taken to enable the integration and optimisation of DER within the distribution system.

In addition to the required capabilities, a number of common actions were identified that must be addressed in the short and medium term.

The EA Technology Open Energy Networks Project report highlighted 11 recommendations that either enable or trial foundational arrangements of any of the four frameworks to operate in the future. These actions underscore the urgent need for a new distributed market approach to the way the system and market is managed. The customer's interests must be at the core of changes. First, the customer message for owners of DER needs to be clear. If we want customers to provide their DER for the benefit of the network, system or market, arrangements must be clear and customers must have access to fair prices for services provided.

Analysis of the models' outputs and stakeholder feedback informs us that customer-centricity is vital in transitioning to a future where the distribution network and DER are integrated and optimised. The enabling actions are outlined below.

Customers are the key to a distribution services market

Recommendation 1: Simple messaging of customer benefit – for those with DER and those without

Key feedback received during the Open Energy Networks workshops highlights that the customer needs to be central to any framework design.

The benefits of distribution level optimisation must be successfully communicated to ensure that all consumers recognise the benefit of investing if we are asking for investment. The proposition must be clear: that services from customer-owned solar and batteries should be utilised to lower the cost of supply for all consumers.

Customers driven by subsidies, high energy prices and climate change will continue to invest in solar, batteries and control devices such as smart thermostats or EV chargers. While these investments lead to a decreased reliance on grid supplied energy, they are rarely sufficient for a customer's exclusive self-supply.

A typical solar PV unit would provide only 30-50 percent of a customer's daily load. The addition of a battery would increase that percentage, but also could provide a series of other services, such as peak generation or demand response for the wholesale market, reserve capacity for the system, or reactive power for the network. These services could help lower costs for all customers by avoiding the need for purpose-built generation or network assets.

Once investment in integration of DER into networks and the system is made, there is capability that can be utilised for a variety of purposes. This includes incentivising customers, or potentially utilising technologies which today are not even considered viable, for example, EV Vehicle to Grid (V2G), distributed hydron production and local diurnal storage.

The role of the aggregator in the distribution services market

Recommendation 2: Define the role of the aggregator and the services it will provide

The workshops highlighted the important role of the aggregator or the retailer in the operation of any distributed market. There is industry-wide confusion surrounding the role of the aggregator and the services it is supplying to markets and networks. This role is not the same as that of a retailer. The retailer manages the risk of high wholesale prices for retail customers. An aggregator's role in the distributed market will be to pay a customer for the use of their DER investment. Of course, any new role will need to be balanced against the need to maintain existing customer protections such as hardship and retailer of last resort provisions. There are consumer laws that legislate services to customers in relation to their DER. These considerations may accord with those the AEMC is reviewing in its examination of regulatory frameworks for stand-alone power systems (SAPS) or wholesale demand response.

The SGAM models determined that all frameworks require DER optimisation. This will ensure that connecting customers to network and market platforms creates additional value for DER owners while ensuring the networks are supported. Customer advocates and aggregators of DER are crucial to this optimisation. There is no reason an existing retailer could not provide this service.

There is a view that the rules as they stand today do not fully describe the aggregator or the services it provides that could create additional value for DER owners. A review of the rules with a defined aggregator role and services in mind will determine if any changes are necessary. A clear articulation of the aggregator's role, obligations and relationships with registered participants is required, in addition to the development of connection and technical standards for DER.

To some degree, the set of wholesale demand response rule changes before the AEMC are expected to shed some light on the future arrangements of a market-facing role for aggregators of customer services. In addition, the VPP demonstrations and other trials may also highlight the need for further regulatory changes.

The aggregator will be vital to the operation of any future framework as this role will communicate with the DSO or any future DMO. The aggregator will likely take on responsibilities usually associated with generators in the current market. This may include provision of data on activity, bidding and meeting dispatch targets, or penalties when they do not. Aggregators will need to use standardised protocols to communicate the activity of the DER and potentially send dispatch instructions to the DER itself.

Further to the role and relationships of the aggregator, the need to ensure that these new services can create additional value for DER owners is critical. As networks become increasingly aware of their capacity, it is important for the industry to define the suite of products and services required by these future DSOs to manage the energy system. DER optimisation can only be realised if system and network needs are understood and if markets have been developed to procure products and services. A well-prepared market will allow registered participants to develop a portfolio of customers for their services and products.

This is an early action required to ensure aggregators have the required infrastructure if they are to provide services in a new distribution services market.

Recommendation 3: Define aggregator, customer and product or service relationship

Following the development and understanding of the services, products, roles and relationships with aggregators and other registered participants, there will be a need to develop customer portfolios to provide products and services. This is already occurring in parts of the system and within networks. It is critical that the industry is developing these portfolios of customers and making the required adjustments to them as more clarity is gained.

The Behind the Meter Code^ developed by a consortium of consumer groups and the Clean Energy Council includes a list of products and services for customers of DER.

This code defines products and services as anything that stores, generates, monitors or trades energy. The code includes solar, batteries, microgrids, demand response devices and programs as well as stand-alone power systems, electric vehicle charging services, power purchase agreements and repair and maintenance of any DER installation.

