Australian Energy Market Commission

Distribution Market Model

FINAL REPORT
22 August 2017

This report sets out the key characteristics of a potential evolution to a future where investment in and operation of distributed energy resources is 'optimised' to the greatest extent possible.

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About the AEMC

The AEMC reports to the Council of Australian Governments (COAG) through the COAG Energy Council. We have two functions. We make and amend the national electricity, gas and energy retail rules and conduct independent reviews for the COAG Energy Council.

Executive summary

The uptake of rooftop solar photovoltaic systems, battery storage, electric vehicles and other technologies at the distribution level in Australia's electricity sector is having a significant impact on the way that consumers use electricity. Technological innovation is making the functions these devices perform smarter, cheaper and more accessible to a wider range of users. This change is greatly expanding the choices that consumers have to manage their energy needs and can potentially deliver significant efficiency benefits as well as improvements to the reliability and security of the provision of electricity services.

These 'distributed energy resources' are capable of providing a range of services to a number of different parties. For example:

- a consumer may use a battery storage system to maximise the value of its solar PV system
- the distribution network business may procure the services provided by that system to manage network congestion
- an energy service company may, on the consumer's behalf, use the system to provide frequency control ancillary services to the Australian Energy Market Operator (AEMO).

Each of these services is a potential source of value and revenue, but not all of these can be monetised together - that is, by the same distributed energy resource at the same time. For example, a battery could be used to alleviate network congestion (by being discharged) or to decrease frequency (by charging), both of which could be required at the same time. The party who controls the asset is therefore required to make trade-offs between the value they place on utilising or selling the various services that the asset is capable of providing at any point in time. For example, one consumer might place a high value on having backup power, and so not provide network or wholesale services in order to have their battery fully charged as often as possible. Another consumer might place a higher value on the payment its local DNSP provides them in return for use of their battery at times of network congestion.

Historically, the development of distribution networks, and the regulatory arrangements that underpin them, have been focused on distribution network businesses providing sufficient network capacity to meet increasing consumer demand while maintaining the safety, reliability and security of electricity supply. There are currently few ways for consumers to signal at a particular point in time whether they would value providing services from their battery to a DNSP or an aggregator, or using the energy themselves.

In light of the increasing uptake of distributed energy resources and the range of services these technologies are capable of providing, distribution system operations and associated regulatory arrangements is likely to require greater consideration of two issues:

- The value from **optimising** investment in and operation of distributed energy resources. Optimisation provides a way to send signals to whoever has control of the distributed energy resource to provide the service that will deliver the most value to the consumer at that point in time. An optimising service, gives consumers the ability to maximise the benefits of an investment in distributed energy resources by enabling them to, if they choose, receive the maximum possible benefit of utilising and selling the full range of services that the distributed energy resource is capable of providing, given transaction and information costs, and technical constraints. Consumers may choose to 'optimise' the operation of their distributed energy resources themselves, or give this function to an agent, for example, their electricity retailer or energy service company, to optimise the resource's operation on their behalf.

- The value from **coordinating** the operation of distributed energy resources with the wholesale market. That is, consideration of how distribution networks can, in both a technical and regulatory sense, enable the efficient use of distributed energy resources in distribution markets and effective access for distributed energy resources to participate in transmission-level markets, such as the wholesale market.

The Commission considers that any evolution of distribution systems needs to be an evolution where consumers and their chosen energy service providers are in the driving seat. This will give these parties more control over how their distributed energy resources are used. The Commission also recognises, however, that while there needs to be consideration of how regulatory and market frameworks should evolve to facilitate choice, that evolution must occur in a way that maintains a safe, secure and reliable supply of electricity. The evolution should balance the benefits from the customer-led roll out of these technologies, with the needs of networks to manage the system impacts.

This report outlines the need for a way to buy and sell energy and related services at the distribution level in a more dynamic way, in response to price signals and consumer preferences. This means that if consumers want to use the electricity from their solar panels or batteries they can, and if they do not need it - or value the income more from selling it more than their own use - they can sell it to whoever values it the most at a particular point in time. These concepts of a distribution-level market are being considered by a number of organisations, and in different international jurisdictions, including the Victorian Essential Services Commission, CSIRO and Energy Networks Australia, and Ofgem.

The report also sets out the key characteristics of a future that enables investment in and operation of distributed energy resources to be optimised to the greatest extent possible, specifically:

- the need for an 'optimising service': a customer-facing, optional service aimed at maximising the value of distributed energy resources

- the function associated with operating the distribution system - the party responsible for maintaining distribution system security as issues become more localised

- consideration of how network capacity is provided i.e. using traditional network build or distributed energy resources.

The Commission makes a number of findings on how these aspects can be further progressed in order to make sure that we have flexible and resilient arrangements for the future. These findings represent short-term actions that need to be undertaken in order to facilitate distribution-level markets, and so more readily incorporate distributed energy resources into our markets. These are summarised below.

These findings are pre-conditions for the development of any distribution-level market. How the market develops, or, indeed, how far it develops, will be driven by consumers and energy service providers acting on their behalf, who will progress opportunities to develop the market organically. Centrally coordinated orchestration of such a market is likely to result in inefficient and costly outcomes.

The analysis undertaken through this project, and the associated findings, are also relevant to the strategic priorities for the development of flexible and resilient energy markets. In particular, the findings align with the Commission's 2015 *Strategic Priorities*, related to network transformation, and are expected to feature in the Commission's 2017 energy sector strategic priorities, which are currently under consideration. The terms of reference for this work are included at appendix E.

Box 1 Summary of findings

1. The AEMC will examine the ways in which parties providing 'optimising services' can better coordinate with wholesale market operations undertaken by AEMO as well as alternative ways of facilitating greater co-ordination between distribution level markets and the wholesale market through the *Reliability Frameworks Review.*

2. Given the regulatory obligations that distribution network service providers (DNSPs) have to maintain a safe, secure and reliable network, the AEMC requests that Energy Networks Australia in consultation with relevant stakeholders (e.g. the Reliability Panel), start to explore what minimum level of control DNSPs need to have over distributed energy resources in order to enable higher levels of distributed energy resources for future distribution level markets, without compromising these regulatory obligations.

3. DNSPs commit to developing and publishing more dynamic information about congestion (i.e. system limitations) and technical issues (e.g. voltage issues) at more localised levels of their networks. The AER, through its development and refinement of the Distribution Annual Planning Report template,[1] will be able to monitor developments in this space and work with DNSPs to make sure such information is being provided on a meaningful, and consistent basis, across the different distribution networks.

4. The AEMC requests that AEMO continue to identify any information gaps related to distributed energy resources for the purposes of maintaining power system security through its *Future Power System Security* work program, such as technical assessments of whether, and if so, at what level of aggregation, data about the operation of distributed energy resources is needed. Such work will be used as an input into the AEMC's *System security* work program.

5. Network tariff reform is a key enabler for the efficient deployment of distributed energy resources. All jurisdictions should allow the DNSPs to progress the implementation of cost-reflective network tariffs including locational pricing.

6. Through the 2018 *Electricity Network Economic Regulatory Framework Review*, the AEMC will consider the arrangements for distribution network access and connection charging for distributed energy resources in Chapters 5A and 6 of the NER.

1 See: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/distribution-annual-planning-report-template

7. The AEMC notes that Energy Networks Australia, has already commenced a program of work to develop nationally consistent distributed energy resources connection guidelines, which includes a review of the process and technical requirements for the connection of micro embedded generators across DNSPs. The AEMC also acknowledges that Energy Networks Australia plan to develop these guidelines in consultation with relevant stakeholders. The AEMC therefore support this approach and requests that Energy Networks Australia proceeds with this work program and uses these stakeholders to obtain industry agreement on a common approach.

8. The AEMC will assess the potential for distributed energy resources to provide frequency control services and any other specific challenges and opportunities associated with their participation in system security frameworks through the *Frequency control frameworks review.*

9. The AEMC requests that the Clean Energy Council explore the merits of seeking accreditation of a body to develop standards, which are not already covered in the NER, that will facilitate the connection of distribution energy resources.

Contents

1 Introduction

1.1 Objective of the project

This project forms part of the Australian Energy Market Commission's (AEMC's or Commission's) technology work program, which seeks to explore whether the energy market arrangements are flexible and resilient enough to respond to changes in technology.[2] It builds on the analysis undertaken by other projects in the technology work program, including the *Integration of storage* report, which was published in December 2015.[3]

The Distribution Market Model project is intended to be a forward-thinking, strategic piece of analysis used to inform the Commission’s assessment of rule change requests, and its advice to governments. The purpose of the project is to examine how distributed energy resources might drive an evolution to a more decentralised provision of electricity services at the distribution level, the incentives or disincentives for business model evolution, and whether changes to the regulatory framework, how distribution systems are operated, and to market design more broadly are needed to enable this evolution to proceed in a manner consistent with the National Electricity Objective (NEO).

To achieve this purpose, the Commission has explored:

- the technical opportunities and challenges presented by distributed energy resources
- what, if any, new roles, price signals and market platforms are required to 'optimise'[4] the deployment and use of distributed energy resources
- how the role of distribution network service providers (DNSPs) may need to adapt to facilitate a transition to a more decentralised market for electricity services
- whether the existing electricity regulatory framework impedes or encourages innovation and adaptation by DNSPs to support the efficient uptake and use of distributed energy resources
- whether changes to the existing distribution regulatory arrangements, or design of the market, are necessary to address any impediments to efficient business model evolution.

The project is not intended to be a prediction of or pathway for future regulatory reform. Rather, it is an exploration of the key characteristics and 'enablers' for a future

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2 See: http://www.aemc.gov.au/Major-Pages/Technology-impacts

3 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Integration-of-storage

4 Defined in section 1.4.

where investment in and operation of distributed energy resources is optimised to the greatest extent possible, while addressing any technical impacts as they arise.

The Commission considers that consumer choices should continue to drive the development of the energy sector. The availability and uptake of distributed energy resources is enabling electricity customers to make decisions about how they consume electricity. These choices are driving investment in particular technologies. Market design and regulatory frameworks may need to be modified to better provide consumers with signals about the costs and benefits of their decisions to allow them to make efficient decisions, aligning individual decisions with the long-term interests of consumers more generally.

The Commission has been amending the regulatory framework over recent years to reflect the changes brought about by distributed energy resources. However, more significant changes to this market design and the regulatory framework may be needed over the long term as the type and prevalence of distributed energy resources increases, and other enabling communication and information technologies become more wide spread. Through this report, the Commission has assessed these proposed changes against the NEO and associated principles that are summarised in Box 1.1.

Box 1.1 Assessment framework

The overarching objective that has guided the Commission's approach is the NEO. The NEO is set out in section 7 of the NEL, which states:

> "The objective of this Law is to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to:
>
> (a) price, quality, safety, reliability and security of supply of electricity and
>
> (b) the reliability, safety and security of the national electricity system."

The Commission has also developed a set of principles to guide its analysis of the technical and regulatory challenges raised by distributed energy resources, the possible models of future distribution system operation that may be available to address them, and their advantages and disadvantages. These principles are summarised below, and discussed in more detail in appendix C:

- facilitating effective consumer choice
- promoting competition
- promoting price signals that encourage efficient investment and operational decisions
- enabling technological neutrality

- preference for simplicity and transparency
- regulate to enable the safe, secure and reliable supply of energy, or where it would address a market failure, where the costs of regulation to consumers associated with addressing the market failure outweigh the cost to consumers of the market failure itself.

1.2 Progress to date

1.2.1 Approach paper

The Commission published an approach paper on this project in December 2016,[5] which:

- communicated the objective and scope of the project
- established the 'starting point' - that is, what the role of a DNSP is under the existing regulatory arrangements
- set out the Commission's analysis of the technical opportunities and challenges presented by distributed energy resources
- described the Commission's framework for how the opportunities and challenges of an increased uptake of distributed energy resources would be assessed through this project
- sought feedback from stakeholders on each of the above items.

The Commission received 24 written submissions on the approach paper, which are available on the AEMC website.[6]

1.2.2 Draft report

The Commission published a draft report on this project in June 2017, which:

- clarified the project scope, key definitions and market design principles in response to stakeholder submissions on the approach paper
- set out the key characteristics and enablers for a future where investment in and operation of distributed energy resources is optimised to the greatest extent possible
- identified and assessed the barriers (if any) to these enablers

5 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Distribution-Market-Model

6 Ibid.

- sought feedback from stakeholders on the materiality of any barriers, and possible ways to address them.

A summary of the draft report is available in the form of a pre-recorded webcast on the AEMC website.[7]

The Commission received 32 written submissions on the draft report, as well as 2,494 submissions from Solar Citizens supporters, which are available on the AEMC website.[8]

The comments made by stakeholders in submissions to the approach paper and draft report have informed the development of this final report, and are discussed and referred to where relevant.

1.3 Purpose of this final report

The purpose of this final report is to build on the views and analysis set out in the draft report, and draw on the feedback from stakeholders in their submissions to the draft report, to:

- further clarify the Commission's thinking on the need for optimisation and coordination under a distributed market model
- provide further analysis of the market and technical enablers of a future where investment in and operation of distributed energy resources is optimised to the greatest extent possible
- set out the Commission's findings on possible ways to address any identified barriers to the development of a market-based approach to the increased deployment of distributed energy resources, and how these will be progressed through current and future projects.

1.4 Key terms

Both the approach paper and draft report set out the Commission's proposed definitions of some key terms, including 'distributed energy resources' and 'distributed generation'. These definitions have evolved over the course of the project, incorporating stakeholder feedback.

Table 1.1 sets out the Commission's revised definitions of these key terms used in this final report. The key changes to these terms, compared to those used in the draft report are:

- Our definition of distributed energy resource is now "an integrated system of energy equipment co-located with consumer load" that is, encompassing both

7 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Distribution-Market-Model

8 Ibid.

'smart' (the ability to respond automatically to short-term changes in prices or signals from wholesale markets or elsewhere in the supply chain) as well as 'passive' devices (for example, a rooftop solar PV system that generates and feeds power into the grid when the sun shines, rather than in response to short-term changes in prices or signals from elsewhere in the supply chain).

It is worth noting that we envisage that these 'passive' devices will become 'smart' as the minimum technical requirements of such systems are updated over time,[9] and, if the incentives to do so exist and the cost of doing so is not prohibitive. This responds to stakeholder feedback that this definition should include both of these types of devices since the majority of existing distributed energy resources are solar PV, which is already having significant impacts.[10] Further, while passive distributed energy resources may be unable to respond to price signals in an operational sense, owners of these devices will respond to price signals and factor in their preferences when making investment decisions. Therefore, both 'smart' and 'passive' devices have the potential to create technical impacts and change the way we think about distribution network operation.

- We have separated out three different areas of optimisation (which are discussed in more detail in chapter 3). Stakeholder feedback highlighted that the Commission had not been clear enough in describing the 'optimising function' and so we have attempted to address this by highlighting the following differences:
  - the 'optimising service' - the customer-facing, optional service to maximise the value of distributed energy resources by responding to network, retail, wholesale, and other service prices, and co-ordination of this with AEMO's central dispatch where relevant
  - the 'distribution system operator' role - that is, the party responsible for maintaining distribution safety and system security as issues become more localised
  - 'network capacity provision' - how network capacity is provided i.e. using network solutions such as network build, or using distributed energy resources.

These terms are defined here for the purposes of describing and explaining concepts in this report only - that is, they are not intended to reflect specific definitions set out in the NER or other regulation, and therefore may have other interpretations or meanings beyond the scope of this report.[11]

9 For example, the Australian Standard 4777:2:2015 prescribes mandatory and voluntary demand response and power quality response models for all inverters installed after October 2016.

10 Submissions to draft report: AER, p. 4; Energy Networks Australia, p. 17; SA Power Networks p. 2; CEEM UNSW, pp. 7-8.

11 Further, not all of the 'services' defined below are services for the purposes of the NER.

Table 1.1 Definitions of key terms

Term	Definition
Common distribution services	The suite of services and activities involved in operating and distributing electricity to customers safely, reliably and securely in accordance with the regulatory framework, for example planning, designing, constructing, augmenting, maintaining, repairing, managing and operating the distribution network to meet demand.
Customer services	The services enabled by distributed energy resources that are of benefit to consumers themselves, for example the ability to manage their electricity demand, reduce their reliance on the grid, maximise the value of their solar PV system, provide back-up supply or arbitrage their retail tariff. These services are described in Figure 2.4.
Distributed energy resources	An integrated system of energy equipment that is connected to the distribution network.
Distribution-level markets	Markets for the provision of electricity services in distribution networks, for example the competitive procurement of services enabled by distributed energy resources for the purposes of managing network congestion or facilitate peer to peer trading.[12]
Distribution system operation function	The function of maintaining distribution system security as issues become more localised, and how this is coordinated with AEMO's central dispatch.[13]
Energy equipment	Includes a range of technologies, such as battery storage, electric vehicles, rooftop solar PV systems, or household appliances such as refrigerators and dishwashers.
Network capacity provision	How network capacity is provided i.e. using network solutions such as network build, or using distributed energy resources.
Network services	Those services enabled by distributed energy resources that can be procured by a DNSP from the owners of those distributed energy resources as an input to providing common distribution services. These services are described in Figure 2.4.
Optimise	To make efficient decisions about investment in and operation of a distributed energy resource, given any technical constraints that leads to minimisation of total system costs.

12 We use the term ‘competitive procurement’ here in the economic sense – that is, the buying and selling of services enabled by distributed energy resources by competing businesses in response to market-based signals, not the DNSP’s provision of the common distribution service, which could include the procurement of network services from distributed energy resources.

13 We use the term in the more general sense of operating the distribution system in a future where there is high levels of distributed energy resources. We do not mean the current term defined in Chapter 10 of the NER, being a "Distribution System Operator, a person who is responsible under the Rules or otherwise, for controlling or operating any portion of a distribution system (including being responsible for directing its operations during power system emergencies) and who is registered by AEMO as a Distribution System Operator under Chapter 2". This definition is a useful starting point, but could need modification in a future with effective distribution-level markets.

Term	Definition
Optimising service	The customer-facing, optional service to maximise the value of distributed energy resources by responding to network, retail, wholesale and other service prices i.e. responding to signals that inform how to invest in or operate a distributed energy resource in a way that delivers the most value at a particular point in time. This function could be carried out by multiple parties, by market participants (e.g. consumers themselves) or consumers' energy service providers responding to price signals and consumer preferences on their behalf.
Smart	The ability to respond automatically to short-term changes in prices or signals from wholesale markets or elsewhere in the supply chain.
Transmission- level markets	Markets for the provision of electricity services at the transmission-level, such as the wholesale market operated by AEMO or the competitive procurement of services enabled by distributed energy resources for the purposes of managing transmission congestion.
Wholesale services	The services enabled by distributed energy resources that can be procured in the wholesale market (i.e. generation of electricity) or used for ancillary services. These services are described in Figure 2.4.

1.5 Project scope

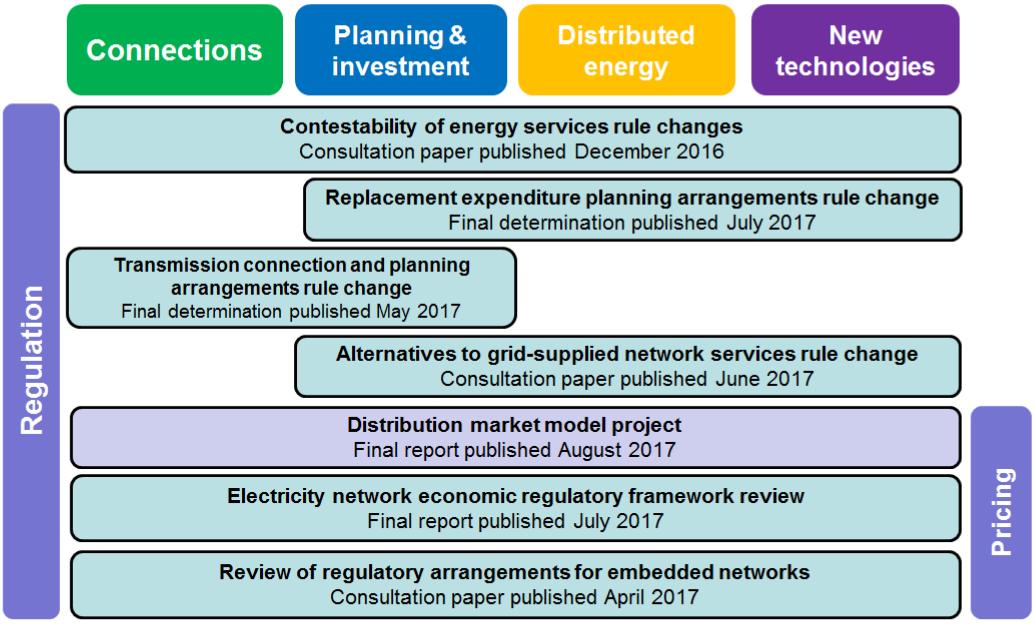
The approach paper and draft report set out the Commission's proposed scope for this project. In submissions to the approach paper, and to the draft report, stakeholders largely supported the Commission's proposed scope for the project, but asked that the AEMC also include consideration of other issues. Appendix A sets out the issues proposed by stakeholders to be included within scope, the Commission's conclusion on whether or not it has been added to the project scope and, if not, whether that issue is being considered though a separate project.

1.6 Related work

This project is intended to complement the range of work being undertaken by the Commission and other parties regarding distributed energy resources, distribution networks and interactions with the electricity regulatory framework. It is intended to be a forward-thinking, strategic piece to inform the Commission’s analysis of rule changes and reviews, and its participation in external projects. These projects are summarised in appendix B.

Figure 1.1 summarises the AEMC related rule changes and reviews.

Figure 1.1 Relevant AEMC rule changes and reviews



The analysis undertaken through this project, and the associated findings, are also relevant to the strategic priorities for the development of flexible and resilient energy markets. In particular, these findings align with the Commission's 2015 *Strategic Priorities*, particularly related to network transformation and are expected to feature in the Commission's 2017 energy sector strategic priorities, which are currently under consideration. The terms of reference for this work are included at appendix E.

1.7 Structure of this report

This report is structured as follows:

- chapter 2 summarises the context for the Commission's consideration of this work
- chapter 3 sets out the Commission's vision for how investment in and operation of distributed energy resources can be optimised under a distribution market model, and how the operation of distributed energy resources can be better coordinated with wholesale markets
- chapter 4 sets out the Commission's findings, informed by stakeholder input, on the near-term 'market' enablers that are needed to underpin any future design of distribution system operations, and ways to address any barriers to the implementation of these enablers
- chapter 5 sets out the Commission's findings, informed by stakeholder input, on the near-term 'technical' enablers that will need to underpin any future design of distribution system operations, and ways to address any barriers to the implementation of these enablers

- appendix A sets out the project scope
- appendix B discusses AEMC and external related projects
- appendix C presents the AEMC's assessment framework
- appendix D presents a potential evolution for distribution system operations
- appendix E provides a copy of the terms of reference for the 2017 *Energy sector strategic priorities.*

2 Background

2.1 Uptake of distributed energy resources will continue to increase

There is expected to be a large future demand for distributed energy resource technologies, such as solar PV, energy storage and electric vehicles. This expected uptake is driven by a range of factors, including:

- the falling costs of these technologies[14]
- increasing functionality of these technologies[15]
- more sophisticated information and control technologies, and fast, cheap computing platforms[16]
- changing consumer attitudes to electricity supply and prices.[17]

An increased uptake of distributed energy resources as a result of these factors is likely to support further innovation, increase the number of parties selling distributed energy resources and associated technologies, and increase the range of products and services available to consumers.

Forecasts support these conclusions. For example, AEMO expects that:

- investment in rooftop solar PV systems will continue to grow, with nearly 20,000 MW installed by 2036-37 compared to less than 5,000MW in 2017[18]
- residential and commercial battery storage uptake will exceed 5,500 MW by 2036–37[19]

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14 For example, Bloomberg New Energy Finance predicts that battery packs are likely to experience cost declines at a rate of 19 per cent for every doubling of production due to productivity and efficiency improvements. Further, that the costs of inverters have halved from 2016 to 2017 due to the entrance of a number of competitive inverter manufacturers that have traditionally made inverters for solar plants. Source: Bloomberg New Energy Finance, Economic for some: Grid-scale batteries in Australia, 3 April 2017.

15 For example, the Tesla Powerwall 2 has double the storage capacity, at close to half the price, compared to the Tesla Powerwall 1, with these two models being released less than two years apart. See: http://www.cleanenergyreviews.info/blog/tesla-powerwall-2-solar-battery-review

16 SAPN notes that remote monitoring and control technology is evolving rapidly, and quickly expanding the range of cost effective solutions available. Installation of more intelligent devices such as distribution transformer monitors, SCADA enabled remote-controlled switching devices and advanced meters will help them to manage risk and network performance. See: SAPN, Distribution Annual Planning Report, p. 23.

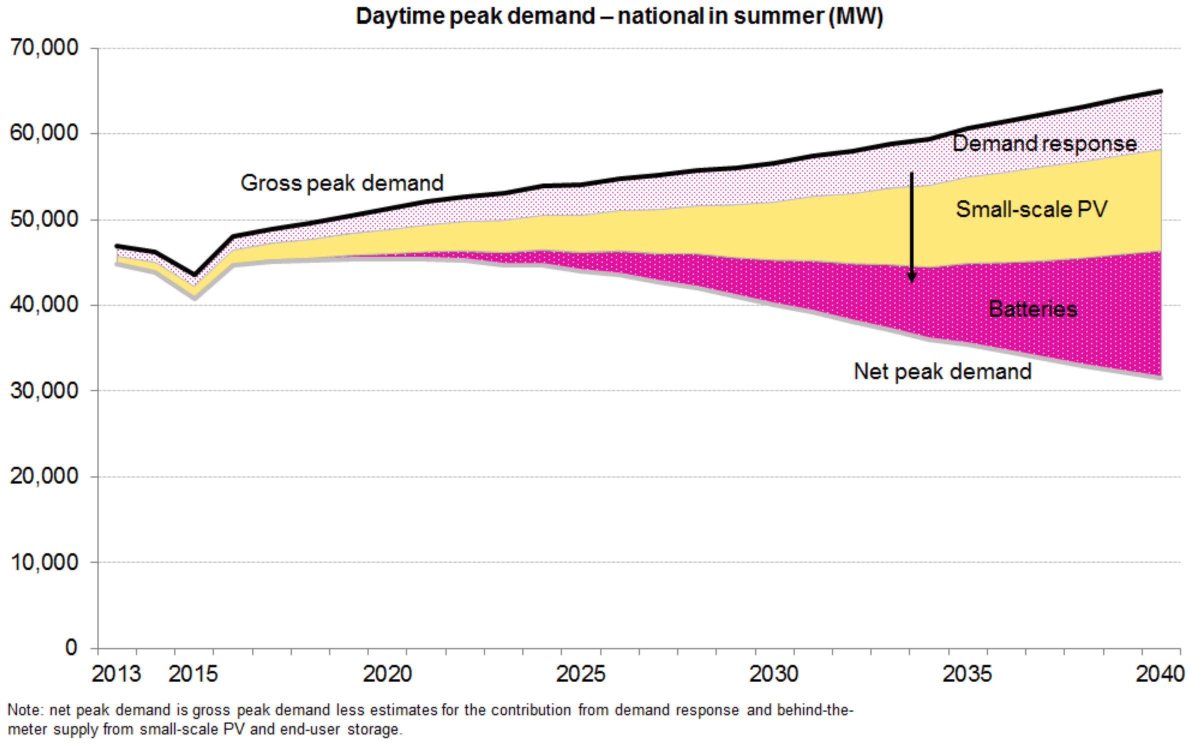
17 The Commission's 2017 *Retail energy competition review* found that energy consumers have more choices to manage their energy use and are looking to take up new technology options. For example: 20 per cent of consumers now have solar panels; 21 per cent are likely to adopt battery storage in the next two years; and 18 per cent are likely to take up a home energy management system in the next two years.

18 AEMO, Electricity forecasting insights for the National Electricity Market, June 2017.

- while electric vehicle sales are forecast to remain low overall in Australia (by comparison with traditional vehicles) in the short term, the rate of increase of uptake will rise from 2020 onward.[20]

The use of some of these technologies is likely to reduce peak demand. Figure 2.1 shows Bloomberg New Energy Finance's forecast of the capacity of demand response, small-scale solar PV and batteries relative to national aggregate peak demand out to 2040.

Figure 2.1 'Behind the meter' capacity relative to national aggregate peak demand



Source: Bloomberg New Energy Finance, New Energy Outlook 2016.

There is also a large number of distributed energy resources already connected to Australia's distribution networks. As of April 2017, there were over 1.66 million solar PV installations in Australia, with a combined capacity of over 5.92 GW.[21]

The existing and projected uptake of distributed energy resources present distribution networks with a range of opportunities and challenges.

19 Ibid.

20 Ibid.

21 See: http://pv-map.apvi.org.au/analyses

2.2 Distribution networks were not originally configured with distributed energy resources in mind

At low levels of penetration, distributed energy resources can be, and have been, accommodated within Australia's distribution networks with little to no coordination or assessment of their cumulative impacts of the network. This is because networks generally have had spare capacity and so some ability to be able to adapt to the technical impacts of distributed energy resources. However, distribution networks are likely to be increasingly affected by distributed energy resources as penetration levels increase: being able to benefit from the services that such distributed energy resources could provide, as well as potentially experiencing a range of technical impacts (particularly if no action is taken to address them). These impacts are prompting some distributors to limit the installation of solar PV in parts of their network.

The approach paper and draft report published on this project set out the Commission's analysis of the key technical impacts, such as those listed in Box 2.1, that an increased uptake of distributed energy resources can present to distribution networks. Stakeholders largely concurred with these technical impacts in their submissions to the approach paper, but had different views about the scale of each impact and how each should be, or is already being, addressed.[22] Distributed energy resources can also provide benefits to distribution networks, as discussed in section 2.4 below.

Box 2.1 Technical impacts of distributed energy resources

- Some distributed energy resources do not provide voltage or reactive power support, which can lead to **voltage stability issues**.
- Distributed energy resources can, by displacing synchronous plant, **reduce grid inertia and frequency response**, which can result in high rates of change of frequency and potential loss of synchronism.
- Inverter-connected distributed energy resources can **increase harmonic distortion**, the impact of which can include excessive heating, nuisance tripping, protection mal-operation and interference with communications
- Distributed energy resources fuelled by intermittent sources of energy can result in **unacceptable levels of flicker**. This is more prevalent on electrically weak networks with large concentrations of distributed energy resources and low fault levels.
- Distributed energy resources with no reactive power support will mean that the rest of the grid will need to supply reactive power, which may result in a **lower grid power factor**.

22 Submissions on approach paper: AEMO, pp. 5-7; Ausgrid, pp. 5-6; Australian Energy Council, p. 3; CitiPower and Powercor, pp. 1-2, 5-6; Clean Energy Council, pp. 6-7; Energy Networks Australia, pp. 15-16; Energy Queensland, Attachment A, p. 9; Jemena, p. 6; University of Sydney and Australian National University, pp. 19-20; Uniting Communities, p. 13.

- If a feeder has distributed energy resources installed, surplus generation is fed back to the grid during times of low load. This reverse power flow may exceed equipment ratings, resulting in **thermal overloading** of equipment.

- Many existing re-closing devices on distribution networks are not capable of reliably detecting distributed energy resources. If the distributed energy resources are not detected, the network could still be live, which can cause **safety issues and unsynchronised switching**.

- Distributed energy resources could **reduce fault levels** to a point where the delineation between a fault and a load is challenging, which may result in the existing protection systems no longer detecting a fault. If the fault is not cleared, this could cause a danger to anyone in the vicinity and damage to equipment.

The nature and magnitude of these technical impacts will differ between distribution networks.[23] For example depending on: the network's size, topology and technical characteristics; the level of uptake of distributed energy resources; as well as other factors, such as jurisdictional requirements, or the culture and practices of the DNSP.[24] Therefore, some distribution networks will experience greater susceptibility to these technical impacts and so need to adapt to accommodate a higher penetration of distributed energy resources more quickly than others.

Indeed, some DNSPs are already experiencing a number of the technical impacts set out in Box 2.1, and so are more progressed than others in gaining awareness of and responding to these impacts as they arise.[25] There is also a number of trials underway seeking to gather better information about the technical characteristics of networks and the impacts, or possible benefits, of distributed energy resources.[26]

23 The KPMG report for the Australian Energy Council also noted this: network impacts are unlikely to be uniform - both in time and magnitude - across all distribution networks. See: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. ix.

24 Energy Networks Australia noted that many of the impacts are being seen today e.g. reverse power flow. Unprecedented penetration of bi-directional electricity flow could breach constraints at the distribution level, and even at transmission level and put overall system security of supply at risk. See: Energy Networks Australia, submission to draft report, p. 1.

25 Conversely, Ausgrid noted that one third of Ausgrid residential dwellings are apartments, as well as one third being rented. Customers in these residences have limited access to distributed energy resources. Accordingly, Ausgrid has not experienced the technical impacts of distributed energy resources to a material degree. See: Ausgrid, submission to draft report, p. 1.

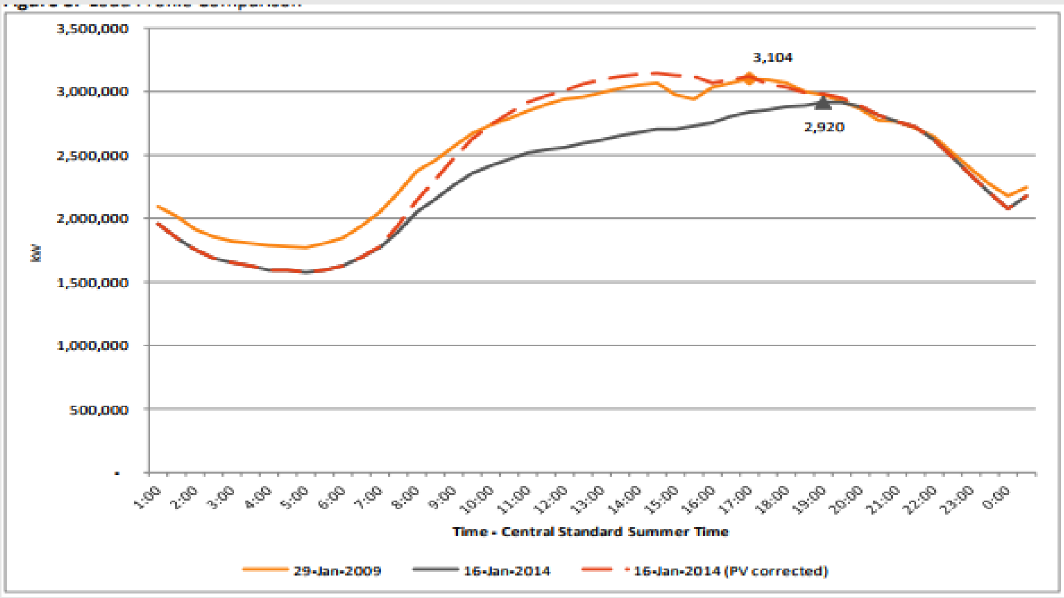
26 For example, the UTS Institute for Sustainable Futures has developed a network opportunity map, which seeks to inform the market about locations where investment in demand management and renewable energy may reduce the need to invest in poles and wires assets. See: https://www.uts.edu.au/research-and-teaching/our-research/institute-sustainable-futures/our-research/energy-and-climate-1

Box 2.2 Example: South Australian Power Networks

Since 2009, SA Power Networks (SAPN) has experienced a significant increase in the level of installed solar PV systems, from negligible penetration levels of less than 20 MW in 2009/10 to installed capacity in excess of 734 MW in 2015/16. This represents more than a sixth of SAPN's peak system demand, and has resulted in SAPN having the equal highest PV penetration levels as a proportion of system demand in Australia. As a proportion of SAPN's 850,000 customers, approximately 25 per cent have a PV system installed.

This has altered the supply-demand balance in most, if not all regions in South Australia. The figure below provides an indication of the effect these PV systems have had on both the daily demand profile since 2009 as well as on shifting the peak demand period at a zone substation level from the traditional 17:00 to 18:00 hours period to 19:00 to 20:00 hours.

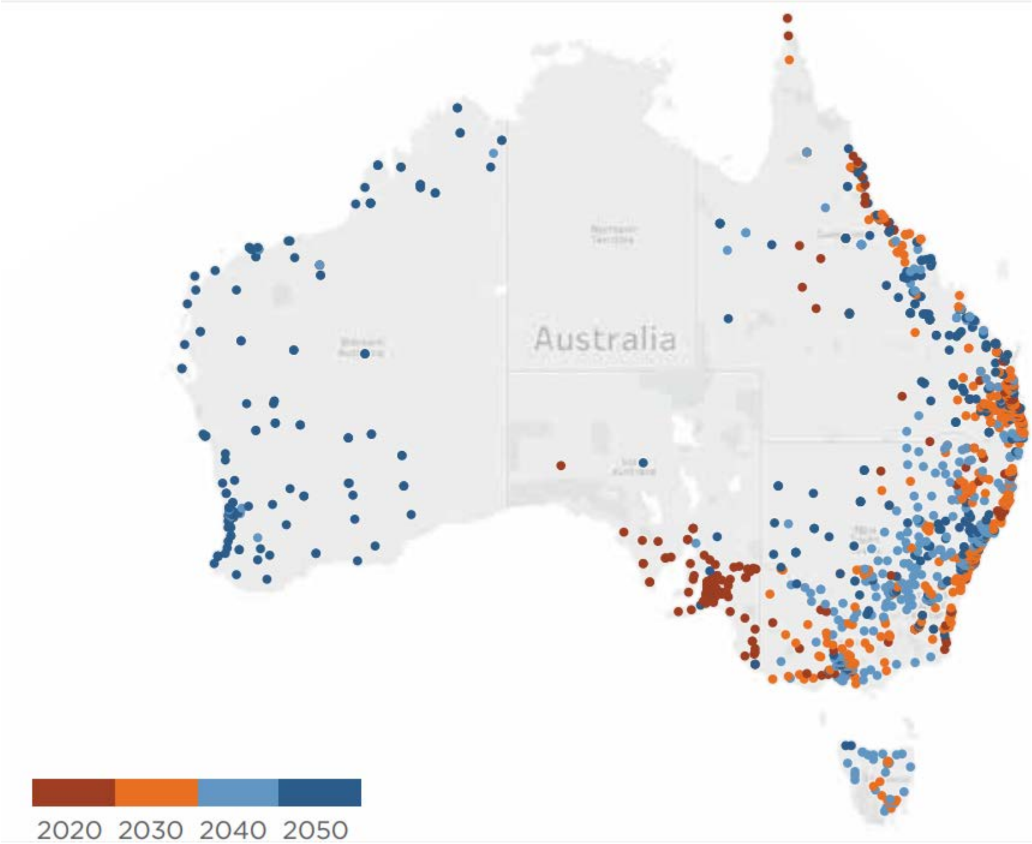
Figure 2.2 Load Profile Consumption



Source: SAPN, Distribution Annual Planning Report 2016/17 to 2021/21, 2016.

Figure 2.3 indicates the projected decade in which zone substations in Australia will reach a threshold penetration of rooftop solar PV adoption (40 per cent). This metric is indicative of reverse power flow i.e. distribution networks having to actively manage two-way flows across their network. The figure demonstrates how different areas of the network will reach threshold penetrations at different times. South Australia is clearly going to experience these issues significantly ahead of other areas of Australia.

Figure 2.3 Decade in which zone substations likely to experience reverse power flow



Source: Energy Networks Australia and CSIRO, Electricity Network Transformation Roadmap: Final report, April 2017.

The Commission considers that the capability of most of Australia's DNSPs to recognise and resolve these impacts is improving, particularly given that the networks were not originally configured to deal with distributed energy resources e.g. there is little monitoring equipment on low voltage parts of the network. As a result, most existing, small distributed energy resources (<5kW) have been connected without detailed analysis of the incremental impact they would have on the network.

Further, the majority of distributed energy resources installed to date, such as rooftop solar PV, are 'passive' - that is, they have no capability for remote communication or control, aside from whatever metering capabilities are installed. These distributed energy resources therefore have limited capability to provide services to anyone other than the person who owns it. A failure to gain an awareness of and address the technical impacts of an increased uptake of distributed energy resources may have a significant impact on the DNSP's ability to fulfil its obligations to provide a safe, secure and reliable supply of electricity to consumers. The owners and operators of distribution networks will therefore adapt to accommodate an increased uptake of distributed energy resources.

However, it is generally not clear how different distribution networks are evolving. Progress varies across DNSPs, depending on the specific issues that each DNSP faces.[27] As a result, consumers and businesses have different experiences in different network service territories, and the impact of distributed energy resources on wholesale market operations is less transparent.

2.3 Distributed energy resources will increasingly affect wholesale market outcomes

Distributed energy resources can also affect power system security at the transmission level and demand patterns at the wholesale level.

AEMO is responsible for power system security, and has noted that in order to manage power system security in an environment where there is a high penetration of distributed energy resources more management tools may be required.[28] AEMO manages power system security by balancing demand needs with available supply through the wholesale market dispatch process. It notes that distributed energy resources have common drivers - such as those discussed below - that underpin their operation, which affects AEMO's ability to forecast demand and to plan for contingency events.

- AEMO notes that, historically, load forecasting has relied on the underlying diversity of consumer behaviour, which means that not all appliances are used at the same time in the same ways. Those that are used at the same time, for example air conditioners, are correlated to weather patterns and so can often be predicted. However, AEMO notes that some distributed energy resources are either undiversified (e.g. rooftop PV which, in a particular region all just generate because the sun is shining, or all not generate due to it being cloudy or night-time) or less predictable in how they operate (e.g. batteries controlled by algorithms set by energy service providers), which can, in aggregate, offset the underlying diversity in consumer demand and change the daily load profile and makes load forecasting more challenging.

- AEMO also notes that an understanding of how load, in aggregate, will respond to system disturbances is important to the ability to manage power system security. Without visibility of how distributed energy resources are programmed to respond to certain system disturbances, such as changes in voltage or frequency levels, AEMO says it is unable to plan efficiently for contingency events.

And, although the use of air-conditioning is forecast to increase, a combination of energy efficiency and rooftop PV means that summer maximum demand for electricity is forecast to occur later in the day and not grow over the next 20 years, while winter

27 For example, the AER recently allowed Energex $25 million to invest in monitoring and remedying issues caused by high levels of solar PV generation. See: AER, Final Decision, Energex determination 2015–16 to 2019–20, Attachment 6 – Capital expenditure, October 2015.

28 AEMO, Visibility of distributed energy resources, January 2017.

maximum demand is forecast to grow faster and become comparable to summer maximum demand from around 2030.[29] These changes will affect the operation of the NEM and the investment decisions of those participating in it. For example, AEMO has forecast that by the end of 2026-27, continued uptake of PV is projected to result in negative minimum demand under certain conditions. This leads to net exports from the distribution network to the transmission grid in aggregate and ultimately from the NEM region during those periods.[30] AEMO is currently investigating the technical limits of the power system with high penetrations of distributed energy resources that cannot be controlled or constrained down like scheduled generation.

2.4 The way we think about the 'design' of distribution systems is changing

Distributed energy resources have a range of technical capabilities, including the provision of energy, voltage control, frequency regulation and reactive power. These capabilities can be used to provide a range of services that are of value to a number of parties, including consumers, retailers, energy service providers, AEMO and network businesses. As a result, a range of parties are able to benefit from the services that distributed energy resources can provide. This was recognised by Energy Networks Australia and CSIRO *Network Transformation Roadmap* that considered the range of benefits distributed energy resources are capable of providing to the electricity system. For example:

- Consumers may use distributed energy resources to manage their demand, reduce their reliance on the grid, maximise the value of their solar PV system, provide back-up supply or arbitrage their retail tariff. Consumers are also expressing an increasing desire to 'trade' the energy they generate with others, otherwise known as peer-to-peer trading. These services are described as 'customer services' in Figure 2.4.

- DNSPs or TNSPs may procure the services provided by distributed energy resources to help them provide common distribution or transmission services, such as reducing peak load in order to defer network augmentation,[31] or to help manage the technical characteristics of their networks, such as those set out in Box 2.1. These services are described as 'network services' in Figure 2.4.

- Electricity retailers, energy service companies or aggregators may use the electricity generated and/or consumed by distributed energy resources in aggregate to manage their risk of participating in the NEM, or for actual participation as a generator in the NEM. These services are described as 'wholesale services' in Figure 2.4.