This broad definition needs to be overlayed with what we expect the future system and network requirements for energy, power, voltage, frequency or other services might be. This work should be done with a wide group of collaborating stakeholders to ensure all customer and technical requirements are captured. Considered in this work should be customer incentive and customer equity. DER owners will likely need to be incentivised to provide services and the framework for how these costs are recovered and from whom will need to be developed.

Industry collaboration to improve network and demand forecasting

Recommendation 4: Aggregators, retailers and market customers provide improved load and generation forecasts

Accurate forecasting of load and generation at all levels of the system will be crucial in the operation of any of the frameworks of a distributed market and an optimised distribution network. As aggregators and retailers amass portfolios of customers who own DER to provide distribution market services and products, there will be a new obligation to collaborate with networks and the system operator to ensure long-term and short-term forecasts are updated. While this may already be occurring through initiatives such as the previously mentioned ISP, a review of the current arrangements will be needed to determine if they are fit for purpose in an increasingly distributed energy market.

Recommendation 5: Create Joint transmission and distribution investment plan

The first AEMO Integrated System Plan (ISP) published in 2018 was the first step to compiling a joint investment plan. It continues to gain traction. The ISP was drafted following the final Finkel Review in June 2017. The plan is an increasingly important document that ensures planning for new services and products address both distribution and transmission networks. The plan ensures system investment requirements for distribution and transmission networks can be made concurrently.

As noted in the ISP:
"The High DER scenario shows the potential for even greater use of DER to lower the total costs to supply, with the NPV of wholesale resource costs reduced by nearly $4 billion, compared to the Neutral case. In this scenario, the projected need for utility-scale investment and intra-regional transmission development to provide access to the incremental REZs is reduced, however it still illustrates the need for greater increased national transmission capacity to take advantage of diversity and better utilise dispatchable resources.

The analysis in the ISP only addresses wholesale level costs, and further work is required to quantify the overall value of DER to consumers. This will require markets which support efficient integration of DER and changes to the distribution system, including system management tools and market interfaces, to maintain security, reliability, and power quality with increased DER."

These joint investment plans will need to address some of the network and system operation issues relating to high DER penetration. These are likely to include under frequency load shedding, behaviour of DER during disturbances and the role of DER in a system restart scenario.

As the distribution network becomes more important for security as more controllable assets are installed, there will likely be further work to understand if and how the distribution network needs to be augmented to allow for DER to operate for the benefit of the system. This could be viewed as analogous to the transmission planning work in the ISP and might suggest where interconnectors between parts of the distribution network could be installed.

Integrating DER into the wholesale market

Recommendation 6: Trial DER participation in wholesale and FCAS markets

The OpEN team recommends trialling DER optimisation and DER access to the markets. This is based on the SGAM analysis that EA Technologies and stakeholders completed which considered the commonality and complexity of each of the functions identified in the modelling. Trials will be important in understanding how the optimisation functions (including distributed and wholesale optimisation) need to operate and integrate. Most of the trials will need to pick up multiple functions, such as aggregator/retailer and distribution constraint development as well as wholesale and distributed optimisation in order to operate effectively.

There are a number of trials already underway with a progression tabled in Figure 22.

Trials offer learnings about the ways in which these frameworks should be designed. The frameworks and the SGAM models give a direction for the types of trials and the types of actors and communications that should be tested. One example is the need for a distributed market. The design of this market needs to be specified and tested using different methods. This will demonstrate what works, what is possible and the distribution-specific design elements that may be required to incorporate such elements as local community energy projects, or peer to peer energy trading. Each of these trials test different existing and emerging gaps, avoiding unnecessary duplication. Trials ensure that market design is based on real world evidence. Emerging markets will be designed to support the networks and systems so that they can provide standardised products and services. The systems or technical requirements must be developed first and markets designed subsequently to provide the necessary products and services for the system needs.

Figure 21. A summary of the Optimisation Functions that will need to be established

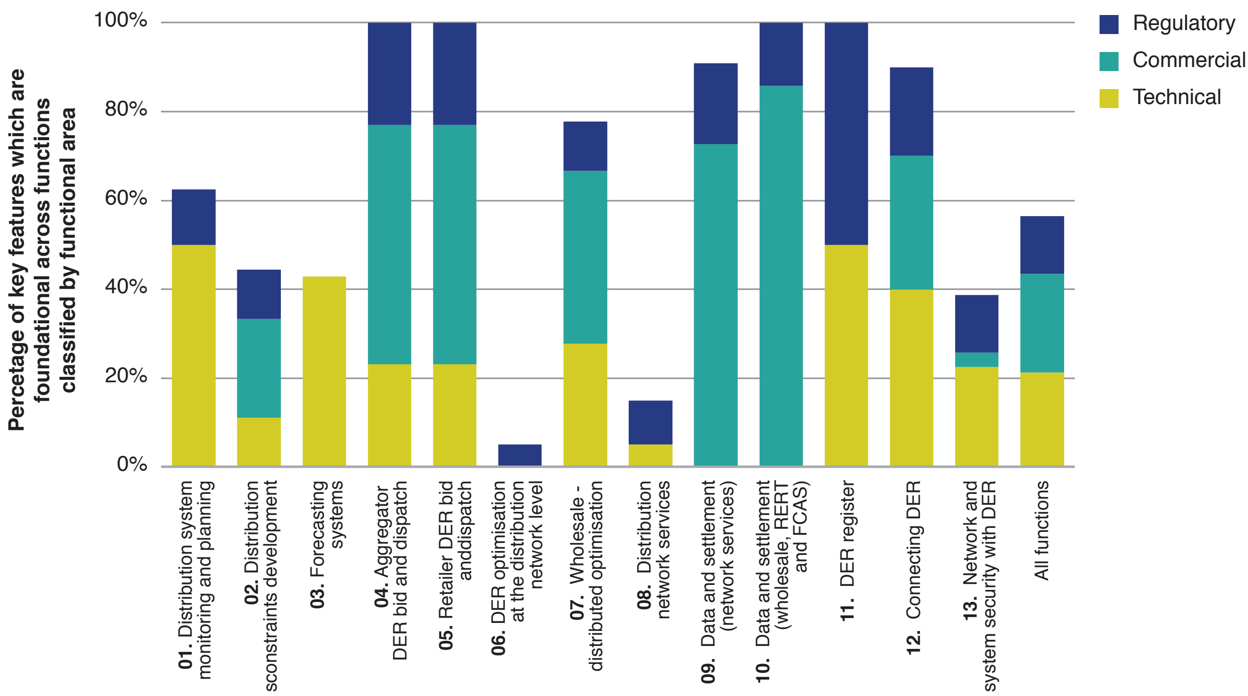
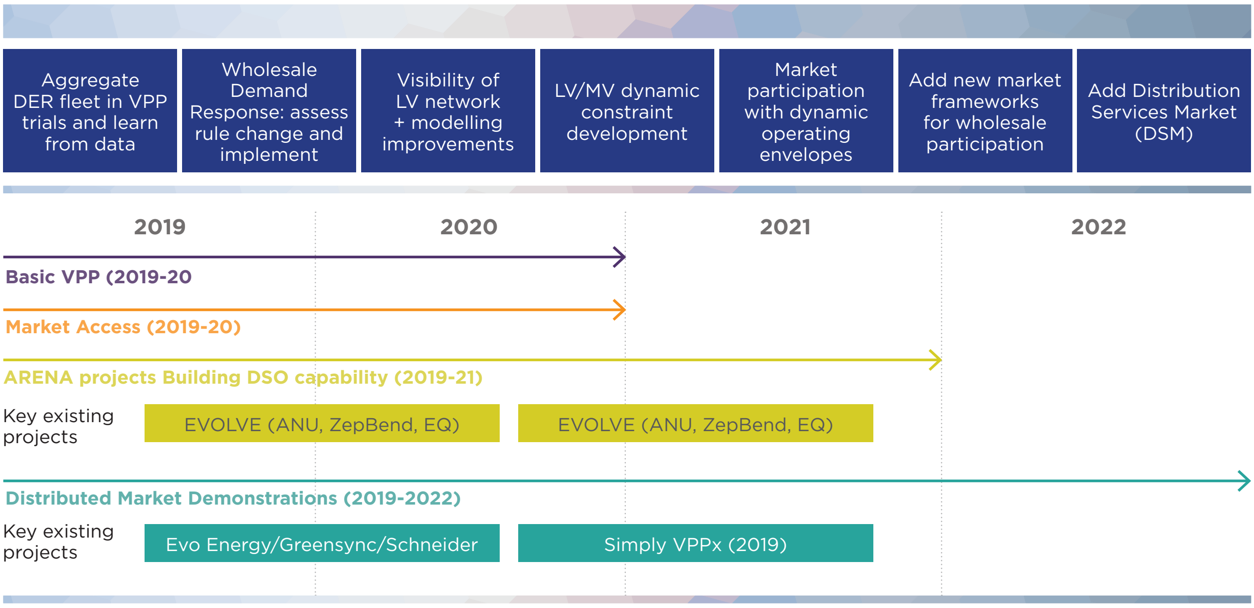


Figure 22. Key projects to test and deliver DSO capability



Several trials and initiatives are focused on different functional areas identified in the original OpEN consultation. The most significant of these is the VPP Demonstrations project, which seeks to allow distribution connected aggregated VPPs to access the FCAS market – the first major step in wholesale market integration. Information about this can be found on the AEMO website.

Recommendation 7: Trial real time dispatch of DER

It is recommended that a framework for dispatch at a wholesale and local level be developed. This should include standard communication protocols, a common bidding process and a common infrastructure that can be then transposed by aggregators/retailers to send signals to DER.

There are various ARENA funded VPP trials testing the systems and processes required for the development and agreement of a standardised communication protocol between the providers and buyers of new value products and services.

The supporting operators and markets need to ensure the release of the additional value. It is important that these projects and the VPP demonstrations continue to collaborate to ensure consistency of data.

The trials of different functions will likely follow an iterative approach, becoming more complex and complete over time. Trials will likely target pockets of the distribution network with high DER installations as these are the most likely to need co-ordination. If a standardised approach with common communications is maintained, these trials should support the rollout of any of the frameworks in the future.

AEMO is running a separate workstream to better integrate stand-alone energy storage systems (ESS) and in time, 'hybrid' systems (a system with ESS, generating system and/or load) in the NEM. This considers changes to the NEM regulatory framework and procedures, processes and systems. Any rule change proposal will seek to define ESS, create a new registration category for bi-directional assets and allow for a single dispatch offer and operation of these assets. AEMO intends to lodge a rule change to the AEMC in June 2019[14].