29 AEMO, National electricity forecasting report, June 2016, p. 3.

30 AEMO, South Australian Demand Forecasts, South Australian Advisory Functions, June 2016, p. 4.

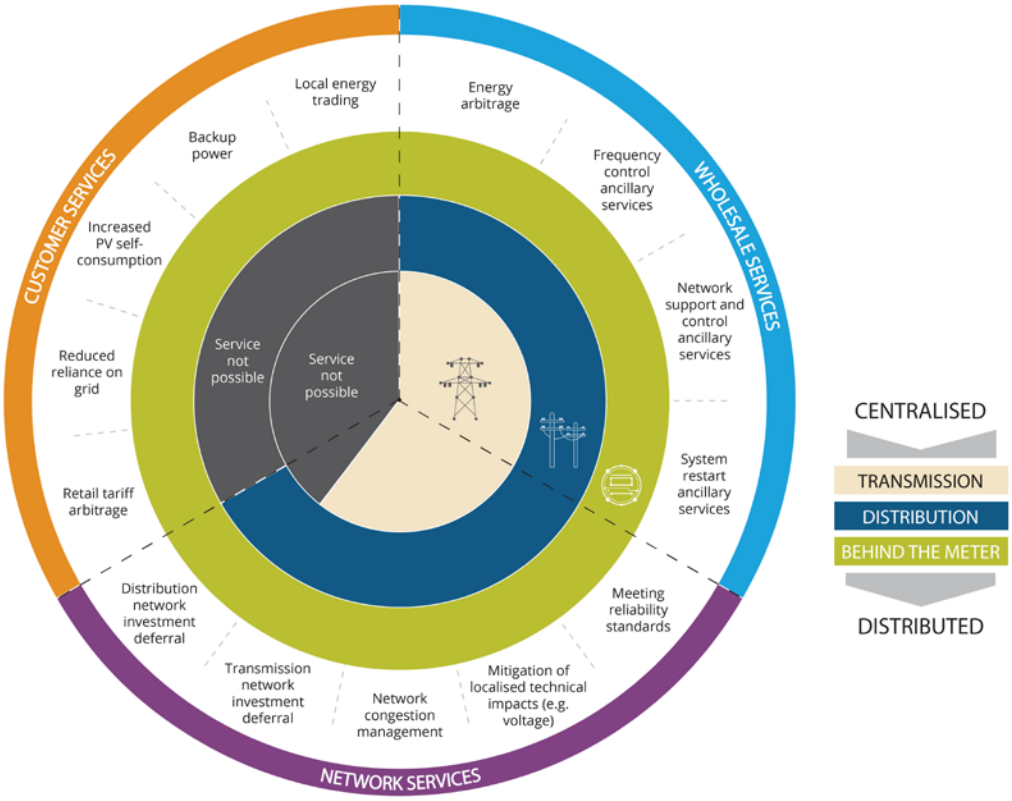
31 For example, in its submission to the approach paper, CitiPower and Powercor referenced modelling that it had undertaken that found that, over the next 10 years, distributed energy resources could have a material augmentation deferral value on some of its zone substations. See: CitiPower and Powercor, submission on approach paper, p. 2.

- Other parties may use distributed energy resources to provide ancillary services, such as frequency control ancillary services, to AEMO. These services are also described as 'wholesale services' in Figure 2.4.

As shown in Figure 2.4, distributed energy resources are capable of providing a range of services to a number of different parties.

If distributed energy resources are 'smart', all of these services can respond in real or near real time. As set out in section 1.4, most distributed energy resources installed to date are not smart. However, the Commission expects that, over time, these sorts of systems will become smart as standards continue to be updated, if incentives or obligations to do so exist and if the cost of doing so is not prohibitive.[32]

Figure 2.4 The multiple value streams of distributed energy resources



Source: This is based on a diagram that was developed by the Rocky Mountain Institute but has been adapted for the Australian context.

Note: The diagram should be read from the outer edges inwards. The coloured concentric circles in the centre illustrate where the distributed energy resource is connected. The grey areas indicate where the physical location of a distributed energy resource means it cannot provide particular services. For example, a battery storage system connected at the distribution or transmission level cannot help an individual consumer reduce their reliance on the grid.

32 We note that Australian Standard 4777.2:2015 prescribes mandatory and voluntary demand response and power quality response modes for all inverters installed after October 2016.

Each of these services is a potential source of revenue, but not all of them can be monetised together - that is, by the same distributed energy resource at the same time. For example, a battery could be used to alleviate network congestion (by being discharged) or to decrease frequency (by charging), both of which could be required at the same time.

The party who controls the distributed energy resource is therefore required to make trade-offs between the value they place on utilising or selling the various services that the distributed energy resource is capable of providing at any point in time. For example, one consumer might place a high value on having backup power, and so not provide network or wholesale services in order to have their battery fully charged as often as possible. Another consumer might place a higher value on the payment its local DNSP provides them in return for use of their battery at times of network congestion.[33]

Box 2.3 Peer to peer trading

Peer to peer trading is an additional customer service that could be provided by distributed energy resources. Peer to peer (p2p) trading of electricity is a relatively new concept that has yet to achieve major uptake, but is generating significant interest in markets round the world. While they remain largely hypothetical at this stage, significant benefits have been theorised.

In a p2p system, households could purchase electricity directly from owners of small-scale distributed energy resources, such as solar PV and batteries. Conversely, owners of distributed energy resources could sell their output directly to other households rather than via a retailer or feed-in tariff.

To a certain extent, p2p markets in electricity represent an accounting exercise rather than a real physical trade. Electricity is not a tangible good. At the point of consumption all electricity is functionally equivalent, regardless of whether it was nominally purchased from a neighbour or a distant large generator. However, this aspect is no different from existing arrangements in the market, where households (for example) purchase energy via retailer that is linked to a particular mix of generation.

By choosing one retailer over another, a consumer sends a signal for the relative amount of generation produced by that retailer's portfolio to increase. Similarly, by purchasing (for example) locally generated electricity on a p2p market rather than relying purely on 'traditional' markets, households would send a market signal for an increase in this type of generation.

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33 Some stakeholders made comments about this diagram. For example, S&C Electric Company considered that distributed energy resources would not be able to provide black start capability; however the Commission is aware of some new technology companies exploring the use of distributed energy resources for this purpose. The Total Environment Centre commented that this diagram is missing 'local energy trading,' - see Box 2.1 - which has now been added in to the diagram.

Peer to peer trading of electricity requires the following four components to take place:

1. Generating energy - there needs to be a critical mass of households and other small-scale entities with distributed energy resources.

2. Providing identity - there must be means to verify that participants in p2p trading are who they say they are.

3. Transporting energy - there needs to be a network or other means of transmitting energy from small-scale products to consumers.

4. Attributing exports and consumption - there must be reliable ways of determining how much energy each participating household has exported and consumed, and will therefore be billed for.

Crucially, elements two and four are required in order to engender *trust*. Participants will be reluctant to transact with each other without a framework that gives them confidence that they are trading with legitimate entities, and that their agreements will be honoured. For example, if a consumer is paying another household to discharge their batteries at a certain time, they must be confident their payments really are going to that household, who will discharge their batteries as promised.

One technology that may turn out to be useful in surmounting the challenges described above is DLT or digital ledger of transactions, which is shared instantaneously across a network of participants. Blockchain, which forms the basis of bitcoin and other cryptocurrencies is one example of a technical component of the digital ledger that refers to the chain of transactions that comprise the ledger. Specifically, digital ledgers records the history of all transactions ever made in units of a particular resource, which are known as 'tokens'. Entries on the ledger assign ownership of a certain value of the resource, or number of tokens, to whoever holds the 'key'. This may, in practice, be an individual or business.

Due to the mathematical and cryptographical techniques used, as well as the fact that multiple copies of the data are held and stored by different users at any given time, it is considered to be either extremely hard or impossible to fake new entries to the ledger. The ledger is also publically accessible and verifiable, meaning that anyone (with sufficient computing power) can audit the history of transactions. This makes it difficult to steal or fake anybody else's tokens, which engenders a high degree of trust.

For the purposes of p2p energy trading, some form of metering will be necessary to record electricity generated, imported or exported by participating households. Importantly, if p2p trading is to operate concurrently with existing markets, these units of energy will need to be recorded separately from electricity purchased via ‘traditional’ intermediaries such as retailers. This may require more sophisticated metering arrangements than are currently the norm.

Information regarding electricity generation, export and consumption could be converted into tokens, which will then be allocated between different participants based on the trades which have taken place. The tokens will then be exchanged for 'money' - either a cryptocurrency based on blockchain, or a 'traditional' currency such as Australian dollars.

One feature of such trading is that transactions can be verified by members of the public. This means that theoretically, the system could operate with little or no external oversight. For example, demand response and decentralised energy services could be traded directly between households and DNSPs. This could have the potential to save on third-party costs (assuming the cost of running the platform itself is relatively low.)

Recently, some trials of peer to peer trading have been announced. For example, AGL is using blockchain technology to allow users to trade surplus energy generated from rooftop panels in a pilot desktop trial. The Melbourne scheme, which is partly funded by a $120,000 grant from ARENA, aims to determine the regulatory and system changes needed to make the market work effectively.[34]

The Commission is interested in the findings from this trial in order to better understand what some of the potential issues (e.g. are there taxation or metering implications) are associated with p2p trading.

Sources: Allens Linklaters, Blockchain Reaction: Nine months on, April 2017; J Murkin, R Citchyan and A Byrne, Enabling peer-to-peer electricity trading, 4th International Conference on ICT for Sustainability, 2016; J Lanchester, When Bitcoin Grows Up, London Review of Books, Vol. 38 No. 8, 21 April 2016.

Historically, the development of distribution networks, and the regulatory arrangements that underpin them, has been focused on DNSPs providing sufficient network capacity to meet increasing consumer demand while maintaining the safety, reliability and security of the network, at lowest cost. There is no 'distribution-level market' as such - DNSPs provide the common distribution service (that is, the provision of the poles, wires and other services to physically enable the supply of electricity to consumers) and the wholesale market produces electricity independently of the provision of the common distribution service.

There are currently few ways for consumers to signal at a particular point in time whether they would value providing services from their battery to a DNSP or an aggregator, or using the energy themselves. While there are some price signals currently existing (e.g. the wholesale spot price), this relies on consumers "seeing" this price and it being passed through to them by either their retailer or their chosen energy service provider, and then the consumer making a decision. But, there is no way for the

34 See: https://leadingedgeenergy.com.au/energy-trading-experiment/

DNSP to send a real-time price signal to consumers with distributed energy resources that they need the services of a distributed energy resource.[35]

We are seeing retailers starting to aggregate the combined capability of consumers' batteries to participate in the NEM, but this typically locks in the resources to only providing services to the wholesale market. Similarly, DNSPs are starting to procure services from consumers batteries, sometimes via an aggregator, to help manage peak demand, but this also means that the consumer is typically only providing one of the value streams it is capable of (although it is likely also indirectly benefiting from an reduced bill). Therefore, the Commission considers that there needs to be a way for consumers to buy and sell energy and related services at the distribution level in a more dynamic way, in response to price signals and their preferences.[36]

In light of the increasing uptake of distributed energy resources and the range of services these technologies are capable of providing, decisions about how the distribution system operates and the associated regulatory arrangements are likely to require greater consideration of two issues:

1. The value from **optimising** investment in and operation of distributed energy resources. As discussed above, distributed energy resources can provide a range of services that cannot all be provided by the same distributed energy resource at the same time. Optimisation provides a way to send signals to whoever has control of the distributed energy resource to provide the service that will deliver the most value at that point in time. An optimising service, gives consumers the ability to maximise the benefits of an investment in distributed energy resources by enabling them to, if they choose, receive the maximum possible benefit of utilising and selling the full range of services that the distributed energy resource is capable of providing, given transaction and information costs, and technical constraints.

   Consumers may choose to 'optimise' the operation of their distributed energy resources themselves, or give this function to an agent, for example their electricity retailer or energy service company, to optimise the resource's operation on their behalf. The ability to optimise the use of distributed energy resources is also likely to lead to greater uptake of distributed energy resources as the returns from investments will be increased.

35 Obviously, more longer-time price signals can be provided by a DNSP through use of a RIT-D process.

36 We note that some trials of more dynamic methods of buying and selling electricity services are underway. For example, the decentralised energy exchange (deX) project, funded by the Australian Renewable Energy Agency (ARENA) and led by GreenSync. The deX provides a marketplace for households and businesses with rooftop solar and batteries to trade with each other and also with network operators. This will allow households and businesses with rooftop solar and batteries to trade with each other and also network operators. The AEMC is participating in the reference group for this trial. See section B.2.7.

2. The value from **coordinating** the operation of distributed energy resources with the wholesale market. That is, consideration of how distributed energy resources can, in a technical, commercial and regulatory sense, provide customer services, network services and wholesale services. The only way for distributed energy resources to provide services to be used in transmission-level markets is first to access such a market by using the distribution network.[37]

Further discussion of both of these issues is set out in chapter 3.

37 The party will also need to have some form or relationship with a registered participant in order to participate in the wholesale market.

3 Optimising and coordinating investment in and operation of distributed energy resources

Optimising the provision of the multiple services provided by distributed energy resources to the parties who value them is likely to result in efficient investment in, and operation of, distributed energy resources in both the long- and short-term. It is also likely to result in more efficient investment in, and operation of, assets that are not distributed energy resources e.g. the networks themselves. Optimisation is therefore likely to become increasingly valuable and important as the number of distributed energy resources installed increases.

3.1 The need for a market-based approach

There are a range of ways to maximise the value of investing in and operating distributed energy resources, from centralised control over their installation and use, to a fully market-based approach with nodal prices and other signals driving investment and usage decisions. There are costs and benefits of any approach. For example, centralised control over the installation and use of the services provided by distributed energy resources may make it easier for DNSPs to manage their networks in a technical sense, but would not support consumer choice or maximise the value of all services that those resources are capable of providing. Centralised planning, and decision making directly by governments or regulated entities, may achieve an orderly rollout of distributed energy resources. Some of the services that could be provided by distributed energy resources are currently provided by regulated DNSPs.

This appears to largely be the approach taken by the New York Public Service Commission, which is implementing the Reforming the Energy Vision (REV) initiative, which, among other things, seeks to transform distribution network businesses into platform providers for an energy market at the distribution level. The initiative subsidises particular investments and technologies, and includes direct investments by regulated energy businesses, with the subsidies paid for by all electricity consumers.[38] However, a centralised planning approach will likely foreclose the considerable potential benefits of a well-functioning market, and may result in trade-offs being made between different objectives by governments on behalf of consumers. It also means that consumers, not competitive businesses, bear the costs of investment risk. Gilbert and Tobin noted in a recent paper that "quite how [the REV] will ultimately look, or whether it will work at all, remains open to debate in the context of a US legal system that allows significant protection for utilities in relation to their regulatory assets and reasonable capital returns".[39]

38 See: http://www3.dps.ny.gov/W/PSCWeb.nsf/All/CC4F2EFA3A23551585257DEA007DCFE2?OpenDocument

39 Gilbert + Tobin, Wrestling with the electricity market transformation, 2017, p. 35.

The Commission considers that, regulation, however well designed, is likely to be a second-best alternative to well-functioning markets at promoting economic efficiency in the long-term interests of consumers (see Box 3.1). Markets put consumers at the heart of decision making. Through markets, technologies and business models that promote value to consumers (as indicated by their individual consumption and investment decisions) will thrive, while those that do not will fail. Markets provide incentives for companies to innovate, either by reducing their costs and passing these savings to consumers in order to remain competitive with their rivals, or by providing new or improved services that are valued by consumers.

Box 3.1 The role of markets

A key feature of markets is that, to a large extent, operational and investment decision making is made by individual parties (companies or individuals) in a disaggregated manner, based on the price of that product or service being bought or sold and the value they derived from that product or service. For these decisions to be efficient:

- price signals need to be sufficiently reflective of the underlying supply and demand conditions for the provision of that product or service
- decision makers need to be exposed to the price signals of as many services as possible.

If the above conditions are not satisfied, price signals will incentivise parties to participate in the market in a way that maximises their individual value, not in a way that is efficient for the system as a whole. An example of this is demonstrated in the direction that consumers choose to face their solar PV panels. Most consumers have historically chosen to face their panels north, even though the output of those panels would be greater at the time of peak network demand if they faced their panels west. So while west-facing panels would produce less total energy, they would produce it at times when it was more valuable, which would reduce network costs to all consumers. However, under existing retail pricing arrangements and feed-in tariff structures, consumers benefited more from facing them north and therefore had no incentive to face their solar panels west.[40]

This outcome is inefficient because the total system value is not maximised, and costs are being imposed on parties that did not cause those costs and have no means to manage them. Economists describe this concept as an "externality". In this context:

- a negative externality imposes costs on parties *other than* the party who controls the distributed energy resource, which means that the party who controls the distributed energy resource does not have a strong financial incentive to limit these costs

40 See: AEMC, Distribution network pricing arrangements, final determination, pp. 38-40.

- a positive externality creates benefits that are not captured by the party who controls the distributed energy resource but instead accrue to other parties, which reduces the controller's incentive to take these actions, even if they would maximise the value to the whole system. The direction in which consumers place their solar PV panel is an example of a positive externality.

For a market to function well, these externalities should be "internalised" to the extent possible - preferably through accurate price signals across as full a range of services as possible. As is discussed in section 4.2, cost-reflective price signals are an important precursor to efficient investment in and operation of the services provided by distributed energy resources.

Therefore, the Commission considers that any evolution of distribution systems needs to be an evolution where consumers and their chosen energy service providers are in the driving seat. This will give these parties more control over how their distributed energy resources are used. The Commission also recognises that while there needs to be consideration of how regulatory and market frameworks should evolve to facilitate choice, that evolution must occur in a way that maintains a safe, secure and reliable supply of electricity.[41] The evolution should balance the benefits from the customer-led roll out of these technologies, with the needs of networks to manage the system impacts.

A transactive market platform - a distribution-level market - provides a mechanism through which the various services that can be provided by distributed energy resources can be bought and sold in a more dynamic way, in response to price signals and consumer preferences. This means that if consumers want to use the electricity from their solar panels or batteries, they can, and if they do not need it - or value the income more from selling it more than their own use - they can sell it to whoever values it the most at a particular point in time e.g. the local network or the wholesale market. Stakeholders were largely in agreement with this vision that was discussed in the draft report.[42]

These concepts of a distribution-level market are being considered by a number of organisations and in different international jurisdictions:

41 This sentiment was expressed by the Energy Networks Australia in their submission to the draft report, specifically that the report should consider how do we optimise investment in, and operation of, distributed energy resources while maintaining reliability, quality and security of supply. See: Energy Networks Australia, submission to draft report, pp. 8-9. Similar comments were made by Energy Queensland (submission to draft report, p. 4).

42 Submissions to the draft report: AGL, pp. 3-4; ENGIE Australia, p. 1; AusNet Services p. 1; AER, p. 1; ENGIE, p. 1; John Herbst (private individual), p. 2; S&C Electric Company, p. 1; Tasmanian Renewable Energy Alliance, p. 1; Alternative Technology Association, p. 1; Australian Solar Council and Energy Storage Council, p. 1; Energy Consumers Australia, p. 1; Greensync, p. 2.

- the Victorian Essential Services Commission discuss an efficient market for grid services that could be used to deliver payments to small scale distributed generators that reflect the true network value produced by their investment[43]

- the CSIRO and Energy Network Australia's *Network Transformation Roadmap* discusses the concept of a "network optimisation market", which would facilitate network procurement of distributed energy resources services, with such markets maturing over time and more sophisticated technology to digital network optimisation markets'[44]

- Ofgem is also looking at the fundamental changes taking place within the energy markets in the British electricity sector. Ofgem is considering ways to open up new markets (including the creation of markets for services at the distribution network level), improve coordination across the system and enable businesses to realise the true value of their services. This will allow, amongst other things, providers of distributed energy resources, to combine various value streams.[45]

These concepts are very much in alignment with what the Commission is suggesting with the creation of a 'distribution market'.

However, there are two main differences between the examples in the Australian context. First, the Commission considers that any market at a distribution level should be thought of as a two-way platform, that is:

- consumers (supply-side) need a way to express their preferences and respond to price signals about how their distributed energy resources can be used i.e. distributed energy resources need to be visible and dispatchable, taking into account consumer preferences, while

- electricity market participants and networks (demand-side) need a way to signal what they are willing to pay for services from distributed energy resources.

Therefore, the market is essentially a matchmaker: it allows consumers, electricity market participants and networks to trade distributed energy services, as well as providing information so that new products and services can be developed for use in such a market. As markets become more sophisticated, such a platform can allow consumers, as well as the whole electricity system, to capture benefits created by the different locations and generation times of distributed energy resources. This differs from the discussion in the CSIRO and Energy Network Australia's Roadmap, which is largely focussed on the buy-side i.e. how *networks* alone could use such platforms to procure distributed energy resource services. The Commission considers that any such consideration of distribution-markets need to be approached from the broad

43 Essential Services Commission, The Network Value of Distributed Generation: Distributed Generation Inquiry Stage 2 Final Report, February 2017, p. i.

44 Energy Networks Australia and CSIRO, Electricity Network Transformation Roadmap: Final Report, April 2017, p. 78.

45 Ofgem, Upgrading our energy system: Smart systems and flexibility plan, July 2017.

perspective of facilitating trading of a large number of participants, and for all of the services that distributed energy resources could provide.

Second, related to the point above, the Commission considers that the role of *consumers* is key in the development or evolution of any distribution-level market. Consumers are seeking greater control over their distributed energy resources and usage, as well as access to new revenue streams from participating in electricity markets. As noted above, consumer-led investment in distributed energy resources means that consumers will drive the uptake of their technology through their choice of products and services. Under such a framework, consumer choices and preferences will influence the level of penetration of distributed energy resources and the types of products and services that are offered. In order to facilitate such a competitive-market, which leads to innovation in products and services, it is essential that consumers can express their preferences through the market. It is only then that there will be efficient use of, and investment in, distributed energy resources across the sector.

The provision of the services provided by distributed energy resources in response to market-based signals has a number of benefits, including that:

- in the short-term, service providers are incentivised to provide services that are valued by consumers, and which are competitively priced
- over the longer-term, service providers innovate in response to consumer demands, and pass a proportion of the value of this innovation through to consumers, either through lower prices, higher service levels of different service offerings.

Nevertheless, there is likely to be a continued role for regulation in any future operation of the distribution system.[46] This is for three main reasons:

1. The fundamental role of a market is to match buyers and sellers and to make sure that, in aggregate, supply matches demand, taking into account any technical constraints. In electricity, this requirement is particularly acute, since electricity cannot be stored (on a network at least). Consequently, any electricity market is likely to have to be "designed" so that electricity can be supplied safely, reliably and securely, including by imposing obligations on parties best placed to manage this requirement.[47]
2. Electricity consumer protections are likely to continue to be required in the future to support retail markets, for example with respect to the rights and obligations of retailers and consumers.

46 City of Sydney noted that it has reservations about the effectiveness of markets on their own to deliver optimal outcomes for electricity supply. See: Submission to draft report, City of Sydney, p. 1.

47 Energy Networks Australia noted that having confidence in minimum security outcomes will likely require regulation. See: Energy Networks Australia, submission to draft report, p. 9.

3. The supply of the common distribution service - that is the provision of physical network capacity to convey or control the conveyance of electricity in a distribution system (i.e. via the distribution network infrastructure itself) - is likely to continue to exhibit natural monopoly characteristics. This means that the provision of this service through competitive markets is unlikely to be in the best interest of consumers.