14 AEMO. 2018 Emerging Generation and Energy Storage in the NEM stakeholder paper. November, 2018. Available at www.aemo.com.au/-/media/Files/Electricity/NEM/Initiatives/Emerging-Generation/EGES_Stakeholder_Paper_Final.pdf

A market for network services?

Recommendation 8: Provide visibility of bilateral network services arrangements

Distribution networks already utilise DER to manage network congestion in the distribution network. These are often bi-lateral relationships designed to meet specific network requirements.

As the circumstances in each network mature, it is likely that a transition from procuring network and system services on a bespoke contractual basis to a real-time market with standardised products and services will occur. It is important that visibility of these bespoke resources is reflected in long-term and operational forecasts for networks and the system. This evolution will require the establishment of intermittent rules and guidelines.

Recommendation 9: Trial a network services market

This recommendation suggests creating a network services market. This will need careful consideration and piloting of network market models (see the next recommendation).

The new distribution services market (DSM) should not be incorrectly conflated with existing network support and control ancillary services (NSCAS). NSCAS are a non-market ancillary service that may be procured by AEMO or transmission network service providers (TNSPs) to maintain power system security and reliability and to maintain or increase the power transfer capability of the transmission network. It is envisaged that TNSPs will continue to engage with NSCAS. TNSPs will retain the option of procuring standardised products and services from the proposed DSM to alleviate transmission network constraints. TNSPs will collaborate with AEMO to determine long-term asset investment plans.

This is already occurring with ARENA funded trials such as the Networks Renewed project. This project tests the ability of DER to provide network services, both demand response and reactive power, to help alleviate congestion in the LV and MV network.

The UK's Power Networks are completing work setting out the parameters of the network flexibility services they are taking to market. To this end, they have developed a Flexibility Roadmap for which we helped them devise current and future requirements[15].

Recommendation 10: Trial an AEMO dispatched market for transmission network services

As detailed, the interactions of both the proposed DSM and the existing NSCAS will be critical to ensure the efficient economic dispatch of resources. AEMO currently dispatches NSCAS resources with the co-optimised wholesale and FCAS services. The addition of this proposed DSM will require coordination with the existing markets and NSCAS. Trialling the new DSM to provide NSCAS for both the TNSP and AEMO will be a critical step in ensuring the intermittent rules are fit for purpose.

Pricing signals for DER customers

Recommendation 11: Investigate appropriate price signals for customer DER

Throughout the consultation phases of this project, stakeholders made it clear that the role of pricing was key. As tariff and pricing reform trials continue, results will be critical for this transition.

The DSO models assume that the current access and pricing arrangements apply with open access and no charges for export for distribution. However, the OpEN team has ensured that new arrangements can be accommodated in these future models. For example, the DSM has been developed with a degree of flexibility. As a result, it has been agnostic to the providers and purchasers of these products and services. It is envisaged that any changes to export pricing and access arrangements will only create different purchasers and providers of these products and services. Policy matters regarding the allocation of export capacity is a key element which will affect the pricing arrangements.

15 UK Power Networks. 2018 Flexibility Roadmap: FutureSmart, A smart grid for all: Our transition to Distribution System Operator. October, 2018. Available at http://futuresmart.ukpowernetworks.co.uk/wp-content/themes/ukpnfuturesmart/assets/pdf/futuresmart-flexibility-roadmap.pdf

The OpEN team has also been consulting with the AER and the AEMC to ensure that tariffs and demand management frameworks are on the radar of governing and ruling bodies. The OpEN team understands that prerequisites for fully integrated pricing are the digital meter rollout into the NEM, implementation of the five-minute settlement rule and changes to network tariff signals and retail prices reflecting the wholesale market. Improved data quality and access could be as important as technological developments.