In the draft report, we talked about creating an 'optimising' function, in order to facilitate this market, which would be carried out by a party responding to price signals. However, numerous stakeholders provided feedback, and asked questions to clarify exactly what the Commission considered this function to entail.[48] In order to more clearly articulate what services and roles are necessary to enable and facilitate such a market, we consider that there are three different aspects that are needed:

- the optimising service - that is, the customer-facing, optional service aimed at maximising the value of distributed energy resources (what was described as the 'optimising function' in the draft report)
- the distribution system operation function - that is, who or what is responsible for maintaining distribution system security as issues become more localised (not addressed in detail in the draft report)
- network capacity provision - how network capacity is provided i.e. using traditional network build or distributed energy resources (not addressed in detail in the draft report).

We discuss each of these three aspects in turn below.

3.2 Optimising service

At its most basic level, the Commission wants to enhance consumers' ability to decide when the value of energy services to them is greater than the efficient costs of providing these services. Consumers will drive where distributed energy resources are installed, and how they are operated, since consumers are generally in the best position to decide what works for them. This is particularly the case with distributed energy resources that are capable of providing a range of services. Each of these services is a potential source of revenue (provided that they are services that other parties are willing to procure), but not all services can be monetised by the same distributed energy resource at the same time. The optimising service helps consumers (or their energy service providers) to make efficient investment and operation decisions - trading off value streams to maximise overall value.

A key question is who would perform this service, and how. The service could be carried out by multiple parties, including simply by market participants themselves

48 Submissions to draft report: AER, p. 5; AusNet Services, p. 1; Ausgrid, p. 3; SA Power Networks pp. 1-5.

(e.g. consumers or their chosen energy service providers) responding to price signals and the preferences of the customer.

Arguably, there are businesses already providing optimising services[49] but they possibly lack full visibility of the value of all services, or granular price signalling for those services to enable a really dynamic response. Wholesale services are largely already priced, but what is missing in the current NEM is an ability to dynamically price the benefits and costs of exports and imports to the system as a whole i.e. including the use of the networks. Currently, only one of these network components is priced: the cost of network used to supply electricity to consumers i.e. load.[50] Over time, once there is more information, there may be value in exploring ways in which the benefits and costs could be better measured and reflected. This would allow consumers to benefit from use of their distributed energy resources, where it provides value to others. These issues are discussed further in section 4.2.

Energy market arrangements should enable consumers to monetise as many of these potential sources of revenue as possible, in accordance with their own interests. In the Commission's view, the best way to achieve this is to develop energy market arrangements that promote consumer choice, while providing a level playing field for market participants i.e. through creating a competitive optimising service market.

In the Commission's view, a level playing field for the provision of optimising services is created if the following conditions are satisfied:

- The optimising service is provided by a party who does not have a specific interest in one or more of those services being provided, or in a particular way, and cannot exert market power or influence on the provision of those services. That is, the optimising service should be provided **separately from the provision of regulated services**. If the optimising function is taken on by a party who has a particular regulatory interest in the provision of a particular service (i.e. where the provision of that service has a higher value to the party who takes on the optimisation function than to what the consumer's preference would be), then that party is acting in accordance with its own interests and is unlikely to make decisions that result in the full value of that distributed energy resource being maximised.

- The optimising service is provided by a party who is **exposed to financial incentives**. Financial incentives provide an understandable and transparent approach to influence behaviour - in this case, the maximisation of all the

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49 For example, Reposit Power is an Australian-based technology company that has developed a software solution to aggregate the capability of residential storage systems. The company's GridCredits platform is designed to capture the value of residential solar PV and storage systems on the customer's behalf by maximising the customer's self-sufficiency and trading additional capacity in the wholesale market as an added value stream. AGL's South Australia Virtual Power Plant (VPP) also seeks to maximise the various value streams that could be extracted from distributed energy resources. See: AGL, submission to draft report, p. 4.

50 Governments may put a value of generation in the form of FITs, but FITs do not reflect the benefit to the system. The objective is typically different: around affordability and environmental concerns.

potential value streams that distributed energy resources are able to provide. Efficient outcomes are therefore best promoted when the commercial incentives on businesses are aligned with the interests of consumers.

These are discussed in turn below.

3.2.1 Separation of regulated and unregulated services

In the Commission's view, it would not be appropriate for a DNSP providing regulated services to provide optimising services because it does not meet the first criterion above. Under existing arrangements, DNSPs are responsible for the provision of common distribution services. They make investment and operational decisions about how to provide these services in accordance with their regulatory obligations.[51,52]

As the Commission set out in the *Integration of storage report*, there are three sets of behaviours from regulated businesses that have the potential to weaken competition to the detriment of consumers. Some form of ring-fencing should then apply where:

- The network business is able to cross-subsidise a competitive service from its regulated activities. A cross-subsidy may impede competition in the competitive market.
- In the course of performing its regulated activities, the network business acquires commercially sensitive information that may provide it with an advantage in a competitive market. Metering data or load profile data are examples.
- The network business is able to restrict competition in a competitive market by restricting access to infrastructure or providing access on less favourable terms than to its affiliate.

In November 2016 the AER completed the revision of the distribution ring-fencing guideline.[53] This new guideline imposes obligations on DNSPs to separate the legal,

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51 This was supported by the AER who noted that DNSPs do not always have incentives which coincide with the long-term interests of consumers, especially when it comes to competing in the provision of distributed energy resources. See: AER, submission to draft report, p. 2. Other stakeholders who supported this criterion include: Submissions to draft report: AGL, p. 4; Clean Energy Council, p. 1; Total Environment Centre, p. 3.

52 AGL also noted the KPMG report, which was prepared for the Australian Energy Council, which identified three risks under the Energy Network Australia's roadmap that could impede development of competitive markets in distributed energy resources: the ability for distributed energy resources to be co-optimised across multiple value streams could be constrained by the arrangements proposed by the roadmap; the ability of NSPs to procure distributed energy services directly from consumers is likely to impede the development of competitive distributed energy resource markets and limit the ability of distributed energy resources to capture the full value of its service; and potential conflicts of interest for the network businesses, especially if the distribution system operator role remains integrated within the distribution network service provider, as proposed under the Roadmap.

53 See: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/electricity-ring-fencing-guideline-2016

accounting and functional aspects of regulated distribution services from other services provided by a DNSP or an affiliated entity. The Commission is of the view that the guideline already prevents DNSPs providing optimising services because it prohibits them from receiving a number of the income streams. Effective monitoring and enforcement of compliance with this guideline is therefore essential to mitigate the risk of DNSPs engaging in the above behaviours and to create a level playing field for the provision of services that are provided on a contestable basis.

Even with effective ring-fencing, market participants may still perceive there to be a conflict of interest for DNSPs providing optimisation services, which may affect how those parties participate in that market and lead to inefficient outcomes.[54,55] Regulators do not have perfect information about the operation of these businesses or their interactions with other market participants. Concerns about how effective measures such as ring-fencing or the economic regulatory framework are at incentivising the preferred behaviours may undermine the desire of others to invest.

Therefore, the Commission considers that, in a future where the penetration of distributed energy resources is high, allowing regulated DNSPs to provide optimising services would not provide a level playing field for market participants. Ring-fencing arrangements may not be able to successfully address the risks or concerns identified above. Further, the concerns about regulated DNSPs being able to exert control over the distributed energy resources and foreclose access are more severe when considering *who* should be able to undertake an optimising service. If the DNSP was to offer an optimising service, and also be a purchaser of network services from distributed energy resources, it would be difficult for consumer preferences to be realised since it is likely that the DNSP would use the provision of the optimising service solely for network services, and so act in favour of itself.[56] This would impact negatively on consumer choice and competition.

The interests of a party who is responsible for providing common distribution services (i.e. a DNSP) are therefore unlikely to be truly independent from the function of optimising the various services that can be provided by distributed energy resources. Incentive-based regulation may provide some ability for DNSPs to consider the value

54 We note that Ofgem is looking at similar issues in its review of future arrangements for the electricity system operator. Ofgem proposes to increase the level of separation between the system operator and transmission operator functions of National Grid. It notes that, as the role of the system operator grows and becomes more complex, there is a need to re-evaluate real or perceived conflicts of interest, and to proactively think about further measures needed to manage or mitigate such conflicts. See: Ofgem, Future arrangements for the electricity system operator: its role and structure, January 2017, p. 25.

55 KPMG in their report for the Australian Energy Council note that perception of independence will be key for market confidence. See: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. xvii.

56 Similar conclusions were reached in KPMG's report for the Australian Energy Council, which noted that since the DNSP is a monopsony buyer of network services, consideration must be given to the risks resulting from DNSP's potentially advantageous position including making sure distributed energy resource owners are insufficiently informed or prepared to enter into such negotiations or contractual arrangements. See: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. xi.

of the provision of those services to other parties. But, the incentives on a DNSP may never be strong enough to allow it to generate benefits for other parties over its own operations. Indeed, incentive-based regulation is not designed to address the ability of DNSPs to exert control over the installation or operation of distributed energy resources and impact on competition.

Some stakeholders[57] argued that retailers (or aggregators) are also not 'independent' and have a specific interest in a particular value stream from distributed energy resources (i.e. the 'consumer' or the 'wholesale' value). However, retailers, including those that are vertically integrated, operate within a competitive market. Therefore, to the extent that these markets are competitive[58] the concerns above should not arise since competitive forces should prevent businesses from favouring one value stream over another. A consumer cannot switch to a different network, but a consumer can 'switch' to other retailers, or engage a third party energy service provider, where they can utilise more choice.

3.2.2 Exposure to financial incentives

In the Commission's view, efficient outcomes are best promoted when the commercial incentives of businesses are aligned with the interests of consumers. The view that financial incentives are likely to lead to more efficient outcomes is widely held (and practised) by regulators internationally, as well in Australia. While all entities are subject to various forms of incentives, financial incentives provide an understandable and transparent approach to influencing behaviour.[59]

The Commission considers that this is particularly important in the context of optimising distributed energy resources. Optimisation should be able to improve over time, adapting to the introduction of new technologies and becoming more efficient. This is best achieved where parties are incentivised to deliver the best value to consumers - those businesses that can deliver will be rewarded with higher shareholder returns and greater market share. Those who fail to innovate and provide value to consumers will exit the market. Therefore, the Commission considers that this is a key consideration in thinking through the optimising function.

3.2.3 Interaction with the wholesale market

It is also essential that whoever seeks to provide this optimising service interacts with the wholesale market, and has incentives (preferably) or obligations to do so. This will

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57 Submissions to the draft report: Clean Energy Council, p. 4; AusNet Services, p. 1; Energy Networks Australia, p. 20; Energy Queensland, p. 6.

58 The AEMC considers retail competition through our annual *Retail competition review,* while the AER monitors wholesale energy markets for compliance with the underpinning legislation and rules. The ACCC also has a role in this in relation to competition law.

59 This was largely supported by stakeholders who commented on this matter in their submissions to the draft report (e.g. AGL, p. 4), although we note that the Total Environment Centre considers that bodies that are clear and objective may be preferable.

assist with the coordination with the wholesale market.[60] Distributed energy resources are, by definition, connected to distribution networks and so, physically at least, can participate directly in any market for the provision of the customer or network services described above. However, for a distributed energy resource (presumably in aggregate) to provide wholesale services, it must first 'see' the wholesale price, and second 'access' the transmission network via the distribution network. While wholesale prices are visible, and there are not currently many technical constraints on distribution networks, this can occur. However, if either of these two conditions are not met, the operator of a distributed energy resource (or its agent) may be unable to maximise the full value of that distributed energy resource because it is unable to 'see' or 'access' transmission-level markets.

Stronger coordination between the provision of services at the distribution-level - e.g. to the DNSP itself - and transmission-level markets is therefore likely to be required to support the efficient operation of distributed energy resources and their participation at both levels. Stronger coordination relies on all relevant parties having sufficient information available to them and for this information to be reflected in price signals that reflect the value of providing all possible services, so that the buyers and sellers of those services can make efficient investment and operational decisions.

From a preliminary position, the Commission considers that there are a number of possible ways this could be achieved, including

- lowering registration/scheduling thresholds so that AEMO has visibility and control over more generation and load in distribution systems in the central dispatch process
- requiring all retailers to 'schedule' their customers' load and/or provide forecasts to AEMO
- imposing obligations on 'optimisers' with DER under their control to bid/offer net generation/load into NEMDE
- setting up a market operator for each distribution network, which could be AEMO itself, the DNSP or some other party.

Alternatively, there might not be a need to consider any of the above options if AEMO has much better visibility of all distributed energy resources and how they are operating, DNSPs have information that enables them to manage more localised technical impacts, and access arrangements are clear.

60 The need for better coordination with the wholesale market was recognised by KPMG in its report for the Australian Energy Council. It noted the example of the load control of hot water systems in South Australia, which has been considered to cause wholesale price spikes and voltage control issues for AEMO as an example of how, where use of distributed energy resources is not coordinated with other market impacts, as potentially being an issue. See: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. 23.

The Commission is currently considering how distributed energy resources could be more effectively co-ordinated with the wholesale market through its *Reliability frameworks review.*[61] This review is reviewing the regulatory and market frameworks needed to support a reliable supply of electricity as the power system transforms to include more variable, intermittent generation and greater variances in, and involvement from, the demand-side. It will consider whether any changes are needed to regulatory and market frameworks to support investment in dispatchable energy, to better allow for energy to be supplied when consumers need it. This will include consideration, amongst other things, of how distributed energy resources could be better coordinated with the wholesale market in order to provide more flexible resources (either demand-side or supply-side) to better manage reliability within the NEM.[62]

Finding 1

The AEMC will examine the ways in which parties providing 'optimising services' can better coordinate with wholesale market operations undertaken by AEMO as well as alternative ways of facilitating greater co-ordination between distribution level markets and the wholesale market through the *Reliability Frameworks Review*.

Dispatchable capacity can be supplied through:

- generation, including large-scale coal and gas plants, as well as some distributed energy resources such as battery storage
- demand response and other demand-side mechanisms, for example, when customers have a financial incentive to curtail their electricity consumption.

Therefore, in exploring these issues, the Review will explore ways in which parties providing optimising services could engage more directly with AEMO e.g. by increasing visibility of distributed energy resources, through considering mechanisms for demand response, or how distributed energy resources could provide flexibility to assist in making intermittent generation firmer.

3.3 Distribution system operation

As electricity cannot be stored (on a network, at least), supply must meet demand at all locations (near) instantaneously for that network to provide a safe, reliable and secure supply of electricity. In the NEM, the responsibility for making sure that supply meets demand lies with AEMO. It does this by dispatching mostly transmission-connected

61 See: http://www.aemc.gov.au/getattachment/acc5cedf-9ece-4550-8ec7-184540e37c4a/Terms-of-reference.aspx

62 In addition, the Commission notes that AEMO is currently engaging with networks on a number of initiatives to explore how power system operations need to evolve in order to maintain security and reliability in light of increasing levels of distributed energy resources.

generation in the least-cost manner to meet forecasts for demand across the system, taking into account physical constraints of the system and ancillary services requirements.

However, as more and more distributed energy resources as well as larger-scale generation are being connected to the distribution network, and two-way flows are being created, there is a need to consider more carefully the operation of the distribution system. It is important to point out that the Commission considers the existence of a safe, secure and reliable network is a prerequisite to any distribution-level market. In the absence of having a safe, secure and reliable network, there would be no market for consumers, and their chosen service providers, to get access to. In a world with high distributed energy resources, the network will be operationally complex. It will be necessary to make sure that the safe, secure and reliable network operation is achieved.

Therefore, it is essential that there is always a DNSP responsible for maintaining a safe, secure and reliable network.[63] Indeed, some networks noted that the design and capacity will always have physical limits that in some cases will constrain a market-delivered optimisation of distributed energy resource services.[64] There are certain parameters that will bind the use, and operation of the distribution network, in order to make sure the integrity of the network is not comprised. Owners of distribution networks will have a key part in undertaking this function.[65]

However, as noted above, there are also benefits from creating a distribution-level market. This can be thought of as increasing economic benefits by allowing for greater power transfers on the network, such as greater energy flows across certain parts of the distribution network, at certain times. It is important to understand the technical parameters under which this could occur. We understand that some DNSPs are already starting to explore ways in which increased visibility of the low voltage parts of their network could be obtained e.g. through smart meter and inverter data, and, importantly, how much of this data is needed. It is important to recognise that greater network visibility (such as communications and data systems) involves costs, and so when DNSPs consider these matters they should also consider the benefits that would be derived from this.

In order to balance the need to maintain a reliable system and maximise the benefits that can flow to consumers, the Commission considers it is important to gain a better understanding of what level of monitoring and control functionality DNSPs need over distributed energy resources in order to maintain system safety, reliability and security

63 Ausgrid noted that DNSPs need to continue to be an integral part of any future market model, providing a safe, reliable and secure electricity supply. See: Ausgrid, submission to draft report, p. 1.

64 Submissions to the draft report: AusNet Services p. 9; SA Power Networks, p. 1.

65 Some stakeholders recognised that DNSPs will need to transition to a system operator role. See: S&E Electric Company, submission to draft report, pp. 2, 5.

at different levels of distributed energy resource penetration.[66] The Commission therefore requests Energy Networks Australia, in consultation with its members, as well as relevant stakeholders, start to explore the tools and operational processes that are necessary for a DNSP to meet its regulatory obligations in a future with high levels of distributed energy resources.[67] This is related to several of the milestones highlighted in the Energy Networks Australia' Network Transformation Roadmap, specifically the milestones around developing approaches and protocols to address the management and exchange of information between networks and distributed energy resources participants and allow effective coordination of the system in real time, supporting full interoperability.[68]

The Commission considers that it is important that this question is considered not just in the context of today's regulatory environment and technology (where it is likely that the DNSPs would consider they need a high-level of control), but also in a future where distributed energy resources could be scheduled, and there is increased visibility on the network. In this sense the Commission would be looking to understand the technical operating standards that need to be maintained and then current and potential future ways of meeting these requirements.

Finding 2

Given the regulatory obligations that distribution network service providers (DNSPs) have to maintain a safe, secure and reliable network, the AEMC requests that Energy Networks Australia in consultation with relevant stakeholders (e.g. the Reliability Panel), start to explore what minimum level of control DNSPs need to have over distributed energy resources in order to enable higher levels of distributed energy resources for future distribution level markets, without compromising these regulatory obligations.

3.4 Network capacity provision

The third optimisation aspect is not necessarily a ‘regulated’ role, but rather the decision making process that a business goes through to determine whether and how network capacity is to be provided to meet their regulatory obligations in relation to having a reliable, safe and secure network. Currently, DNSPs have a regulatory

66 This is consistent with KPMG's finding that future work needs to establish clear and effective operational procedures and boundaries in relation to how a DNSP may use distributed energy resources, including a framework for governing how a DNSP would be allowed to curtail distributed energy resources when necessary to maintain network security. See: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. 40.

67 Energy Networks Australia notes that distribution networks are today addressing the impact of distributed energy resources on the network. Networks are increasing their capacity for monitoring and control; and adopting simple, relatively inexpensive solutions wherever possible, such as 'tapping down' the distribution transformer voltage. See: Energy Networks Australia, submission to draft report, pp. 9-10.

68 Energy Networks Australia and CSIRO, Electricity Network Transformation Roadmap: Final report, April 2017, p. 72.

obligation to supply load reliably. They make decisions about how to provide network capacity to meet that obligation in accordance with the incentive framework in the rules.

The key principle of network regulation in the NEM is that it is based on incentivising NSPs to provide services as efficiently as possible. It does so by locking in NSPs' revenue allowances prior to each regulatory control period. With revenue locked in, NSPs are incentivised to provide services at the lowest possible cost because their returns are determined by their actual costs of providing services. If NSPs reduce their costs to below the estimate of efficient costs, the savings are shared with consumers in future regulatory periods.

Under incentive regulation, it is not the role of the regulatory framework to determine what the ideal or efficient level of uptake of non-network solutions should be. Rather, the current framework provides a number of incentives and obligations for non-network options to be adopted where it is efficient to do so. For example:

- Regulatory investment tests for distribution require DNSPs to assess the costs and benefits of each credible investment option (i.e. traditional network build or use of non-network options) to address a specific network problem to identify the option, which maximises net market benefits (or minimises costs where the investment is required to meet reliability standards).

- Demand management incentive scheme and demand management innovation allowance: The DMIS will provide DNSPs with an incentive to undertake efficient expenditure on relevant non-network options relating to demand management. The scheme will reward DNSPs for implementing relevant non-network options that deliver net cost savings to retail customers. The DMIA provides DNSPs with funding for research and development in demand management projects that have the potential to reduce long term network costs. The allowance will be used to fund innovation projects that have the potential to deliver ongoing reductions in demand or peak demand.

A key part of these frameworks is that sufficient information is provided to consumers, i.e. those who provide distributed energy resources, so they can make efficient investment and operation decisions. The Commission recently made a rule in relation to the *Local generation network credits* rule change request.[69] The final rule requires DNSPs to publish information about expected system limitations, in accordance with a template prepared by the AER on distribution annual planning reports. The report will include information on:

- the name or identifier and location of network assets where a system limitation or projected system limitation has been identified through the forward planning period

- the estimated timing of the system limitation or projected system limitation

69 See: http://www.aemc.gov.au/Rule-Changes/Local-Generation-Network-Credits

- the proposed solution to remedy the system limitation
- the estimated capital and operating costs of the proposed solution and
- the amount by which peak demand at the location of the system limitation or projected system limitation would need to be reduced in order to defer the proposed solution, and the dollar value to the DNSP of each year of deferral.

The system limitation report will be published annually in conjunction with each DNSP's annual planning report. The AER's distribution annual planning report template was produced following the AEMC's final determination on the *Local generation network credits* rule change. The rule change required that the AER publish a guideline on the system limitations report. It is intended to be a living document that will evolve in response to stakeholders' needs in a timely manner.[70] By providing key information about system limitations in a consistent and accessible manner, the report will allow providers of non-network solutions to focus on locations where their solutions could be used to defer or avoid investment in the network. These reports will be a useful starting point for providing information to consumers. However, we expect that DNSP's will, over time, have access to much more dynamic temporal and locational data about these issues, which should be shared with consumers and market participants to support the development of distribution-level markets.[71]

Finding 3

DNSPs commit to developing and publishing more dynamic information about congestion (i.e. system limitations) and technical issues (e.g. voltage issues) at more localised levels of their networks. The AER, through its development and refinement of the Distribution Annual Planning Report template, will be able to monitor developments in this space and work with DNSPs to make sure such information is being provided on a meaningful, and consistent basis, across the different distribution networks.

70 See: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/distribution-annual-planning-report-template

71 This was supported by AGL who noted that DNSPs should make available sufficient and useful data about the characteristics and location of those network needs and the costs of alternative network investments. AGL, submission to draft report, p. 5. Similarly, by KPMG in its report for the Australian Energy Council who noted there need to be further consideration about how to provide effective and clear information to consumers regarding their distributed energy resource capability and how to maximise value from their investment. See: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. 30.