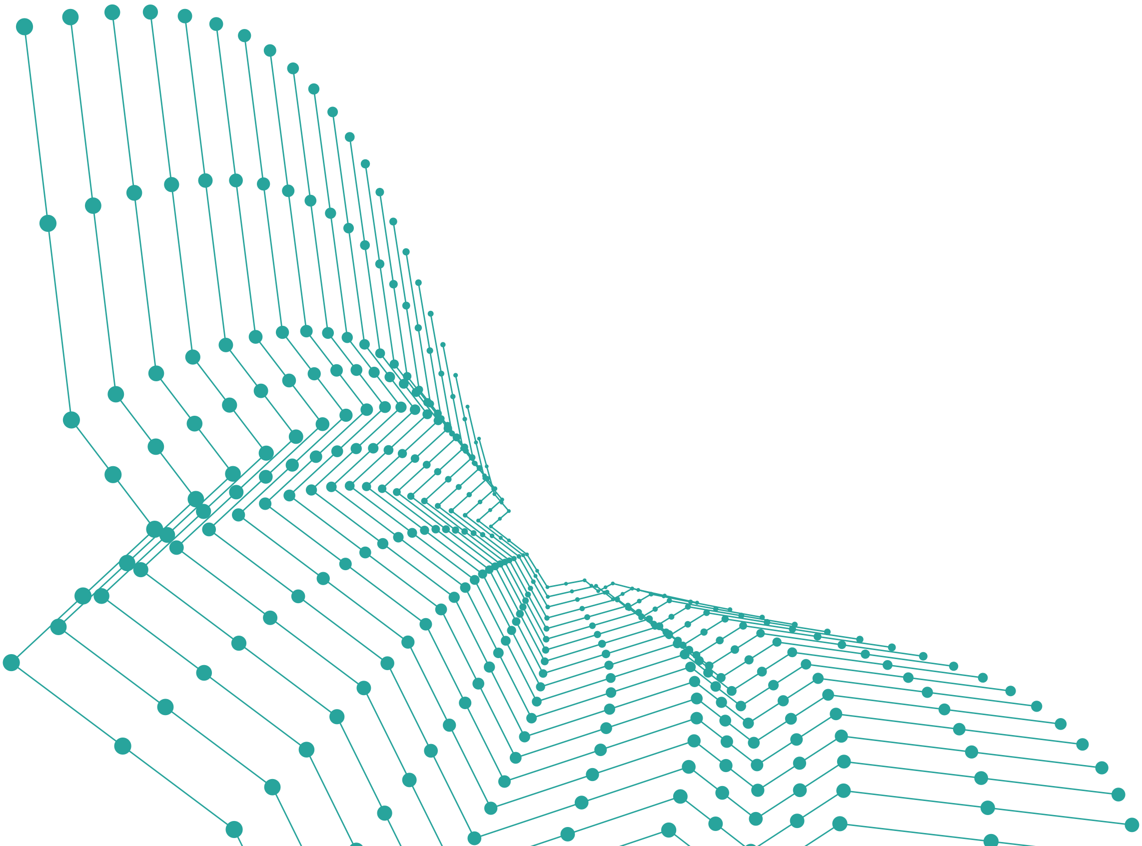
The OpEN team will continue to consult with the AER and the AEMC to ensure that pricing arrangements, tariffs and demand management frameworks are developed with learnings from this work.

Next steps

The Open Energy Networks project is working towards its final recommendations. The final recommended framework should be one that stakeholders agree will deliver the largest net benefit and value to all customers. Also of consideration is the need to incentivise DER customers and we must technically manage the network and system, both increasingly reliant on DER.

To reach a conclusion a cost-benefit analysis will be completed on each of the four models. The methodology to be used for the cost benefit analysis has been constructed similarly to the UK's Open Networks. This builds on the CSIRO cost benefit framework report published with this document.

The framework recommendation will also utilise the recently completed detailed SGAM modelling. This is a considered piece of work. The complexity of each framework and the set of sophisticated communication processes and governing standards, including the levels of latency and the need to manage issues such as cyber security and customer protections has been a significant undertaking.



Conclusion

There is much to be done to ensure that the investment being made in DER in the distribution network today and in coming years can be utilised for the benefit of all.

The reducing cost of technology and the largely state-based energy policies supporting solar PV and batteries will continue to spur increased customer installations. The required capabilities and recommendations that we make in this report lay the groundwork for any future framework for optimising the distribution network and will make it easier to technically operate the distribution network and the energy system in a high DER environment. However, even if none of the market frameworks are adopted, the required capabilities outlined in this report are critical to manage the ever-increasing levels of DER connecting to the distribution system. The required capabilities will enable better integration of DER into the grid.

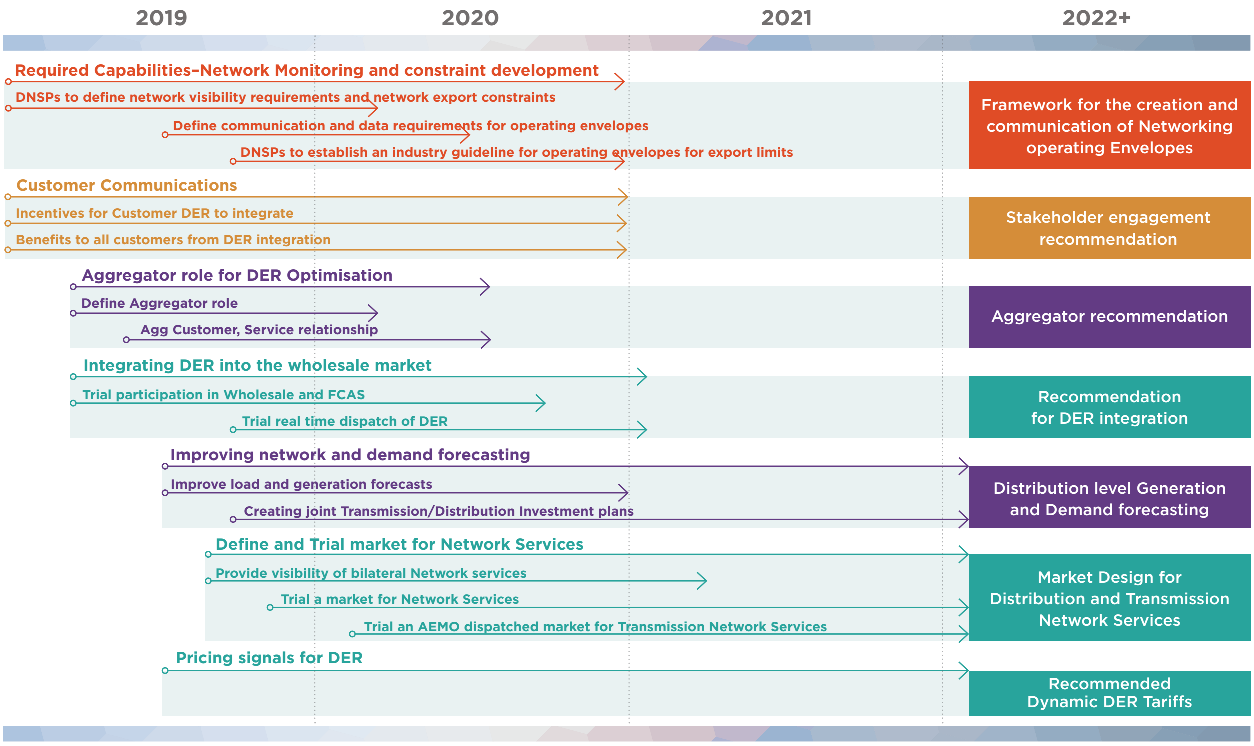
Targeting investment into areas of very high DER penetration and pilots and trials will be important to avoid a scenario where the industry enters blindly into an expensive and broad ranging set of reforms that deliver little customer benefit. Some of these pilots and trials have already begun, largely with ARENA funding. However, there is still a need to address a broad set of issues that DER has wrought in the Australian energy market. These include improving LV network visibility, improving forecasting and planning of transmission and distribution to maximise the benefits from DER, integrating DER into the wholesale market and standardising the procurement of DER for network services.

Early trials and pilots are raising several policy related questions that need to be addressed. These include network access rights for DER and equity with existing installations, appropriate tariffs to manage DER (especially aggregated DER integrated into the wholesale market) and the regulatory investment tests to benchmark investments aimed to optimally manage DER in the distribution networks.

There is also much work being done to ensure that DER can continue to be safely installed and integrated into the network and the system. This includes better standards of installed devices and improved connection processes. Energy Networks Australia and AEMO strongly support this work but do not see this as substitute for the need for a framework for co-ordinating and optimising DER in the distribution network.

A summary of the key recommendations and the timelines for their delivery is illustrated below.

Figure 23. Key recommendations and timelines



Appendices:

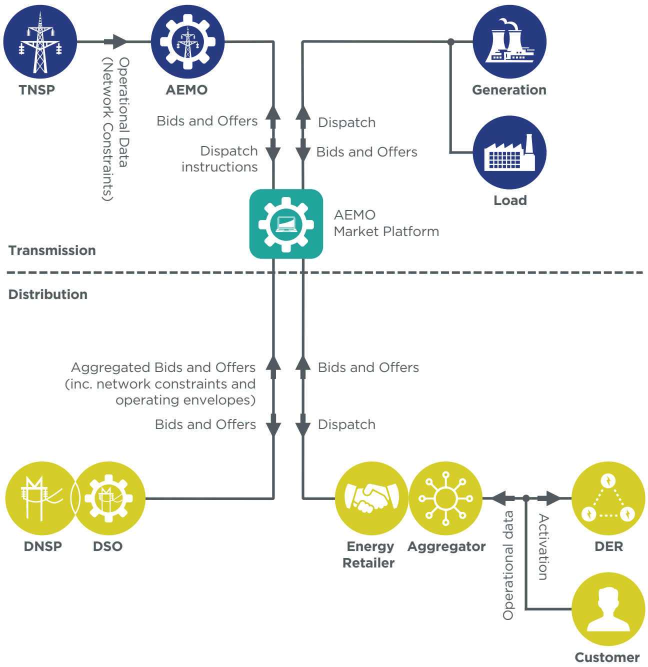
State and Territory DER incentives

Figure 24. Chart showing DER incentives by State and Territory

State/ Territory	Program name	Policy/Incentive	Renewable energy target
ACT	Next Generation Energy Storage	$25 million fund aims to provide subsidised battery storage for 5,000 Canberra homes and businesses by 2020.	100% by 2020
NSW	Smart Energy for Homes & Businesses Smart Batteries for Key Government Buildings	$50 million for up to 200MW (home & business - $1,000 incentive per home). $20 million for up to 13MW (gov buildings).	Supports national Renewable Energy Target
SA	Hornsadle Power Reserve Home Battery Scheme SA Virtual Power Plant	100 MW/129 MWh lithium-ion battery operational. Proposed $100m grants program to facilitate batteries in 40,000 homes. Solar & Batteries for up to 50,000 homes (mix of public housing and privately owned).	Supports national Renewable Energy Target
VIC	Battery Storage Incentive Solar Homes Package	$40 million for up to $5,000 off as many as 10,000 battery systems (on homes with pre-existing solar). $1.34 billion for up to $2,225 off as many as 650,000 solar systems.	25% by 2020 40% by 2025
QLD	Interest – free loans for solar & storage	Loans up to $4,500 for up to 3,500 home solar systems. Loans up to $6,000 and grants up to $3,000 for as many as 500 battery systems. Loans up to $10,000 and grants up to $3,000 for as many as 1,000 solar + battery systems.	50% by 2030
NT		Home Improvement Scheme previously offered up to $4,000 vouchers for purchases including solar and batteries. Participants were required to fund at least 50%.	50% by 2030
TAS		Battery of the Nation pumped hydro feasibility study. Proposed $200,000 micro-grid pilot.	100% by 2022
WA	No specific policy		Supports a national target