However, there may also be concerns that DNSPs are driven toward network solutions over contracts with other parties to provide network capacity because either:

- the current NER could incentivise capital expenditure over operating expenditure[72]
- many of the contractual relationships surrounding use of operational solutions are untested (e.g. in relation to how "firm" a particular aggregation of distributed energy resources may be, taking into account the fact that consumer choice is a key part of how distributed energy resources are used), and so, DNSPs may not engage such services in order to minimise their risks associated with not meeting operational requirements e.g. STPIS penalties.

This issue is outside of the scope of this project, and has been considered through the Commission's recent *2017 Electricity Network Economic Regulatory Framework Review*.[73] This review highlighted that though recent and ongoing changes to the economic regulatory framework have sought to strengthen incentives to NSPs to seek alternatives to traditional network solutions, some stakeholders remain concerned about biased incentives for NSPs to prefer capital expenditure. In response to this concern, for the 2018 edition of this review, the Commission will review financial incentives that network businesses face in delivering economically regulated services under the existing regulatory framework. This analysis will be particularly focussed on the financial incentives network businesses face to deliver their regulated services using distributed energy resource based solutions, relative to traditional network solutions.

The analysis would include assessments of the incentives network businesses face to undertake:

- capital or operating expenditure service delivery methods
- long or short asset life service delivery methods
- network or non-network service delivery methods
- in-house or third party service delivery methods.

The Commission will also examine frameworks that overseas regulators have adopted as a result of findings that their previous regulatory frameworks did not provide balanced incentives for service delivery methods. This will include the total expenditure based frameworks adopted in the United Kingdom for electricity, gas and water regulation. Under these frameworks the distinction between capital and operating expenditure (both in assessment and recovery method) is removed. This will

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72 This was noted by CEEM UNSW, who commented that the preference for capital expenditure over operating expenditure is likely to persist without more fundamental regulatory reform. See: CEEM UNSW, submission on draft report, p. 6.

73 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Electricity-Network-Economic-Regulatory-Framework

therefore address Finkel recommendation 6.8, that the AEMC should assess alternative models for network incentives and revenue-setting.[74]

However, in a world with significant amount of distributed energy resources, more significant changes may be required in the future. For example, in the way in which the network is planned, in how forecasts are developed, and how overall network performance is optimised. In order to move to such a world, this will require the development of new systems and techniques, and improvements in operational capability, as discussed above. One such aspect that may need to be considered further is whether more fundamental changes to the network capacity provision role are required.

3.5 Conclusion

Therefore, in order to have a competitive distribution-level market, the Commission considers that there are three distinct aspects that need to be considered:

- the optimising service - that is, the customer-facing, optional service aimed at maximising the value of distributed energy resources
- the distribution system operation function - that is, the party responsible for maintaining distribution system security as issues become more localised
- network capacity provision - how network capacity is provided i.e. using traditional network build or distributed energy resources.

The Commission has also set out our findings on how these aspects can be further progressed in order to make sure that we have flexible and resilient arrangements for the future. Appendix D sets out an indicative evolutionary path for distribution system operation. This is not intended to articulate a particular regulatory path or outcome, or predict the types or level of technology uptake in the future. But, considering this path has allowed us to assess what might be needed in order to facilitate the optimisation and coordination of investment in and operation of distributed energy resources across the whole electricity system, in order to further progress the three aspects described above.

Based on the discussion above, we have considered what the 'enablers' of these aspects are. These are discussed in the following chapters: chapter 4 focuses on the 'market aspects' and chapter 5 focuses on the 'technical aspects'. The Commission considers that these enablers are more short-term actions that can be taken to advance the development of distribution system operation, and more readily incorporate distributed energy resources into our markets.

74 This was supported by the Clean Energy Council it its submission to the draft report (p. 1).

4 Market enablers

This chapter sets out the Commission's views on the near-term enablers that are needed to underpin any future design of distribution system operations in a way that meets the objectives set out in appendix C. This chapter focuses on the 'market enablers', specifically:

1. information
2. network tariffs
3. network access and connection charging.

The Commission's preliminary views on these enablers were set out in the draft report. Stakeholders provided a range of views on each, which are referenced where relevant throughout this chapter.

4.1 Information

Markets work most efficiently when its participants have access to sufficient information to help them make decisions about how to invest and operate in that market. A functioning market for the optimisation of distributed energy resources is likely to have many participants, including consumers, retailers, aggregators, technology providers, network operators, system operators and market operators. Information, and equal access to it, is essential for optimisation and the competitive provision of the services enabled by distributed energy resources. It is also necessary to support the proper functioning of distribution networks and the power system as a whole in a way that is safe, reliable and secure.

The Commission considers that there are three main types of information that will be needed to support these outcomes:

- Information DNSPs need to better understand their networks and provide price signals to others.
- Information needed by parties providing optimising services, and consumers to inform how they use energy and to enable market participation.
- Information AEMO needs to maintain power system security.

Each of these is discussed in turn below.

4.1.1 Information DNSPs need to better understand their networks and provide price signals to others

As the uptake of distributed energy resources increases, the aggregate technical impact they have on distribution networks is also likely to increase. A DNSP's ability to effectively plan to resolve the needs of its network and connect new distributed energy resources will therefore depend on it having knowledge of what these needs are. Better, upfront awareness of the localised characteristics and capabilities of its network helps a DNSP to proactively manage issues as they arise and set connection requirements that are proportionate to the expected operation of the distributed energy resource.

The Commission understands that most DNSPs currently lack sufficient visibility of the technical capability and characteristics of lower-voltage parts of their networks – although this does vary between DNSPs. The focus of distribution operations to date has been on the provision of a reliable and safe supply of electricity to consumers based on one way flows of electricity from large, transmission-connected generators to consumers at the ends of distribution networks. Therefore, DNSPs have historically not needed detailed information about the technical characteristics of lower levels of the network, as this could largely be predicted.

However, as set out in section 2.4, the need to more actively manage distribution system operations is likely to increase as more distributed energy resources are installed and two-way electricity flows increase. This will mean that distribution systems need to be more actively managed, like transmission systems are currently. DNSPs will need much more information about the lower-voltage parts of their networks to better inform how they operate and invest in those networks. As noted in chapter 3, there are costs and benefits associated with this and so networks will need to consider the most efficient ways to collect information, as well as how much information and visibility that they need over their network.

Analysis and recommendations

Where, and what, distributed energy resources are being installed

A key part of helping DNSPs understand their networks is knowing what distributed energy resources are installed, and where.[75] The most cost-effective way to get this information is to collect it when distributed energy resources are being installed. Under the existing NER, information about distributed energy resources, including storage and solar PV systems that are connected to the distribution network by retail customers, should already be captured by DNSPs when processing a connection application or amending an existing connection agreement.[76] DNSPs' existing connection applications require consumers (or their agents) to provide certain information about proposed embedded generation, including type, size, make and model. Static information about the location and technical characteristics of distributed

75 SA Power Networks noted that DNSPs should invest now to better identify the location, and understand the use of, distributed energy resources within their networks and to manage the technical challenges they present. See: SA Power Networks, submission to draft report, p. 1.

76 In the Commission’s 2015 *Integration of Storage* report, we concluded that a retail customer seeking to connect storage capability at their premises to the distribution system with the intention of exporting electricity to the grid – whether in conjunction with a solar PV system or as a standalone device – would be captured by the existing definition of 'micro-embedded generator' in the NER, as long as the connection is of the kind contemplated by Australian Standard 4777 (Grid connection of energy systems via inverters). See AEMC, Integration of Storage, final report, December 2015, p. 74.

energy resources should therefore already be captured by DNSPs when they process a new connection.

Consumers may also wish to modify an existing connection to include distributed energy resources e.g. to install solar panels, or retrofit an existing solar PV system with storage capability. Under the NERR, small customers are required to inform the DNSP of any proposed change that it is aware of in plant or equipment, including metering equipment, or any change to the capacity or operation of connected plant or equipment that may affect the quality, reliability, safety or metering of the supply of energy to the premises or the premises of any other person. Small customers are also required to inform either the retailer or the DNSP of any permanent material change to the energy load or pattern of usage at the premises.[77]

The Commission understands that some DNSPs have raised concerns that consumers (or their agents) do not always inform them of modifications to existing connections.[78] Therefore, appropriate compliance and enforcement measures are needed to make sure that this occurs, and in a consistent manner across distribution networks.[79]

It is also worth noting that the COAG Energy Council recently agreed to initiate the development of a national register for distributed energy resources (solar generation and batteries) to be administered by AEMO.[80] A rule change proposal is to be developed by end August 2017 and the intention is to have the register commence operation by end 2018. Ministers noted that the rule change proposal may include revising rules for customer connection and/or retail contracts to clarify the information customers provide to distributors and/or retailers about distributed energy resources to provide a default national data collection option where jurisdictional arrangements are not in place.[81]

The COAG Energy Council also agreed that officials should work with AEMO to prioritise development of a standard format for collection of data on distributed energy resources. As an interim measure ahead of establishing the national register, Ministers noted officials will work with stakeholders, including network businesses, installers, AEMO and the Clean Energy Regulator to increase data collection of distributed energy resources, particularly storage equipment, which can be fed into the register once it is established. AEMO is currently working with officials to develop a standard format for the collection of distributed energy resources data.

77 See schedule 2, clause 6.2 (c) and (d) of the NERR.

78 In some instances this is because consumers may not have an incentive to do so, e.g. if notifying the DNSP would require them to upgrade equipment.

79 This view was shared by S&C Electric Company in its submission on the draft report.

80 The Energy Storage Council is also currently developing a battery storage register, which could also assist with increasing visibility on where batteries are installed in the NEM. See: Australian Storage Council and Energy Storage Council, submission to draft report, pp. 1-2.

81 See: http://www.coagenergycouncil.gov.au/publications/energy-market-transformation-bulletin-no-05-%E2%80%93-work-program-update

How distributed energy resources are being operated

In addition to knowing what distributed energy resources are being installed, and where, DNSPs are also likely to need information about how distributed energy resources are being operated to understand the localised technical impacts, if any, distributed energy resources are having on their network.

Investment in new equipment and smart IT/communications infrastructure is likely to be needed to provide DNSPs with detailed information about the technical characteristics of lower-voltage parts of their networks. Energy Networks Australia and SA Power Networks agreed with this conclusion in its submission to the draft report.[82] The costs of such an investment may be significant if the DNSP seeks a lot of granular data, in real time, at a number of locations across its network. DNSPs might seek a capital allowance for this form of expenditure approved by the AER, provided that it can demonstrate that the expenditure meets the capital expenditure objectives (i.e. its regulatory obligation to provide a safe, reliable supply of electricity), and that the costs of that expenditure are efficient.

The economic regulatory framework set out in the NER is designed to enable DNSPs to invest in a way that enables them to meet their obligations with respect to the supply of electricity to consumers. It is not yet clear to the Commission that the framework enables DNSPs to consider investments that help them better understand their networks and the impact of distributed energy resources when that investment relates to the supply of electricity - i.e. exports from distributed energy resources.

Some DNSPs have a threshold under which systems are automatically pre-approved for connection to the network. Therefore, many small distributed energy resources (<5kW) are connected without detailed analysis of the incremental impact they have on the network. The threshold differs between DNSPs and depends on the type of line a customer is connected to.[83] Information about the localised technical impacts of distributed energy resources can help a DNSP observe broader trends to make more informed decisions about how to operate its network, and whether and how to address any impacts through its investment and planning processes. This information can also be used to inform the development of network tariffs set by DNSPs, for example to incentivise or dis-incentivise the installation or operation of distributed energy resources in different areas of the network at different times.[84]

However, the Commission understands that very little information about how distributed energy resources are being operated is being collected. There are several possible reasons for this:

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82 Submissions on draft report: Energy Networks Australia, p. 15; SA Power Networks, p. 1.

83 Such observations were also made by KPMG in their report for Energy Consumers Australia. It notes that in Victoria, four of the five DNSPs have a threshold of 10kW, while AusNet Services has a threshold of 4.6kW. This may led to some confusion for customers, particularly those on the edge of AusNet Services network. See: KPMG, Residential PV: Customer Experiences and Future Developments, A report for Energy Consumers Australia, December 2016, p. 58.

84 Distribution network tariffs are discussed in section 4.2.

- There may not be the equipment or systems in place to support the creation or collection of this granularity of data, but this will likely change with the introduction of the competition in metering framework and the introduction of a new framework for B2B communications, both from 1 December 2017. Therefore, technological innovation, combined with relevant Australian standards, is seeing meters, inverters and battery storage technologies increasingly being equipped with the capability for remote, two-way communication of information. The Commission therefore expects that, over time, most distributed energy resources will have the technical capability to produce and share information about how it is being operated.

- The parties collecting and managing that data currently (e.g. energy service companies, or consumers themselves) may not be currently required to share that information. At existing levels of penetration, it may not be possible to draw strong conclusions about the broader impacts or benefits of distributed energy resources operation. However, as distributed energy resources uptake increases, as it is expected to do, this information will become increasingly valuable to those parties who operate the network, those who undertake the 'optimising' function and the system as a whole.

An important consideration is how granular such data on the operation of distributed energy resources needs to be. The Commission considers that not all parties need highly granular data on the operation of distributed energy resources down to the household level. For example, from a power system security point of view (discussed further below), AEMO is likely to only need information down to a zone substation level. The same is true for DNSPs to understand the localised technical impacts distributed energy resources are having on their network. Conversely, consumers may need access to more granular information, such as metering data, in order to understand what the best energy service offering is for them.[85]

As discussed in section 3.3 the Commission understands that DNSPs are currently exploring ways in order to improve visibility of the technical impacts of distributed energy resources on their network, and encourages further progression of this work.

4.1.2 Information needed by parties providing optimising services and consumers to inform how they use energy and to enable market participation

Efficient investment in and operation of distributed energy resources relies on parties providing optimising services having access to information about:

85 In 2014, the AEMC made new rules to make it easier for consumers to obtain information about their electricity consumption from distribution network companies and retailers in an easy-to-understand, affordable and timely way. Therefore, the existing NER: allow customers to obtain their electricity consumption data from their distributor as well as their retailer; allow other parties authorised by customers to request access to electricity consumption data from retailers and distributors; and requires retailers and distributors to comply with minimum requirements relating to the format, timeframes and costs when a customer, or a party authorised by that customer, requests electricity consumption data.

- where distributed energy resources could or should be installed
- the costs of installing and operating distributed energy resources on the distribution network
- any constraints (including network constraints) that may affect how the distributed energy resources are operated
- opportunities for distributed energy resources to provide services to other parties or markets, and the value that is placed on those services being provided.

This information is likely to help parties providing optimising services to tailor their service offerings in a way that maximises opportunities for the distributed energy resource to provide services to other markets.

Analysis and recommendations

In submissions to the draft report, some stakeholders highlighted the importance of DNSPs making available sufficient and useful information about the characteristics and location of network needs, and the costs of alternative network investments, to support investment in distributed energy resources.[86]

The AEMC's final rule on the *Local generation network credits* rule change request requires DNSPs to publish a system limitation report that includes, among other things, the location of network assets where a system limitation or projected system limitation has been identified, the DNSP's proposed solution to remedy the system limitation and the amount by which peak demand at the location of the system limitation or projected system limitation would need to be reduced in order to defer the proposed solution. Such information will enable providers of non-network solutions to better understand system limitations in distribution networks where their solutions could be used to defer or avoid investment in the network. The Commission expects that these reports will evolve over time so that they provide much more dynamic locational and temporal information about system limitations.

Other parties are also seeking to find and publish more information about the technical characteristics of distribution networks. For example, the AREMI map, developed by CSIRO’s Data61 in partnership with ARENA, Geoscience Australia and the Clean Energy Council, emerged out of recognition that a large amount of mapping data and information relevant to the energy industry is collected and managed by different parties, not centralised in a single location.[87]

The mapping tool consolidates data from a range of organisations to support "developers, financiers and policy makers in evaluating spatial renewable energy

86 Submissions on draft report: AGL, p. 5; Centre for Energy and Environmental Markets, UNSW, p. 14.

87 See: https://arena.gov.au/project/aremi-project/

information".[88] It includes data sets produced by the Institute of Sustainable Futures on areas of network constraint, planned investment and the potential value of decentralised energy resources in networks across the NEM. While there are caveats around the accuracy and completeness of the data, such information provides a valuable first step in helping a range of parties better understand the characteristics of the networks in which they are investing and operating. It may also help to incentivise consumers to locate and operate in the 'right' areas, for example areas where connection costs are low or where distributed energy resources can be used to help alleviate network constraints.

Box 4.1 Demand response and distributed energy resources

Demand response is a form of demand side participation, which includes actions that a consumer can take to alter or shift its electricity consumption in response to changing market conditions. In the NEM, the supply side of the market provides electricity at a price, and the demand side (i.e. consumers) directly or indirectly through a service provider respond to the price or the value of the product or service presented to them on that price.

Technological developments, market and regulatory developments and innovation by demand side management providers over the past decade has made it easier for consumers across all sectors (industrial, commercial and residential) to adapt their consumption patterns in order to manage their electricity consumption, and, in turn their expenditure:

- Home energy management systems can provide demand response and deliver load reductions in a way that goes largely unnoticed by the customer.
- Price signals, either in the form of cost reflective pricing or direct incentives, can encourage customers to shift energy use away from peak times, avoiding inefficient investments in energy equipment and more drastic load shedding events.
- Given appropriate incentives, voluntary load reductions by commercial and industrial users could serve as an alternative to involuntary load shedding to address lack of reserve conditions.

The opportunities for, and barriers to, demand response are being considered through the Commission's *Reliability frameworks review.*

4.1.3 Information AEMO needs to maintain power system security

An increased penetration of distributed energy resources has the potential to affect broader power system security. AEMO, as the party responsible for maintaining overall power system security, is therefore likely to need more information about

88 See: https://nationalmap.gov.au/renewables/

power flows on distribution networks as the uptake of distributed energy resources increases. This information can be used to help AEMO manage power system security and conduct forecasting.

Analysis and recommendations

AEMO is currently, or has recently considered, ways to improve its visibility in respect of its role in maintaining power system security:

- AEMO's demand side participation guidelines, will require registered participants to submit demand side participation data annually at the national metering identifier (NMI) level from April 2018
- AEMO is also undertaking a range of work in the context of distributed energy resources and power system security, including its *Visibility of distributed energy resources* project.

The Commission encourages AEMO to progress its work on what visibility is needed to maintain power system security, and will work with AEMO on progressing any findings from that report.

Finding 4

The AEMC requests that AEMO continue to identify any information gaps related to distributed energy resources for the purposes of maintaining power system security through its *Future Power System Security* work program, such as technical assessments of whether, and if so, at what level of aggregation, data about the operation of distributed energy resources is needed. Such work will be used as an input into the AEMC's *System security* work program.

4.1.4 Conclusions

As set out above, there are a number of mechanisms by which DNSPs, AEMO and other parties can require the collection of, and access, data about distributed energy resources. There are also several organisations that are seeking to address perceived gaps in the level of information required to make decisions about how to manage, invest in and operate distributed energy resources, including output data in real time.

Therefore, the Commission considers that there are already existing processes underway to improve 'information' about distributed energy resources. Indeed, some networks are already starting to explore ways that they can get better visibility of their networks. This should be a key focus for networks over the next few years, since better information will further assist with the development of more cost-reflective data.

The most useful data is data that is accurate, granular, timely and universal (i.e. collected from everyone). However, there are trade-offs to be made. Importantly, the costs associated with collecting, managing and disseminating data should not outweigh its value or usefulness. The Commission has developed a number of questions in relation to what needs to be considered when thinking through new mechanisms to collect, manage and disseminate data in order to make sure that the benefits of the mechanism outweigh the costs, including:

- What level of information is required? Is there a need for consistency across network areas in what data should be collected?
- How often does the data need to be collected and updated?
- What is the cost of collecting the data? Does it require investment in new equipment and systems?
- Is there a way that the data could be collected under the existing regulatory arrangements, or is a new process warranted?
- What is the administrative burden of providing, collecting and managing this data?
- Will it be compulsory for consumers to provide the data? Who has access to the data? Do the answers to these questions raise privacy or confidentiality issues that would need to be addressed?
- Are there ways to incentivise consumers to provide the data?
- Who would collect and own the data? Would data collection be centralised or decentralised? How will the data be collected in a consistent format?
- Where would the data be stored? Would additional investment be required to store and manage the (likely) large amounts of data?
- What are the privacy concerns? Are there any security concerns?

4.2 Network tariffs

4.2.1 Background

Efficient markets are characterised by effective participation of both the supply and demand sides. As set out in the previous section, effective participation in markets relies on parties having access to the information they need to invest and operate in those markets. An important component of this is information on the efficient costs. This allows consumers to compare the value they place on using the network against the costs caused by their use of it.

Tariffs are a means by which DNSPs recover the costs of providing network services from consumers. Historically, the costs of providing network services were smeared across all consumers connected to that network. As a result, individual consumers were not directly faced with the costs that were incurred to supply them with electricity at the location they were connected to the network and at the times they used it.

In November 2014, the AEMC made a rule that requires DNSPs' pricing decisions to be guided by a pricing objective – that network prices should reflect the business' efficient costs of providing services to each consumer. The intention is that, over time, network tariffs will better reflect how much it costs to serve individual consumers.

Cost-reflective network tariffs are a precursor to

- consumers understanding the costs associated with their use of the network, so that they can make more informed choices about how they use electricity and participate more actively in the energy market
- DNSPs understanding the costs and value of distributed energy resources
- consumers and their agents seeing the value of providing services to networks
- the co-optimisation of distributed energy resources services with wholesale markets.

Fully cost reflective tariffs comprise two key components:

- Locational – signals that reflect the costs of supplying network services to consumers at a particular location in the network.
- Temporal – signals that reflect the costs of supplying network services to consumers at a particular point in time.

Network tariffs that comprise both of these components can be used to reflect supply and demand conditions across a network, and to incentivise or dis-incentivise the consumption or production of electricity in a way that helps reduce the costs of providing the network service. DNSPs can, through network tariffs, signal network constraints that could incentivise consumers in particular areas to invest in and operate distributed energy resources and/or provide network services.

4.2.2 Analysis and findings

Importance of cost-reflective tariffs

The *Network Transformation Roadmap* produced by Energy Networks Australia and CSIRO highlights the importance of efficient and fair electricity pricing in the transformation of the energy sector. It recognises the value of cost reflective pricing in allowing consumers to make more informed decisions about how they use electricity, but also the delivery of lower network costs. The roadmap also highlights the risks associated with less cost reflective pricing structures or distorted incentives, for example over investment in the networks leading to higher prices for consumers.[89] The Essential Services Commission of Victoria set out a similar view in its final report on the network value of distributed generation, concluding that distributed generation

89 Energy Networks Australia, Electricity network transformation roadmap, Final report, April 2017.

can and does provide network value, including through reducing network congestion, which can potentially defer network augmentation and thus reduce network costs.[90]

Numerous stakeholders to this review supported the importance of cost-reflective network tariffs.[91] A key issue is the need to build public understanding and support.[92]

Many of the technical issues set out in section 2.2 can be addressed through better balancing of supply and demand, which can be achieved if customers are faced with signals that reflect the value and costs of their electricity consumption and distributed energy resources use to the system. This can prove challenging in electricity networks due to the physical nature of electricity – supply and demand conditions vary substantially by location and time - influencing value and cost across these dimensions.

A number of network businesses are already taking steps to develop pricing models that enable them to defer network investment, decrease network risks and provide value to customers. For example, Ergon Energy distribution has developed an Optimal Incremental Pricing method, which enables it to value the risk in a network based on several key criteria, including forecast growth, network capacity and demand management intervention expenditure.[93] It uses these criteria to put a price on peak demand in a specific location, to make sure that its demand management programs operate early in the risk cycle and only in locations where there is a chance of network investment.

Cost reflective tariffs are also important to help realise the full value of distributed energy resources and related technologies. There are nearly 2.8 million advanced meters at residential and small business premises in Victoria, which are capable of providing a whole range of services to networks and to consumers themselves, including time of use tariffs. Following the introduction of a moratorium on time of use pricing in 2010, the Victorian government has now mandated that DNSPs only adopt opt-in approaches to new distribution network tariff structures. Consumer take up of opt-in tariffs tends to be low when compared to mandatory or opt-out approaches. Opt-in tariffs have already, and will continue to slow the transition to and uptake of cost-reflective tariffs and so restrict the benefits that can be gained through the use of new technologies and services.

Further, many DNSPs have network pricing requirements placed on them through jurisdictional obligations that seek to meet a number of social and equity objectives. For example, uniform tariff policies are in place in Queensland, Tasmania and South Australia. In these jurisdictions, small customers must be provided with or offered the same tariffs regardless of location. As a result, these tariffs do not signal the relative

90 Essential Services Commission, The network value of distributed generation, Stage 2 final report, February 2017.

91 Submissions to draft report: AGL, p. 10; Ausgrid, p. 3; Energy Networks Australia, p. 22; SA Power Networks, p. 3; CEEM UNSW, p. 14; ATA, p. 2.

92 Submissions to draft report: Clean Energy Council, p. 3.

93 See: https://www.ergon.com.au/network/network-management/demand-management/pricing-network-risk

costs of providing network services to customers at different locations within a single network.

If signals about the value of distributed energy resources are not reflected in network tariffs, the full value that distributed energy resources can provide to consumers, DNSPs and other parties is unlikely to be realised. Fully cost reflective tariffs that are not diminished by government or commercial intervention means that network operators do not have to resort to more drastic measures to manage the technical impacts of distributed energy resources, such as imposing tighter requirements on or completely restricting the connection or operation of distributed energy resources. Such decisions do not optimise investment in and use of distributed energy resources because the full value of that distributed energy resources is not able to be realised, and may act to discourage further uptake of distributed energy resources.

Implementation issues

The implementation of cost reflective pricing will create the essential foundation for future reforms, including more advanced pricing options such as export tariffs. Export tariffs could be used to better signal the costs and value of exporting electricity to the network, and may replace the need for governments to set feed in tariffs to reflect this value.[94] This is intrinsically linked to the discussion of access in section 4.3 below.

The new network pricing rules are now being implemented. DNSPs, retailers, governments and consumer groups must now work together to implement them.

Retailers have an important role in the implementation of cost reflective tariffs. Consumers do not pay network businesses directly for network services. Instead, retailers pay network charges to DNSPs and charge consumers a bundled price. The retail price includes a component that recovers the network charges paid by the retailer to the DNSP in relation to the consumer's use of the network. A key role of retailers is to manage the risks associated with the costs of various electricity supply inputs, including network charges, and to package these inputs into a range of retail offers for consumers. The introduction of cost reflective pricing provides retailers with additional tools to manage this risk. This allows consumers to select the retail tariff that best aligns with their preferences.

Some stakeholders have suggested that retailers should be required to structure their retail prices in a way that matches the structure of network prices. The Commission does not consider that such a requirement on retailers would benefit consumers. Retailers operate in a competitive market and outcomes for consumers will be improved if retailers are free to design their prices as they see fit in response to consumer preferences and the other costs retailers face. However, because network charges are retailers' largest cost, they will have some incentive to pass on network price signals to consumers in some form when deciding how to structure their retail

94 In May 2017 the Queensland Minister for Energy directed the Queensland Competition Authority to provide advice on the development of a time varying solar feed-in tariff for regional Queensland. See: http://www.qca.org.au/electricity/regional-consumers/advice-to-government

prices. But, we do not necessarily need consumers to see these tariffs in order to get efficient outcomes - as long as their representatives see the tariffs, and manage this accordingly.

Similarly, ENGIE Australia noted that there are a number of practical issues to overcome, such as the complexity of the tariffs conflicting with customer preferences for easy to understand offerings from retailers.[95] As noted above, retailers will design their prices as they see fit in response to consumer preferences, and so, presumably will factor such considerations into account.

Some stakeholders considered additional principles should be added to the cost-reflective pricing principles e.g. "the setting of network tariffs and charges must take into account the long-term interest to the electricity consumer that is served by efficient use of energy both now and into the future".[96] Full implementation of cost reflective tariffs will take time to phase-in, in order to allow development of more dynamic tariffs while meeting the customer impacts pricing principle in the NER.[97] A lot of these issues raised above by stakeholders are largely around perceived equity or fairness issues, and so, in time should be overcome as experience with, and education of, cost reflective tariffs increases.

The Commission considers that the continued implementation of network tariff reform is important. Notably, DNSPs in NSW, ACT, Tasmania and the Northern Territory are soon due to submit their first round of full five year tariff structure statements outlining their plans for the upcoming regulatory periods. The Commission recommends that market participants, governments, consumer groups and the AER further progress this implementation.

Finding 5

Network tariff reform is a key enabler for the efficient deployment of distributed energy resources. All jurisdictions should allow the DNSPs to progress the implementation of cost-reflective network tariffs including locational pricing.

Future pricing

Historically, distribution networks were built for one-way flows from generators through the transmission network to consumers on the distribution network. As discussed above, to the extent that any distributed energy resources would have been installed, it is likely that they would have received 'free' access. For example, consider a power line that carries power from the transmission network to a residential suburb. If a consumer in that suburb installed a distributed energy resource, benefits would accrue to the consumer - that is, the household would be able to export electricity to the grid, and earn money from their energy be aggregated and sold in the FCAS markets.

95 Submission to draft report, ENGIE Australia, p. 2. Similar sentiments were also raised in other submissions, AusNet Services, pp. 10-11.

96 Submission to draft report, City of Sydney, pp. 3-4.

While the export of electricity is able to be accommodated on the current network with low levels of DER penetration, as more DER are installed this may no longer be the case. The direction of electricity flows on distribution networks is changing, and switching more often. This is imposing new costs. As discussed in section 2.2, higher levels of distributed energy resources can have a range of technical impacts on distribution networks, for example voltage stability, frequency stability, harmonics and flicker. For some of these impacts, a market already exists to enable the procurement of services to address that impact. For example, FCAS are procured by AEMO to manage frequency across the system, and are paid for on a causer pays basis. For other impacts, better management of supply and demand will help to resolve it.

It is likely that some impacts (such as voltage issues) can be resolved through the design of new mechanisms, particularly for those impacts that are more localised. There may also be benefit in exploring whether additional tariff types should be introduced to signal and so recover benefits and costs associated with the externalities of providing services by means of distributed energy resources, e.g. reverse flows leading to voltage issues on distribution networks.

In the draft report, stakeholders were asked to comment on whether there are:

- any other barriers to the development and implementation of cost-reflective network tariffs, and if so, how material those barriers are and whether there other means for them to be addressed

- any 'missing markets' or 'missing prices' beyond those that will be implemented through cost-reflective network tariffs, and if so, what they are.

Energy Networks Australia noted that more sophisticated forms of incentives and price signals are likely to evolve as the sophistication of grid architecture and markets increase. This will necessarily require the development of transparent information for distributed energy resource participants on the network requirements.[98] Further, the AER consider that the transition to fully cost reflective pricing is likely to be a long-term objective. Additional consideration could be given to what other measures, along with better price signals, are needed to incentivise efficient investment and use of distributed energy resources in the short- to medium-term.[99]

As noted in chapter 3, currently only one of the four values/costs is priced: the costs associated with using the network to consume electricity. Consumers (when they are generators) are not paid for the benefits the provision of services from their distributed energy resources may have on the distribution system. And, generators do not pay any charges beyond connection costs, or receive any payment for benefits of the services that they provide. In the future, the Commission considers that there could be benefit

97 Which requires DNSPs to manage the impact of annual price changes on consumers.

98 See: Energy Networks Australia, submission to draft report, p. 15.

99 See: AER, submission to draft report, p. 1. This could also include consideration of Energy Queensland's concern that the give year duration of the tariff structure statement does not provide the flexibility for cost-reflective network tariffs to keep pace with market and technology developments. See: Energy Queensland, submission to draft report, p. 11.

in considering ways to recognise the benefits of load (for example, if there is an export constraint in one area of the network), as well as the benefits and costs of energy.

This would need to occur on a localised basis, based on information at that particular part of the network i.e. a one size fits all solution will not work. This is consistent with the Commission's recent final determination on the *Local generation network credits* rule change request, where the AEMC concluded that the impact of distributed energy resources on networks depends on where the generator connects to the network, as well as the time of generation. Therefore, any payments associated with this need to be specific and depend on those factors. This finding was also reached by the Victorian ESC in their enquiry into the true network value of distributed generation.

Such issues are discussed further below.

4.3 Network access and connection charging

4.3.1 Background

Access means different things to different people, in different contexts. Here, we refer to getting access to use the distribution or transmission network and so getting access to distribution- or transmission-level markets. Historically, distribution networks have significant spare capacity and so, as distributed energy resources have connected, gaining access to these markets to provide distribution services has not been a problem, for example engaging in a RIT-D process for network support services. However, this may not be the case going forward, and so, in the draft report the Commission considered whether there may be issues with access, and connection charging in the future.

Access at the transmission level

It is necessary that flows of electricity across transmission and distribution networks are consistent with the networks' physical capability. That is, generators' and consumers' collective access to the networks must be consistent with their capacity and not cause system security issues.

All transmission and distribution networks in the NEM currently operate under an open access regime for the connection of generation. Box 4.2 describes the history of these arrangements in relation to the NEM's transmission networks.

Ensuring that access is consistent with the physical capacity of the transmission network is managed through the wholesale market's scheduling process. In any 5-minute scheduling period, AEMO's NEMDE dispatches the lowest cost combination of scheduled generators to meet forecast net demand, subject to constraints, including constraints on the transmission network. This approach is known as open access.

Box 4.2 Open access in transmission networks

Transmission and distribution networks in the NEM operate under an open access regime in which generators have a right to negotiate a connection to the transmission network, but no right to the regional reference price, i.e. there is no firm access. Scheduled generators earn revenue by being dispatched.[100] Physical dispatch of electricity is determined by the dispatch offers of scheduled generators and the physical realities of the transmission network.

However, the operation of this regime is confused by both rule 5.4A and rule 5.5 of the existing NER, which cover access arrangements relating to transmission and distribution networks respectively.

The Commission considered the operation of rule 5.4A (the rule applying to transmission) in a number of projects, including the *Transmission frameworks review*, the *Optional firm access, design and testing review*, and the *Transmission connection and planning arrangements* rule change request. This clause described an ability for generators to negotiate a form of firm financial access with the TNSP and seek compensation from the TNSP in the event that it is constrained on or off, in return for an access charge.

In all projects, we concluded that the provisions in that rule were unworkable and, as far as we are aware, had not been applied successfully to date. In May 2017, the Commission decided to delete rule 5.4A from the NER commencing 1 July 2018, making it clear that the NEM operates under an open access regime.[101]

Generators only pay a shallow connection charge; in turn, they do not receive firm access: they can be constrained off through the scheduling process, if it is necessary in order to maintain the integrity of the network, despite bidding to sell electricity at a price below the market price.

The focus of transmission businesses, including their operation and investment decisions, is to deliver a reliable supply to consumers (for which consumers pay TNSPs through TUOS charges) and to make offers to connect to generators and loads that wish to connect to their network (for which generators and loads pay).

The development of transmission infrastructure to enable the export of energy from generators will only occur to the extent that it is necessary to ensure consumers receive a reliable supply of electricity.[102] There is no obligation on TNSPs to provide capacity

100 We note that semi-scheduled and non-scheduled generation receives what is effectively priority access to the regional reference node.

101 See: http://www.aemc.gov.au/Rule-Changes/Transmission-Connection-and-Planning-Arrangements

102 While constrained scheduled generators could contribute to the cost of making an investment to alleviate a constraint which would not otherwise be relieved through the processes described above, its incentives to do so are limited because of the free-rider problem: other generators would

to any individual generator. However, given the obligation on TNSPs to reliably supply their customers, customers fund investments in the transmission network that enable export of energy from generators and relieve congestion where necessary. The costs of the assets necessary to provide a reliable supply are recovered solely from load.

Access at the distribution level

As with the management of access for generators to the transmission network, the management of access that a distributed energy resource is provided to the distribution (and transmission) network is important since it influences:

- the access the distributed energy resources has to various values streams reliant on network access, and so decisions regarding investment in, and operation of, distributed energy resources
- how the network is planned
- the operation of the network.

Historically, before the uptake of distributed energy resources, patterns of demand on distribution networks were relatively stable and predictable. DNSPs and TNSPs are subject to reliability standards, the outcome of which is that distribution and transmission networks are built out to meet demand. As a result, there has been limited congestion on distribution networks, and so there has been sufficient capacity to meet the needs of the limited number of distributed energy resources that export electricity to the grid. Currently, parties connected to the distribution network 'access' the NEM by using the common distribution services provided by the DNSP. Essentially, the consumer is paying to buy electricity at its local transmission node, and have the electricity transported across the distribution network to its premises.

Connection charging

Currently, distributed energy resources must pay a charge to connect to the distribution network. This charge varies with the type of connection - that is, whether the connection service is classified as a standard control service, alternative control service or negotiated distribution service. It also depends on the size of the distributed energy resource being connected, whether it is co-located with a consumer and by network area. Once connected, distributed energy resources do not pay to use the network to export the electricity they produce. There are also limitations on connection charges for embedded generators below a certain size, meaning that connection costs may exceed charges. That means that all of the capital and operating costs of building and maintaining the network, as well as any difference between connection costs and connection charges, are recovered from all consumers through general network charges.

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also have access to the additional capacity created under the open access framework. Consequently, a scheduled generator has limited means to manage the risk of being constrained off.

4.3.2 Analysis and recommendations

The issues of access and connection charging received the most comment from stakeholders.[103] While some stakeholders supported deletion, or modification, of clause 6.1.4[104],[105] others did not.[106] Some parties supported the continuation of an open access regime,[107] others expressed the view that exploration of different access regimes may be useful.[108] Issues can be summarised as:

- further work is needed to understand whether distributed energy resources create benefits, or impose costs on the distribution network[109]
- further work is needed in order to understand what consumers want e.g. loss of open access for distributed generators or imposition of charges for export of energy from distributed generators may prompt a death spiral;[110]
- consideration of alternatives and their costs and benefits,[111] such as the introduction of a reliability standard for distributed energy resource services;[112]
- consideration needs to be given to the arrangements at the transmission level: large generators currently do not pay for access, beyond a shallow connection charge;[113]
- consideration of these issues should not just be one-sided i.e. there should be consideration of costs, when distributed energy resources increases burden on the network, but rewards when distributed energy resources would provide benefit to the network;[114]

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103 See: Solar Maximiser, submission to draft report, pp. 1-2.

104 Clause 6.1.4 of the NER prohibits a DNSP from charging a distribution network users (such as an owner of a distributed energy resource) distribution use of system charges for the export of electricity by that users to the distribution network.

105 See: S&C Electric Company, pp. 3, 8; SACOSS and St Vincent de Paul, pp.1-2; AGL, p. 10; ENGIE Australia, p. 4; Australian Storage Council and Energy Storage Council, pp. 2-4; Ausgrid, p. 3; Essential Energy, p. 1; SA Power Networks, p. 4; UNSW CEEM, p. 17; Energy Queensland, p. 18.

106 See: Submissions to draft report, City of Sydney, p. 12; Clean Energy Council, p. 5; Total Environment Centre, pp. 4-5; ATA, p. 4.

107 Submissions to draft report: Australian Storage Council and Energy Storage Council, p. 2; CEEM UNSW, p. 16; Clean Energy Council, p. 5;.

108 Submissions to draft report: C&C Electric Company, p. 8; AER, pp. 7-8; ENGIE Australia, p. 3.

109 See: Private individual, submission to draft report, p. 1; S&C Electric Company, pp. 6-7; Total Environment Centre, pp. 4-5; CEEM UNSW, p. 17.

110 Submission to draft report, City of Sydney, pp. 1, 8.

111 See: Submissions to draft report: Clean Energy Council, p. 5;

112 ENGIE Australia, p. 4.

113 See: Private individual, submission to draft report, p. 1; City of Sydney, p. 6; Total Environment Centre, p. 6.

114 See: Northern Alliance for Greenhouse Action, p. 1; Eastern Alliance for Greenhouse Action, pp. 1-2; SACOSS and St Vincent de Paul, p. 2.

The Commission considers that there are two separate issues with access at the distribution level that need to be clearly set out. As more generation is being connected to distribution networks, these may not continue to operate on an unconstrained basis as has historically occurred.[115]

Large scale generation

For large scale generation connected to the distribution network it is clear that an open access regime exists. The Commission understands that some DNSPs, for larger-scale generation, are starting to replicate the arrangements that exist at the transmission level, reflecting the fact that constraints are starting to appear on distribution networks e.g. in some particular parts of the distribution network, DNSPs are advising AEMO of constraints, which are being implemented into the wholesale market and so affecting dispatch of these generators. Therefore, for large-scale generation the Commission considers that the current framework is fit for purpose.

Distributed energy resources

While congestion caused by large scale generation can be managed through AEMO's processes, it is not clear that this can assist with congestion created by more distributed energy resources being installed. For example, some consumers may invest in distributed energy resources in order to export electricity to the grid to provide network or wholesale services. If every consumer on a street installed distributed energy resources, it is likely that congestion would start to occur at this localised level if all of these resources exported electricity to the grid at the same time.

If this is the case, it may not be appropriate for consumers who made an investment decision assuming that they would be able to use that distributed energy resource in a particular way to be 'constrained off' with no compensation, which is what occurs under an open access regime since consumers have no way to manage this,[116] and the use of these distributed energy resources could provide benefits to the system. However, an obligation on the DNSP to build out constraints to accommodate this additional generation may not be fair or efficient because the costs would be shared by all parties, but the benefits would only be captured by those with distributed energy resources. There is also not a strong incentive for the owner of the distributed energy resource to pay to build out the constraint, as there may be a risk that others would connect and constrain the network again, with no means for the owner to manage the risk (unlike large-scale generation, which can manage this risk through offering into the wholesale market).

Under an open access framework, consumers in increasingly constrained networks may end up being 'constrained off'. Under the existing NER, the DNSP is required to

115 However, the Commission expects that DNSPs will still be required to meet load reliability obligations.

116 Unlike large scale generators who use their offers into the wholesale market to influence their level of dispatch.

make an offer to connect to consumers who request it (provided technical requirements are met), including those with distributed energy resources. Anecdotally, the AEMC understands that some DNSPs are restricting the connection of distributed energy resources, particularly solar PV, in areas of the network that are constrained. For example, in a study for Energy Consumers Australia, KPMG noted that some DNSPs have turned down connection applications that require approval due to system constraints (although they suggest this is a minority) and, research suggested that some customers have been told that they cannot connect their system due to capacity limits in the system. KPMG note that it is not clear how widespread and significant these issues are, but that they will continue to grow.[117]

Energy Queensland noted in their submission to the draft report that they are not permitted to refuse connection of distributed energy resources in areas of the network that are constrained. Instead, the customer is offered alternative options for connection when a constraint is found to exist as part of a technical assessment, for example: partial or full export limitation; spreading connections evenly across three phrases; leveraging reactive power control functionality in inverters; or performing connection augmentation. Where augmentation of the shared distribution network is necessary, the customer may be required to pay a capital contribution towards those costs (in line with the Australian Energy Regulator's (AER's) connection charge guidelines and distributor connection policies). However, as small customers with less than or equal to 100 amps per phase in Energex's distribution area and 80 amps per phase or 10 kVA on Single Wire Earth Return (SWER) lines in Ergon Energy's distribution area are exempt from the requirement to pay a capital contribution towards shared network augmentation, almost no residential customers are required to contribute to shared asset augmentation triggered by the installation of a distributed energy resource.

Interaction with charges

The Commission's final determination on the *Local generation network credits* rule change concluded that embedded generation may result in other costs being incurred by DNSPs (e.g. additional spend on networks to maintain the reliability of the network, such as upgrading switchgear in order to prevent the risk of higher fault levels), with these costs varying on a case by case basis.

Similarly, the Essential Services Commission of Victoria recently undertook a review of the network value of distributed generation. It found that "because of the characteristics of network value, a broad-based feed-in tariff is unlikely to be an appropriate mechanism to support the participation of small-scale distributed generation in a market for grid services. The value of the grid services that distributed generation can provide is too variable - between locations, across times and between years - to be well suited for remuneration via a broad-based tariff."

Therefore, the AEMC's preliminary view is that one-off connection charges may not be appropriate when there are large amounts of distributed energy resources connected to

117 See: KPMG, Residential PV: Customer Experiences and Future Developments, A report for Energy Consumers Australia, December 2016, p. 60.

a network, because the costs caused and benefits created by those resources are variable, depending on where they are connected and when they are being used.

To date, there have been large amounts of spare capacity on distribution networks, and so any charges levied (e.g. connection charges) have been broad-brush in approach. As noted above, going forward there is no longer likely to be the case: distributed energy resources can provide benefits, as well as potentially impose costs on a network. Therefore, charging is likely to need to change, and become more specific, so that these benefits and costs are accounted for, and so consumers do not face cross-subsidies.

Conclusion

The Commission therefore considers that there are differences between access by large-scale generators, and access by distributed energy resources, that need to be considered. For example, households are unlikely to have the knowledge or resources to understand constraints on the network that might affect their decision to invest in a distributed energy resource in the way that large-scale generators do when connecting to the network. Further, while higher voltage transmission and distribution networks can be managed by constraints, through a centrally dispatched system, it is unlikely that this would be practical for the low-voltage, residential street level.