Market frameworks

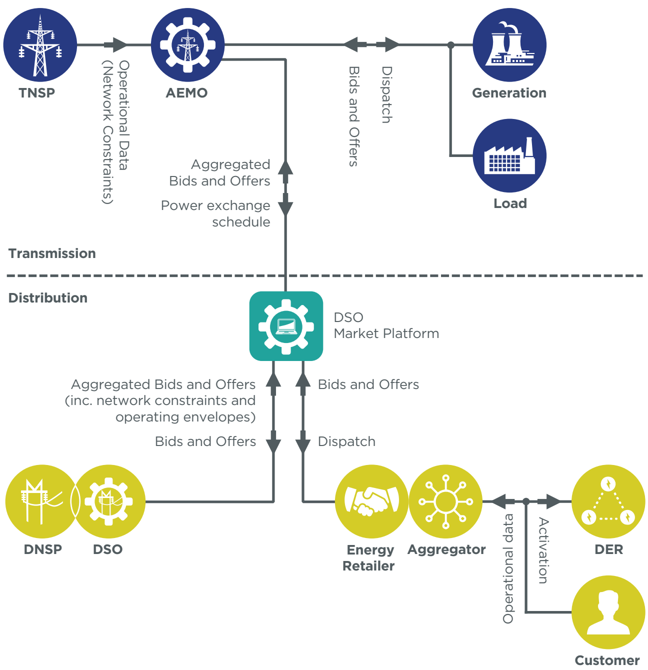
Figure 25. Model 1: Single Integrated Platform



Key characteristics

Market arrangements	» 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

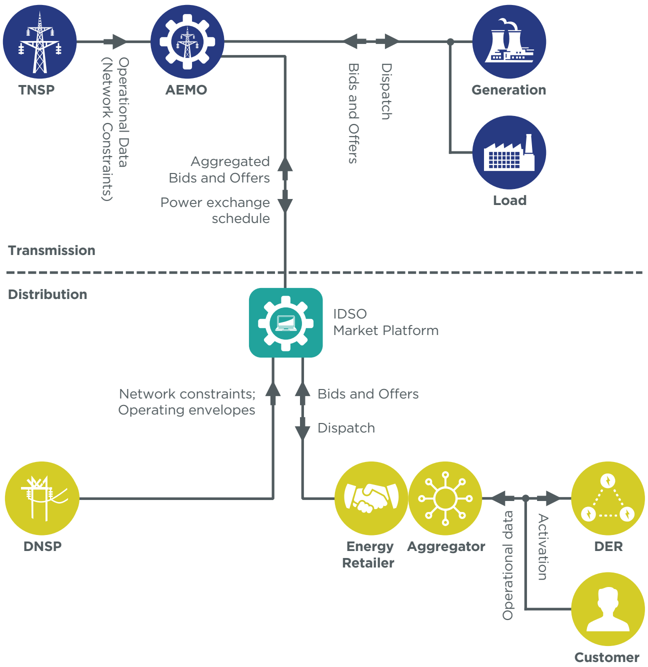
Figure 26. Model 2: Two step tiered platform



Key characteristics

Market arrangements	» 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

Figure 27. 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

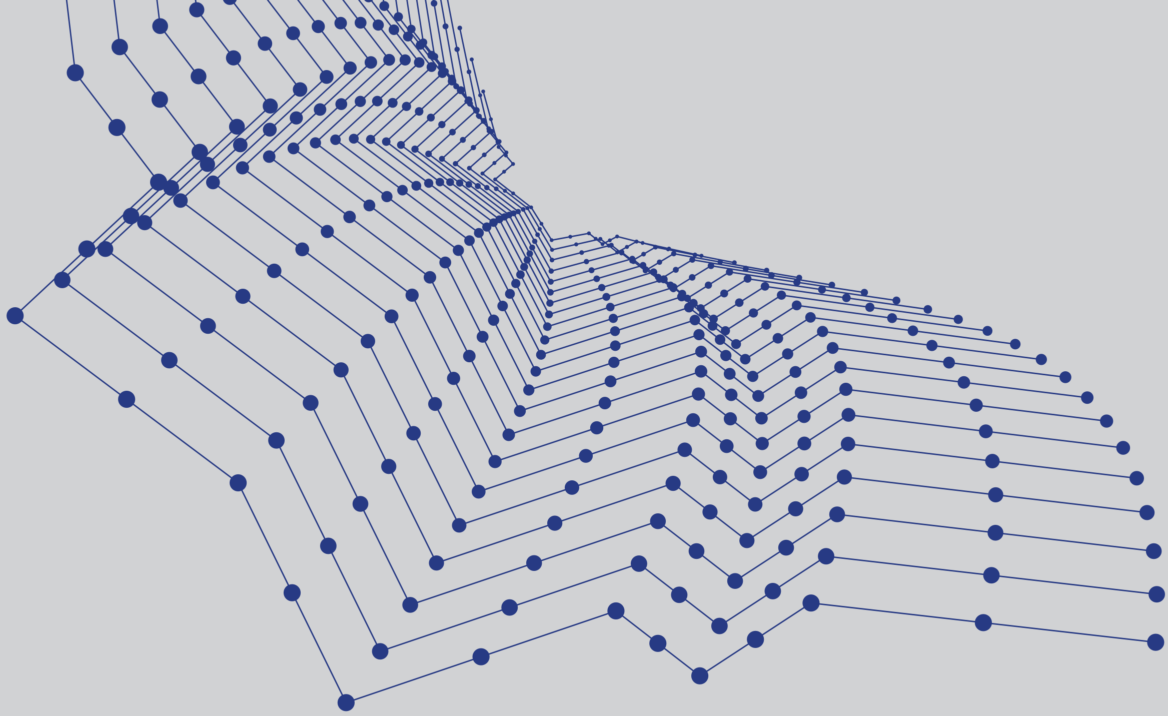
Figure 28: Examples of issues identified by participants from the Functional Specification workshops