The Commission therefore considers it may be beneficial to undertake a holistic assessment of access and connection charging arrangements as they relate to distributed energy resources. This will be carried out through the Commission's 2018 *Electricity Network Economic Regulatory Framework Review*, which will involve consultation with stakeholders.[118]

The Commission reaffirms its position that given that an open access regime applies to distribution networks, it would be worthwhile reviewing rule 5.5 of the NER to determine whether it could be deleted (as the transmission-level equivalent has) to make it clear that it is an open access regime at the distribution level.[119]

Finding 6

Through the 2018 *Electricity Network Economic Regulatory Framework Review*, the AEMC will consider the arrangements for distribution network access and connection charging for distributed energy resources in Chapters 5A and 6 of the NER.

118 This was supported by the AER, who considered that the AEMC should continue to look at these issues relating to access and connection charging. See: submission to draft report, AER, pp. 7-8. Similarly, the KPMG report for the Australian Energy Council also discussed further work needing to be done on access arrangements for distributed energy resources. See: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. 64.

119 This was supported by the AER who consider that rule 5.5 should be deleted regardless of whether there is open or firm access. See: submission to draft report, AER, pp. 7-8.

5 Technical enablers

This chapter sets out the Commission's views on the near-term enablers that will need to underpin any future design of distribution system operations in a way that meets the objectives set out in appendix C. This chapter focuses on the 'technical' enablers, specifically:

1. technical requirements and processes for connection
2. Australian standards.

The Commission also raised these enablers in the *Integration of storage* report, and considers that they are still key issues to consider or be addressed.

The Commission's preliminary views on these enablers were set out in the draft report. Stakeholders provided a range of views on each, which are referenced where relevant throughout this section.

5.1 Technical requirements and processes for connection

5.1.1 Background

To interact with the network, such as through charging or consumption, a distributed energy resource must be connected to the electricity network. To do so, the person who owns the distributed energy resource must enter into a connection agreement with the local DNSP.

The connection arrangements set out in the NER establish the obligations and processes by which generating systems and loads connect to a transmission or distribution network. The regulatory framework for small loads and generating systems connecting to a distribution network is set out in Chapter 5A of the NER. These rules apply (among others) to:

- retail customers
- micro embedded generators (e.g. retail customers with solar PV or battery storage systems)
- non-registered embedded generators (connecting a system of less than 5 MW but larger than a micro embedded generator).

Through consultation on this project, the *Integration of Storage* report and other AEMC projects, the Commission has been made aware of a number of concerns stakeholders have with connecting distributed energy resources to distribution networks. These can be split into two main issues:

1. The actual technical requirements for connection.

2. The process for connection.

These are discussed in more detail below.

Technical requirements for connection

DNSPs necessarily need to apply some minimum requirements to the connection of distributed energy resources to make sure that those resources can technically and safely interface with the rest of the network. The technical requirements applicable to the connection of distributed energy resources may depend on a number of factors, including whether the distributed energy resource:

- constitutes an alteration to an existing connection or a new connection
- will be used to export electricity to the network
- constitutes part of an existing generating system (e.g. retrofitting an existing solar PV system with storage capability).

The technical requirements imposed by the DNSP will also likely depend on:

- the characteristics of the network to which the distributed energy resource is connecting
- the DNSP's ability to manage the expected operation of the distributed energy resource in a way that enables it to meet its regulatory obligations with respect to system safety, reliability and security.

The technical requirements in Chapter 5A of the NER for the connection of retail customers are much less prescriptive than those for registered participants that connect under Chapter 5 of the NER.

For example, Chapter 5A does not contain any specific requirements or guidance on the technical specifications of connections by retail customers to distribution networks, either with embedded generation or without, like there are in Schedule 5.2 of the NER for registered generators. Rather, it contains broad requirements that the terms and conditions of model standing offers or negotiations for connection services must, for example, cover "the safety and technical requirements to be complied with by the retail customer".[120] As a result, DNSPs have a large degree of discretion over the specific technical requirements for the connection of retail customers, including those with distributed energy resources, to their networks.

This means that DNSPs also have reasonably broad discretion as to how they communicate those requirements to parties seeking a connection to their network. Energex and Ergon Energy have developed a joint connection standard containing detailed technical requirements and performance standards to "provide proponents of micro embedded generating units information about their obligations for connection to

120 See: 5A.B.2(b)(4) of the NER.

and interfacing with the Ergon Energy or Energex networks".[121] However, there is no obligation under the NER for DNSPs to develop or publish such a standard.

Process for connection

Chapter 5A of the NER sets out the process for establishing a connection to a network, and the arrangements by which NSPs charge for connections.

There are three types of connection services defined under Chapter 5A, set out below. DNSPs develop model standing offers for basic and standard connection services, which are approved by the AER in accordance with certain requirements set out in Chapter 5A. We have used Energex's connection policies and standards as an example to explain how a DNSP might distinguish between the three.

- **Basic connection services.** In general, these services cover the majority of simple connections by retail customers, including those retail customers that are micro embedded generator connections. For Energex, basic connection services include the connection of load for most retail customers and connection of micro embedded generators up to 5kW where no network augmentation is required.

- **Standard connection services.** These are connection services that DNSPs can develop a standing offer for but are not covered by the basic connection service definition. For Energex, standard connection services include unmetered connections, e.g. street lighting.

- **Negotiated connection services.** These are connection services for which a standing offer does not exist, or if the customer elects to negotiate the terms and conditions of its connection. For Energex, negotiated connection services include micro embedded generator connections below 5kW where augmentation is required and micro embedded generator connections between 5-30kW where no augmentation is required. Chapter 5A sets out the process and framework by which parties negotiate for a negotiated connection service.

5.1.2 Analysis and recommendations

Technical requirements for connection

In their submissions to the draft report, a number of stakeholders expressed concern that the current arrangements empower DNSPs to determine the uptake or use of distributed energy resources through the technical requirements they impose as a condition of connection to their network,[122] for example by:

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121 See: https://www.ergon.com.au/__data/assets/pdf_file/0005/198698/STNW1170-Connection-Standard-for-Micro-EG-Units.pdf

122 Submissions on draft report: AGL, pp.6, 12; City of Sydney, p. 12; Clean Energy Council, p. 6; ENGIE Australia, p. 5.

- setting export limits
- restricting capacity
- requiring that inverters include specific demand response capabilities to allow DNSPs direct control
- mandating the provision of grid services, such as reactive power.

These stakeholders have indicated that there is not always transparency of what these requirements are when seeking a connection to the distribution network, and question whether the requirements are proportionate to what is being connected or how it is proposed to be operated. A joint ClimateWorks Australia and Seed Advisory consultation paper published in February 2017 concluded that, under current arrangements, "there is no oversight of, or mechanism to review, the appropriateness of DNSPs' requirements and the costs they may impose on connections, or the community as a whole."[123]

In its submission to the draft report, Ausgrid indicated that it places limitations on distributed energy resources through technical requirements because it understands the technical impacts of such resources and imposing those requirements will enable it to meet its regulatory obligations regarding electricity supply.[124] AusNet Services explained its approach to the approval of micro embedded generation assets so that customers have flexibility in how and what they connect, whilst helping to make sure that network impacts such as voltage rise are contained to manageable levels.[125] By contrast, Energy Networks Australia noted that, in the absence of investments in monitoring, modelling and planning capabilities, DNSPs will need to continue to rely on broad brush limits on distributed energy resources, such as hard, network0wide export limits, which it acknowledged were highly inefficient given that such limits may only be required for short periods and in certain locations on the network.[126]

The Clean Energy Council submitted that it would be helpful to develop an agreed methodology for distinguishing between:

- what network services are reasonable to require as a condition of connection in order to address the impact of that distributed energy resource on the network
- the network services for which the distributed energy resource ought to be financially remunerated.[127]

The Commission agrees with the Clean Energy Council's position on this. The Commission considers that the installation, connection, optimisation and control of

123 ClimateWorks Australia and Seed Advisory, Plug & Play: Facilitating grid connection of low emissions technologies, February 2017, p. 7.

124 Ausgrid, submission on draft report, p. 2.

125 AusNet Services, submission on draft report, p. 11.

126 Energy Networks Australia, submission on draft report, p. 15.

127 Clean Energy Council, submission on draft report, p. 6.

distributed energy resources should, except for system security and safety reasons, be determined through market-based signals. This approach will most likely to lead to efficient outcomes because it promotes consumer choice while providing a level playing field for market participants.

To support the efficient uptake of distributed energy resources, technical requirements for the connection of distributed energy resources should be clear, proportionate and relevant to what is being connected and how it will be operated. Overly onerous technical requirements are likely to increase the costs of connection and limit the range of services that could be provided competitively, which may deter consumers from installing distributed energy resources, or incentivise them to find ways to install distributed energy resources without approval from the DNSP. On the other hand, technical requirements that are too low have the potential to create or exacerbate the technical impacts of distributed energy resources on distribution networks.

Similar conclusions were drawn in an assessment by The Customer Advocate on the solar PV connection framework in Queensland,[128] which considered that:

- the technical requirements for grid connection should be targeted and appropriately balance efficiency and customer choice with the ongoing requirement of the safe and reliable operation of the electricity network
- the cost, process, approval and timeliness to connect and install solar PV should be fair, reasonable, transparent and in step with other jurisdictions
- a customer's decision to connect a solar PV system should be supported by transparent and well-communicated information from network owners.

The assessment indicated that connections of solar PV in Queensland did not always meet these objectives, and made a number of recommendations on ways for this to occur, including in relation to the technical requirements of connection, harmonisation of connection standards, and the technical impacts of the aggregated capability of distributed energy resources.

A lack of consistent technical requirements across and within network areas, or a lack of transparency regarding the reasons why different technical requirements are being imposed, can increase the transaction costs of connecting distributed energy resources. In submissions to the AEMC's *Integration of Storage* report, a number of stakeholders (including some DNSPs) expressed support for the development of a standardised approach to the technical assessment of micro embedded generation across DNSPs. The Commission also tested this idea in the draft report for this project, which received broad stakeholder support.[129] These stakeholders were of the view that standardisation would:

128 The Customer Advocate, Assessment of the solar PV connection framework in Queensland, February 2016.

129 Submissions on draft report: AGL, p. 12; Alternative Technology Association, p. 6; Ausgrid, p. 4; Australian Solar Council and Energy Storage Council, p. 3; CEEM UNSW, p. 21; City of Sydney, p. 12; S&C Electric Company, pp. 3, 10; Ausgrid, p. 4.

- simplify connections for parties operating within or across distribution areas (for example, retailers or energy service providers)
- reduce administrative burden on DNSPs
- provide transparency and certainty in the connection process
- support a level playing field for the provision of distributed energy resources and the services they enable.

While Ausgrid noted that there are a range of jurisdictional regulations that may inhibit a purely national approach, it and Energy Queensland expressed support for such a review in their submissions to the draft report.[130]

Greater transparency in the technical assessment of the connection of distributed energy resources, and standardisation of such an assessment where appropriate, reduces transaction costs for both consumers and connecting DNSPs, and supports a more consistent and predictable approach to the connection of distributed energy resources. The Commission therefore sees value in reviewing the technical requirements that apply to the connection of distributed energy resources, particularly small-scale, residential/small business systems (i.e. micro embedded generators), to assess their appropriateness, potential for standardisation and how they affect the DNSP's ability to control what is connected to their network.

This view is consistent with a recommendation made in the Energy Networks Australia / CSIRO Network Transformation Roadmap, which identified the development of national guidelines to standardise the connection of distributed energy resources as a critical action to facilitate better integration of growing numbers of customer resources into the grid.[131]

In their submissions to the draft report, Ausgrid and Energy Queensland suggested that any move toward greater standardisation should be led by the DNSPs themselves, in consultation with relevant stakeholders, perhaps through an industry body such as Energy Networks Australia.[132] KPMG, in its report for the Australian Energy Council, also noted that a key area for further work is to develop new connection standards for distributed energy resources.[133]

As explained above, Energex and Ergon have developed a joint connection standard containing detailed technical requirements and performance standards applicable to the connection of micro embedded generation to their networks, which it developed in consultation with relevant stakeholders. And, as noted in Energy Queensland's submission to the draft report, the NSW Government recently engaged a consultant to

130 Submissions on draft report: Ausgrid, p. 4; Energy Queensland, pp. 17, 19.

131 Energy Networks Australia and CSIRO, Electricity Network Transformation Roadmap: Final report, April 2017, p. 17.

132 Submissions on draft report: Ausgrid, p. 4; Energy Queensland, pp. 17, 19.

133 See: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. 64.

undertake a review of the embedded generator connection standards across the NSW DNSPs to determine whether there is potential for standardisation.[134] The Commission supports these efforts toward greater standardisation of the technical requirements for connection across DNSPs, and considers that these efforts can be used to help inform the development of a NEM-wide standard for all DNSPs.

The Commission notes that since that time the Victorian Government has also announced a project to develop a standardised grid connection solution. The aim of the 'e-cube' is to allow solar and wind projects to easily connect to the distribution network, and suit a range of system sizes, connection types and network requirements.[135]

Process for connection

Stakeholders raised some concerns about the connection process for distributed energy resources in their submissions to the draft report,[136] including that:

- that the form, format and process for connecting differs between DNSPs
- connection processes can be cumbersome and time consuming for proponents
- the time taken for DNSPs to assess connection applications can be long
- applicants for negotiated connections can experience excessively large up-front costs for their projects.

Similar sentiments have been expressed through other projects.[137][138]

In the Commission's view, the process for connecting to the network should be clear, efficient and proportionate to the distributed energy resources being installed. Overly onerous process requirements for relatively straightforward connections may act as a barrier to the installation of distributed energy resources.

In 2014 the Commission published a final determination on the *Connecting embedded generators under Chapter 5A* rule change request.[139] This rule change involved a

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134 Energy Queensland, submission on draft report, p. 20.

135 Lily D'Ambrosio MP, Media Release, Fast-tracking renewable energy into the grid, 31 July 2017.

136 Submissions on draft report: AGL, p. 6; City of Sydney, p. 12.

137 See: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review

138 The Commission undertook a comprehensive review of the transmission connection process through the *Transmission connections and planning arrangements* rule change request. The final rule, published in May 2017, set out significant changes to the arrangements by which parties connect to the transmission network to improve transparency, contestability and clarity in the transmission connections framework, while maintaining clear accountability for outcomes on the shared transmission network that affect consumers. See: http://www.aemc.gov.au/Rule-Changes/Transmission-Connection-and-Planning-Arrangements

comprehensive review of the connection process in Chapter 5A as it relates to embedded generators (i.e. systems of less than 5 MW but larger than a micro embedded generator), but did not relate specifically to the connection of micro embedded generators. The Commission therefore considers that the processes DNSPs set out for the connection micro embedded generators would benefit from review to determine their appropriateness and whether there is potential for standardisation across DNSPs. The proposed review of the technical requirements for the connection of distributed energy resources (above) provides a good opportunity for the arrangements by which DNSPs process connections to their networks to also be reviewed.

Energy Networks Australia's analysis of current Australian market frameworks has also identified issues with inconsistent technical standards for grid connection of distributed energy resources.[140] Energy Networks Australia notes that since this issue has been identified as a major concern by industry stakeholders in numerous reports and review, the development of national guidelines to standardise the connection of distributed energy resources into the grid has been identified as a flagship project in its implementation of the network transformation roadmap. This project is now in the process of being enacted.

Energy Networks Australia aims to publish a set of nationally consistent distributed energy resources connection guidelines that outline the technical requirements to facilitate streamlined integration of customer distributed energy resources. Specifically this project aims to:

- scope all aspects of the technical requirements to be included in a set of national standards or guidelines
- obtain and deliver both internal and external stakeholder acceptance and support for the proposed guidelines
- develop the set of nationally consistent distributed energy resources connection guidelines, and publish and publically release them as Energy Networks Australia documents for use by network companies and proponents.

The Commission therefore acknowledges the proposed work by Energy Networks Australia, to conduct a review of the process and technical requirements for the connection of micro-embedded generators across DNSPs to determine a common approach. Such a review was supported by numerous stakeholders.[141]

139 See: http://www.aemc.gov.au/Rule-Changes/Connecting-embedded-generators-under-Chapter-5A

140 Energy Networks Australia, submission to draft report, p. 24.

141 Clean Energy Council, submission to draft report, p. 5.

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The AEMC notes that Energy Networks Australia, has already commenced a program of work to develop nationally consistent distributed energy resources connection guidelines, which includes a review of the process and technical requirements for the connection of micro embedded generators across DNSPs. The AEMC also acknowledges that Energy Networks Australia plan to develop these guidelines in consultation with relevant stakeholders. The AEMC therefore supports this approach and requests that Energy Networks Australia proceeds with this work program and uses these stakeholders to obtain industry agreement on a common approach.

With respect to the technical requirements for the connection of micro embedded generators, the review could consider:

- what technical requirements are being applied by each DNSP
- why these requirements are being applied - that is, what issue is the technical requirement trying to address
- whether these requirements are proportionate to what is being connected
- whether there is potential for standardisation across DNSPs or, at the very least, standardisation of a set of minimum technical requirements
- if so, the best means to enable standardisation, for example through an industry standard or the NER.

With respect to the process for the connection of micro embedded generators, the review could consider:

- the form and format of DNSPs' existing connection processes
- the fees charged by different DNSPs to process similar connection applications
- the transparency of DNSPs' assessment of connection applications
- the degree of negotiating power proponents have in the connection process
- the timeframes within which different DNSPs process similar connection applications
- whether there is potential for standardisation across DNSPs and, if so, the best means to enable standardisation.

Ability for distributed energy resources to support system security

The *Independent Review into the Future Security of the National Electricity Market*, published in June 2017, noted that AEMO's ability to address the technical and system security impacts of distributed energy resources is affected by "outdated connection standards and control mechanisms" and that "with appropriate communications infrastructure, standards and aggregation mechanisms in place, distributed energy resources can provide significant opportunities to improve power system security".[142] Recommendation 2.5 in that report is that the AEMC "review the regulatory framework for power system security in respect of distributed energy resources, and develop rule changes to better incentivise and orchestrate distributed energy resources to provide essential security services such as frequency and voltage control".

The Commission self-initiated the *Frequency Control Frameworks Review* on 7 July 2017.[143] The review will progress a number of recommendations made by the Commission in the *System Security Market Frameworks Review* to address current concerns with frequency performance and to consider how best to integrate faster frequency control services offered by new technologies into the current regulatory and market arrangements. The terms of reference for this review include consideration of the potential for distributed energy resources to provide frequency control services, and any other specific challenges and opportunities associated with their participation in system security frameworks.

> **Finding 8**
>
> The AEMC will assess the potential for distributed energy resources to provide frequency control services and any other specific challenges and opportunities associated with their participation in system security frameworks through the *Frequency control frameworks review.*

5.2 Australian standards

5.2.1 Background

Standards play an important role in supporting the safety and integrity of the technologies that underpin Australia's energy systems. A well-functioning market for distributed energy resources optimisation is aided by the development of standards that define minimum safety and quality requirements for the connection and operation of distributed energy resources and related technologies. For example, in response the AEMC's identification of the technical impacts of distributed energy resources in the approach paper, some stakeholders noted that, since October 2016, all inverters have been required to meet AS 4777.2:2015 Grid connection of energy systems via inverters –

142 Independent Review into the Future Security of the National Electricity Market, final report, June 2017, pp. 62-63.

143 See: http://www.aemc.gov.au/Markets-Reviews-Advice/Frequency-control-frameworks-review

Inverter requirements.[144] This standard includes requirements such as reactive power capability and limits to be compatible with requirements of network businesses, and includes new voltage and frequency set-points. It also requires inverters to have demand response mode capabilities, which allow a remote operator to alter the inverter system to operate in a certain way, such as disconnecting from the grid, preventing generation of power or increasing power generation.

Under current arrangements, standards for Australia's energy sector are developed and adopted by Standards Australia, a non-government, not-for-profit standards organisation.[145] Standards Australia forms technical committees of relevant stakeholders to develop standards through a process of consensus. The AEMC has no direct involvement in the development of standards.

Australian standards set fundamental parameters for how distributed energy resources can be installed and operated. While the use of all Australian standards is voluntary, they can be (and are often) called up into regulation or contracts. For example, 'micro-EG connection' (for example the connection of a small-scale rooftop solar PV system) is defined in the NER by reference to Australian Standard (AS) 4777 - Grid connection of energy systems via inverters. As such, standards can have a significant impact on consumer decisions about which products and services to buy, and how those products and services can be used.

In 2016 Standards Australia, in collaboration with Energy Networks Australia, launched a work plan for improving Australian standards to support a future with distributed energy resources.[146] This work informed some of the milestones in the Energy Networks Australia and CSIRO *Network Transformation Roadmap*, including the development and implementation of new guiding principles for standards committees, alignment of relevant technical committees with international standards committee structures and the development of standards "critical for the transformation of the industry", including with respect to interoperability, communications, control systems and data.[147]

As a result of this work and other Standards Australia initiatives, a number of committees have been updating and creating new standards to accommodate the rapid uptake of distributed energy resources and related technologies, including inverters, battery storage and demand response.

144 Submissions on approach paper: Ausgrid, p. 2; Clean Energy Council, p. 6.

145 See: http://www.standards.org.au

146 See http://www.standards.org.au/OurOrganisation/News/Documents/Roadmap%20for%20Standards%20and%20the%20Future%20of%20Distributed%20Electricity.pdf

147 See: http://www.energynetworks.com.au/electricity-network-transformation-roadmap

5.2.2 Analysis and recommendations

Interaction between Australian standards and the NER

In the Commission's view, consumer choices should continue to drive the development of the energy sector. So, while standards are important to mandate minimum safety requirements and technical capabilities for distributed energy resources and related technologies, the Commission considers that they should not be used to mandate the provision of discretionary services or technical capabilities that may be better provided on a commercial basis in response to market signals.

Standards should therefore be forward looking and fit for purpose.[148] Standards that lag behind the uptake of distributed energy resources may exacerbate the technical impacts of distributed energy resources, or limit 'smart' capability, both of which are likely to be costlier to address retrospectively when issues arise. On the other hand, highly specified standards are likely to increase the costs of distributed energy resources technologies and possibly seek to address issues that may not eventuate, which may inhibit uptake. Standards therefore need to strike a balance between these two objectives. Well-developed standards that consider the expected high penetration of distributed energy resources, and their likely uses and technical impacts, will likely increase the ability of distribution networks to adapt to future technical challenges, and for the owners of distributed energy resources to participate actively in the energy market. A number of stakeholders supported these views in their submissions to the draft report.[149]

However, it is not clear to the Commission that this balance has been, or will always be, struck in a context of rapid technological change. The Commission therefore considers there may be merit in further exploring the interface between Australian standards and the NER in relation to distributed energy resources and related technologies.