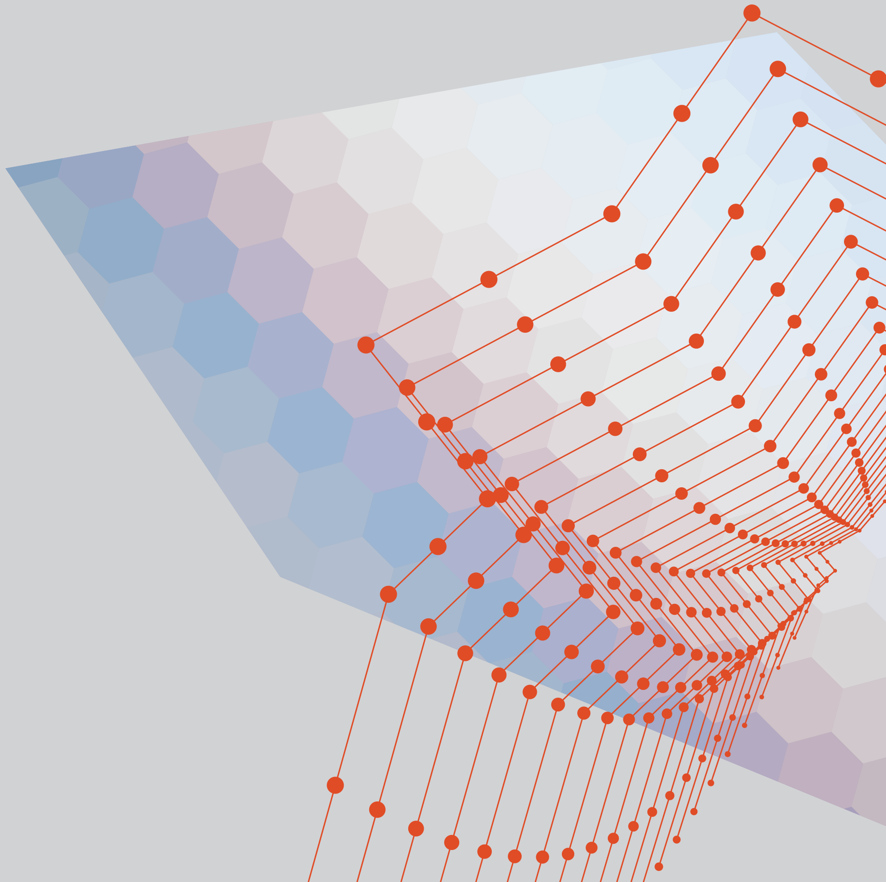
In Scope

- Should DNSP as DSO also settle local markets?
- Who clears bids for Wholesale and FCAS when iDSO or DNSP is DSO?
- Latency of communications may affect ability of DER to bid and dispatch, how best to design to allow for autonomous operation?
- Should Distributed Optimisation be NEMDE like or Nodal pricing?
- LV network – limited visibility and mixed DER penetrations
- Should Distributed Optimisation be NEMDE like or Nodal pricing?
- Should DER be able to "double dip" wholes and network services?
- Who manages Reserve Contracts for DER?
- Priority for Dispatch Network v Wholesale
- Are there privacy issues associated with sharing DSO network constraint data
- Should Distributed Optimisation be NEMDE like or Nodal pricing?
- Should others have access to DER register – ie Retailer/ Aggregator
- DER Assest Management – who manages the process when customers churn retailers?

Out of Scope

- Can DER help manage VCR
- Consumer Equity – share DER benefits
- Who defines DER device cyber security settings?
- Should DER have firm access or should it be pay to play?
- What is the role of Tariffs/ Pricing signals?
- How is the Market going to define aggregations – what MW threshold is appropriate?
- Aggregator vs Retailer – what are the differences, NER considerations?
- What is the role of TNSP
- Inverter Technical Settings – how best to ensure voltage and system security are managed
- What is the role of manufacturer and Installer of DER in the Market?
- What about loss factors – DLF/MLF?
- Is there a more Consumer Centric model that can be adopted in Distribution market?
- What are the customer rights with respect to Aggregator contracts?





AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Energy Networks Australia