Standards development process

Since first exploring the application of Australian standards in the context of the energy sector in the *Integration of Storage* report, the Commission has become aware of a number of issues stakeholders have with standards development under Standards Australia processes.

The Commission considers it essential that:

148 This was recognised by the CSIRO and Energy Networks Australia *Network Transformation Roadmap*, which presented a series of three milestones around reinforcing the key role that standards play in enabling more transactive power systems by supporting interoperability between technologies, providing consistent frameworks for design and implementation, and ensuring safety. p. 88.

149 Submissions on draft report: AGL, p. 12; ENGIE Australia, p. 4; Energy Queensland, p. 18.

- standards development committees are appropriately representative of all affected stakeholders, including consumers themselves
- committee members and others involved in the standards development process have regard to the implications for competition and consumer choice when developing and commenting on standards.

In its submission to the draft report, Energy Queensland noted that each standard takes a significant time to develop and implement, which can in large part be attributed to the fact that standards are developed by volunteers who receive no financial reward and almost always require the support of their organisation to accommodate the significant time commitments involved. Energy Queensland submitted that, given the rapid pace of technological change, it will become increasingly important for standards to be reviewed regularly to remain relevant, and that this will be a significant challenge for the market.[150]

In its submission to the draft report, the Clean Energy Council stated that there is an opportunity to improve standards, reduce inconsistent grid connection requirements, improve safety and reliability and reduce costs to consumers, but that what is missing is an institution or forum in which these proposals can be considered.[151]

Energy Consumers Australia noted that in recognition of the important role that standards can play, and the reasonable requirements an industry might have to control its own standards, it is possible for an industry to establish an accredited Standards Development Organisation.[152] Energy Consumers Australia notes that there have been recent adverse commentary about proposed battery installation standards.[153] Similar tensions could emerge in relation to all of the relevant standards.

As recognised by Energy Consumers Australia, Standards Australia has powers that enable it to accredit other organisations to develop their own industry standards and have these recognised as Australian standards. Organisations wishing to become a standards development organisation are usually representative organisations (e.g. industry association, professional body, consumer association) with a membership of allied interests (organisations and/or individuals).

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150 Energy Queensland, submission on draft report, p. 19.

151 Clean Energy Council, submission on draft report, p. 5.

152 Energy Consumers Australia, submission on draft report, p. 10.

153 See for example: http://reneweconomy.com.au/standards-australia-renews-threatof-home-battery-storage-ban-43719/

According to Standards Australia, some of the benefits of accreditation include:[154]

- ownership of the standards development process and the ability to determine the development program, the level of resources and the timeframes to meet stakeholders' requirements
- building stakeholder confidence in the organisation by involving all relevant interest groups in the development of the standards
- a more efficient and effective industry / sector though the development and promotion of nationally recognised Australian standards.

The Commission considers that there is merit in the electricity sector exploring the costs and benefits of accrediting a separate organisation to develop sector-specific standards particularly in relation to distributed energy resources.[155] The Clean Energy Council noted that there is an opportunity to improve standards, reduce inconsistent grid connection requirements, improve safety and reliability and reduce costs to consumers, but that there is no forum in which these proposals can be considered.[156]

Finding 9

The AEMC requests that the Clean Energy Council explore the merits of seeking accreditation of a body to develop standards, which are not already covered in the NER, that will facilitate the connection of distribution energy resources.

154 See: http://www.standards.org.au/StandardsDevelopment/accreditation/becoming_accredited/Pages/default.aspx

155 This was supported by Energy Consumers Australia in its submission to the draft report, which noted that the AEMC should initiate its own inquiry into the use of standards in the development of markets and the desirability or otherwise in establishing a Standards Development Organisation for the energy sector.

156 Clean Energy Council, submission on draft report, p. 5.

A Project scope

The approach paper set out the Commission's proposed scope for this project, as summarised below:

- In scope:
  - the technical and regulatory challenges of distributed energy resources for distribution networks
  - the National Electricity Law (NEL) and the National Electricity Rules (NER)
  - interactions between distributed energy resources and other markets (including wholesale and retail markets) but only to the extent that distributed energy resources can participate in, and affect, those markets
- Out of scope:
  - the National Energy Customer Framework - that is, the National Energy Retail Law (NERL) and National Energy Retail Rules (NERR)
  - the design of transmission-level markets (including the wholesale electricity market) or retail markets

In submissions to the approach paper, and to the draft report, stakeholders largely supported the Commission's proposed scope for the project, but asked that the AEMC also include consideration of other issues.[157] Table A.1 sets out the issues proposed by stakeholders to be included within scope, the Commission's conclusion on whether or not it has been added to the project scope and, if not, whether that issue is being considered though a separate project.

157 Submissions on approach paper: AEMO, p. 2; AER, p. 1; Cambridge Economic Policy Associates, pp. 3-4; Clean Energy Council, p. 3; Eastern Alliance for Greenhouse Action, pp. 2-3; Energy Consumers Australia, pp. 8-13; Energy Networks Australia, pp. 5-7; Energy Queensland, Attachment A, pp. 2-4; Northern Alliance for Greenhouse Action, p. 2; Origin Energy, p. 2; Uniting Communities, pp. 2-3. Submissions to draft report: AER, pp. 3-4; Centre for Energy and Environmental Markets UNSW, pp, 4,7; Eastern Alliance for Greenhouse Action, p. 2; Northern Alliance for Greehouse Action, p. 2.

Table A.1 Project scope

Issue proposed by stakeholders to be included within scope	Included within scope? (Yes/No)	Reasoning
The National Energy Customer Framework	No	Broader consumer protection issues, including those raised by the uptake of distributed energy resources, are being considered through other projects, including those being undertaken by the COAG Energy Council.[158]
Development and application of Australian Standards	Yes	While the AEMC does not have control over the development of Australian Standards, they can have a significant impact on consumer decisions about which products and services to buy, and how those products and services can be used, and are therefore relevant to consider through this project.
Collection and sharing of data	Yes	The collection and dissemination of information is vital to inform decisions about how parties invest and operate in markets, and is therefore relevant to consider through this project.
Systems, metering arrangements, IT infrastructure that may be needed to underpin a more dynamic, real time 'optimisation' model	Yes	The degree of required investment in new systems and infrastructure will likely be influenced by how distribution system operations and markets are designed, and therefore affect the costs and benefits of certain market designs.
AEMO's information needs	Yes	Distributed energy resources have the potential to affect how AEMO manages power system security, which is relevant to this project. We also note that AEMO is considering such issues through its work on the visibility of distributed energy resources.[159]
Standalone power systems and micro-grids	No	These issues are being considered through the *Alternatives to grid-supplied network services* rule change. The Commission will undertake a broad assessment of the issues through this rule change, including developing a principles-based framework about how these issues should be considered.[160] Stakeholders should also review the Commission's submission to the COAG Energy Council's

158 See: http://www.coagenergycouncil.gov.au/council-priorities/energy-market-transformation

159 See: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf

160 See: http://www.aemc.gov.au/Rule-Changes/Alternatives-to-grid-supplied-network-services

Issue proposed by stakeholders to be included within scope	Included within scope? (Yes/No)	Reasoning
		stand-alone systems consultation paper, which highlights:[161] • current issues with the regulatory framework relating to the supply of electricity to customers via stand-alone energy systems which are largely excluded from the national regulatory framework, in relation to both economic regulation and consumer protections • possible restrictions on the uptake of stand-alone energy systems under the current regulatory framework which may undermine price efficiency and the overall reliability and safety of electricity supply. Such detriments may grow over time if they are not addressed because distributed energy resources are become more viable financially and provide significant opportunities for increased efficiency of electricity supply • principles for the development of a consumer protection and economic regulatory framework to allow the efficient uptake, investment in, and supply and use of stand-alone energy systems.
Environmental and social objectives	No	Consistent with the NEO and the Commission's approach to applying the energy objectives,[162] this project will not consider the achievement of environmental or social objectives.
Grid connection standards	Yes	The process and requirements in the NER for connecting distributed energy resources to a distribution network can affect the uptake and operation of distributed energy resources, and are therefore relevant to consider through this project.
Consideration of how more efficient investment in, and operation of, distributed energy resources, could contribute better ways to manage any 'death spiral' that could eventuate.	Yes	The project implicitly considers this through consideration of how to maximise value of distributed energy resources.

161 See: http://www.aemc.gov.au/Major-Pages/Market-transformation/AEMC-Submission-on-stand-alone-energy-system-consu.aspx

162 See: http://www.aemc.gov.au/About-Us/Engaging-with-us/Decision-making-process/Applying-the-energy-market-objectives.aspx

B Related projects

B.1 AEMC projects

B.1.1 Electricity network economic regulatory framework review

In August 2016, the COAG Energy Council tasked the Commission with monitoring developments in the energy market, including the increased uptake of distributed energy resources, and providing advice on whether the economic regulatory framework for electricity networks is sufficiently robust and flexible to "continue to achieve" the national electricity objective (NEO) in light of these developments. The Commission is required to publish its findings annually.

The first report was published by the Commission on 18 July 2017.[163] The Commission used the first report to review the operation of the economic regulatory framework, how it has evolved against the backdrop of change in the past decades and identified areas that may require further investigation in future reports. As the first report of the annual review, the 2017 report provides a foundation for assessing the performance of the framework, rather than recommending changes.

B.1.2 Contestability of energy services rule changes

The COAG Energy Council submitted a rule change request in September 2016 seeking changes to the distribution service classification framework and service classification definitions in the NER to "enable the contestable provision of services from emerging technologies".[164] A subsequent rule change request was submitted by the Australian Energy Council in October 2016 seeking amendments to a number of aspects of the NER to "support the development of competitive markets in services which are or should be contestable".[165] These rule change requests focus on the regulation of services provided by assets that are able to provide value streams in both contestable and regulated markets, for example battery storage technologies.

The Commission released a consultation paper discussing the rule change requests in December 2016 and is due to publish draft determinations in August 2017.

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163 See http://www.aemc.gov.au/Markets-Reviews-Advice/Electricity-Network-Economic-Regulatory-Framework

164 See http://www.aemc.gov.au/Rule-Changes/Contestability-of-energy-services#

165 See http://www.aemc.gov.au/Rule-Changes/Contestability-of-energy-services-demand-response

B.1.3 Replacement expenditure planning arrangements rule change

On 18 July 2017, the AEMC made a rule to increase the transparency of retirement, de-rating and replacement decisions by electricity network service providers.[166]

Made in response to a rule change request submitted by the AER, the rule has the effect of including network asset retirement and de-rating information in network service provides' annual planning reports. It also extends the current regulatory investment test frameworks to include replacement expenditure. A number of auxiliary amendments to the NER have also been made in the rule.

The rule also includes an implementation approach for the new requirements.

B.1.4 Alternatives to grid-supplied network services rule change

In September 2016, Western Power submitted a rule change request that seeks to address a perceived lack of clarity in the NER about the ability of network businesses to receive regulated revenue for using non-network options, particularly stand-alone power systems, to help "meet their objectives of delivering safe, reliable and affordable electricity services to their customers."[167] The Commission commenced public consultation on this rule change request in June 2017 and a draft determination is due in September 2017.

The Commission also made a submission to the COAG Energy Council's consultation on the regulatory implications of stand-alone energy systems in the NEM in October 2016.[168]

B.1.5 Review of regulatory arrangements for embedded networks

In December 2015, the AEMC made a rule to reduce the barriers to embedded network customers accessing retail market offers.[169] In the final determination, the AEMC recommended that the COAG Energy Council ask the AEMC to undertake a review of arrangements for embedded networks under the NERL and NERR. The AEMC commenced consultation on this review in April 2017.[170] The review will determine whether the existing regulatory arrangements under the NERL and NERR for embedded network customers remain appropriate, and will examine broader issues related to embedded networks in the NEL, NER, National Gas Law, National Gas Rules and jurisdictional instruments.

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166 See http://www.aemc.gov.au/Rule-Changes/Replacement-Expenditure-Planning-Arrangements#

167 See http://www.aemc.gov.au/Rule-Changes/Alternatives-to-grid-supplied-network-services

168 See http://www.aemc.gov.au/Major-Pages/Market-transformation

169 See http://www.aemc.gov.au/Rule-Changes/Embedded-Networks

170 See http://www.aemc.gov.au/Markets-Reviews-Advice/Review-of-regulatory-arrangements-for-embedded-net#

B.1.6 Local generation network credits rule change

In July 2015, the Commission received a rule change request from the City of Sydney, Total Environment Centre, and the Property Council of Australia seeking to amend the NER to require DNSPs to calculate the long-term economic benefits that embedded generators provide to distribution and transmission networks, and pay embedded generators a local generation network credit that reflects those estimated long-term benefits.[171] The Commission made a final determination in December 2016 to not implement local generation network credits, but instead require DNSPs to complete an annual system limitation report providing certain information that would enable providers of non-network solutions to focus on locations where they could defer or reduce the need for DNSPs to invest in the network.

B.1.7 System security work program

The AEMC's system security work program comprises the *System security market frameworks review* and five rule change requests on related matters.[172] The Commission published a final report for the review on 27 June 2017.[173] The final report made nine recommendations for changes to market and regulatory frameworks to support the shift towards new forms of generation while maintaining power system security.

The Commission also published draft determinations for the *Managing power system fault levels*[174] rule change request and the *Managing rates of change of power system frequency*[175] rule change request on 27 June 2017. The draft rules:

- introduce regulatory arrangements to require network service providers to maintain the system strength at generator connection points above agreed minimum levels, with new connecting generators required to ' do no harm' to previously agreed levels of system strength
- place an obligation on transmission network service providers to provide minimum required levels of inertia, or alternative equivalent services, to allow the power system to be maintained in a secure operating state.

Final rules for these two rule change requests are due to be published on 19 September 2017. The Commission will also be considering on a mechanism for market-based provision of inertia through consultation on the *Inertia ancillary service market* rule

171 See http://www.aemc.gov.au/Rule-Changes/Local-Generation-Network-Credits#

172 The Commission published a final determination on two of the rule change requests on 30 March 2017. See: http://www.aemc.gov.au/Rule-Changes/Emergency-frequency-control-schemes-for-excess-gen

173 See: http://www.aemc.gov.au/Markets-Reviews-Advice/System-Security-Market-Frameworks-Review

174 See: http://www.aemc.gov.au/Rule-Changes/Managing-power-system-fault-levels#

175 See: http://www.aemc.gov.au/Rule-Changes/Managing-the-rate-of-change-of-power-system-freque

change request submitted by AGL.[176] The Commission is due to publish a draft determination on this rule change request on 7 November 2017.

B.1.8 Generating system model guidelines rule change

In November 2016, AEMO submitted a rule change request that seeks to revise the requirements of AEMO's generating system model guidelines to make sure that they remain relevant and effective for new and emerging technologies, and adequately address other aspects of the power system such as embedded generation, voltage support equipment, and control and protection systems for accurate planning, operation and analysis.[177] A draft determination was published on 20 June 2017. Stakeholder submissions on the draft determination closed on 1 August 2017.

B.2 External projects

B.2.1 Energy Networks Australia and CSIRO: Electricity network transformation roadmap

Energy Networks Australia, together with the CSIRO, has developed a roadmap that sets out a pathway for the transition of electricity networks by 2025.[178] The objective of the roadmap is to position network businesses and the energy supply chain for the future as consumer needs evolve, and to set out some 'no regrets' actions that will "enable balanced, long term outcomes for customers, enable the maximum value of customer distributed energy resources and position Australia’s networks for resilience in uncertain and divergent futures". The roadmap, published in April 2017, concluded that the full value of millions of customer owned distributed energy resources can only be realised in a connected future that enables multidirectional exchanges of energy, information and value.

B.2.2 AER: National distribution ring-fencing guideline

The AER published a national electricity distribution ring-fencing guideline on 30 November 2016.[179] The purpose of the guideline is to support the development of competitive markets for energy services and efficient investment in network and customer services seeking to eliminate the advantage a DNSP or its affiliates may otherwise have in providing contestable services. It replaces the various state-based ring-fencing instruments that were originally designed to separate the provision of network services from the provision of retail and generation services. The guideline

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176 See: http://www.aemc.gov.au/Rule-Changes/Inertia-Ancillary-Service-Market

177 See http://www.aemc.gov.au/Energy-Rules/Generating-System-Model-Guidelines#

178 See http://www.ena.asn.au/electricity-network-transformation-roadmap

179 See http://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/electricity-ring-fencing-guideline-2016

was developed in collaboration with the AEMC and in consultation with relevant stakeholders.

B.2.3 COAG Energy Council: Energy market transformation

The COAG Energy Council has initiated a market transformation program to make sure regulatory frameworks are "fit for purpose to cope with the effects of emerging technologies and to enable consumers to benefit from innovative services while mitigating any risks."[180] As part of this program, the COAG Energy Council released three consultation papers seeking feedback on issues relating to stand-alone energy systems, consumer protections and registration systems for battery storage. The AEMC made submissions to all three.[181]

In May 2017 the COAG Energy Council released a draft report and consultation paper on a cost/benefit analysis for the development of a battery storage register.[182] The issues and solutions raised through the market transformation program are relevant but separate to this Distribution Market Model project.

On 3 August 2017, an Energy Market Transformation Bulletin was released, setting out the COAG Energy Council's recommendations on how the key areas of work will be taken forward, specifically:[183]

- Consumer protections:
  - Minsters noted that while current consumer protections are generally sufficient for behind the meter products, they considered an industry-led Code of Conduct would support consumer protections for customer acquiring new energy products and services. Ministers agreed to write to representative industry groups asking industry to lead the development of a Code of Conduct for new energy products and services. While there are clear benefits in industry taking the lead, Ministers may reconsider whether further regulatory intervention is required in the future.
  - Ministers also considered that consumers would benefit from improved information that explains the laws and protections that apply in different supply arrangements. Energy Consumers Australia have been asked to develop a range of information products such as facts sheets, infographics and online tools.

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180 See http://www.scer.gov.au/current-projects/energy-market-transformation

181 See http://www.aemc.gov.au/Major-Pages/Market-transformation

182 See: https://prod-energycouncil.energy.slicedtech.com.au/publications/%E2%80%A2-energy-market-transformation-bulletin-no-04-%E2%80%93-national-battery-storage-register

183 See: http://www.coagenergycouncil.gov.au/publications/energy-market-transformation-bulletin-no-05-%E2%80%93-work-program-update

- Ministers agreed to request Energy Networks Australia to coordinate the development of consumer information that can be consistently provided across all network service providers. This information should prompt consumers to be aware of changes in availability or reliability standards, changes in consumer protections, the potential cost of reconnecting to the grid in future, and other relevant information.
- Consumers are offered greater choice with the expanding range of energy services and products, however there is a risk of some consumers getting products that don't meet their needs or offer poor value. Ministers agreed to request the Australian Competition and Consumer Commission prioritises the investigation of predatory practices of behind-the-meter sellers, and monitor other consumer protection issues related to the provision of behind-the-meter energy services.

- Stand-alone power systems:
  - Ministers agreed that consistency is desired in jurisdictional frameworks for the regulation of stand-alone power systems. Therefore, Ministers agreed Energy Market Project Transformation Team (EMTPT) should engage with relevant jurisdictional bodies and regulators and the Australian Energy Regulator to develop a best practice model for jurisdictional regulation of 'off-grid' stand-alone power systems.
  - Ministers further agreed to EMTPT developing a proposal for changes to the national framework to address regulatory gaps for transferring from grid connected energy services to stand-alone power systems and relevant regulatory arrangements. EMTPT will consult with stakeholders in developing this scope of work.
- Battery storage:
  - Ministers agreed to initiate the development of a national register for DER (solar generation and batteries) to be administered by the Australian Energy Market Operator (AEMO). A rule change proposal is to be developed by end August 2017 and the register to commence operation by end 2018.
  - Ministers noted that the rule change proposal may include revising rules for customer connection and/or retail contracts to clarify the information customers provide to distributors and/or retailers about DER to provide a default national data collection option where jurisdictional arrangements are not in place.
  - Ministers also agreed officials should work with AEMO to prioritise development of a standard format for collection of data on DER.
  - As an interim measure ahead of establishing the national register, Ministers noted officials will work with stakeholders, including network businesses,

installers, AEMO and the Clean Energy Regulator to increase data collection of DER, particularly storage equipment, which can be fed into the register once it is established.

Finally, it also announced that the EMTPT has commenced a project looking at existing and alternative regulatory incentive frameworks that may improve flexibility and encourage innovation and efficiency in electricity network investment.

B.2.4 Standards Australia: Standards and the future of distributed electricity

Standards Australia partnered with Energy Networks Australia through its Electricity Network Transformation Roadmap process to develop (in consultation with stakeholders) a roadmap on standards and the future of distributed electricity. The driver for the development of the roadmap was that "a strategic approach to standardisation for electricity networks had not been devised in Australia" and therefore the roadmap's stated purpose was to "support the strategic rollout of standards in Australia as electricity networks transition to a true ecosystem of prosumers".

The roadmap was published in May 2017.[184] It describes the current state of relevant standards and standards development committees, and sets out a plan of action for topic areas where consensus among stakeholders indicated a need for urgent work to be undertaken. Standards Australia has also produced roadmaps to support standardisation efforts in advanced metering[185] and energy storage.[186] The Commission was involved in the development of these roadmaps, and will continue to be involved in their implementation.

B.2.5 AEMO: Future power system security program

AEMO has established a program of work to assess and address the technical impacts that are likely to emerge as the NEM generation mix continues to change and consumers become increasingly active in how their demand is met. The Future Power System Security program seeks to identify opportunities and challenges to power system security and stability that could arise in the long-term, and promote solutions as soon as practicable where appropriate.[187] The Commission is working with AEMO and stakeholders to develop a comprehensive set of potential solutions that take into

184 See http://www.standards.org.au/OurOrganisation/News/Documents/Roadmap%20for%20Standards%20and%20the%20Future%20of%20Distributed%20Electricity.pdf

185 See http://www.standards.org.au/OurOrganisation/News/Documents/Roadmap%20for%20Advanced%20Metering%20Standards%20-%20Report.pdf

186 See http://www.standards.org.au/OurOrganisation/News/Documents/Roadmap%20for%20Energy%20Storage%20Standards.pdf

187 See https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability

consideration issues raised by consultation across its own system security work program.

B.2.6 Essential Services Commission of Victoria: Inquiry into the true value of distributed generation

In September 2015, the Essential Services Commission of Victoria was asked to undertake an inquiry into the true value (include economic, social and environmental value) of distributed generation.[188] The inquiry comprised two stages: the first explored the energy value of distributed generation and was finalised in August 2016, while the second looked at the network value of distributed generation and was finalised in March 2017.

B.2.7 Greensync and ARENA: Decentralised energy exchange

The decentralised energy exchange (deX) is pilot project funded by the Australian Renewable Energy Agency (ARENA) and led by GreenSync.[189] The project seeks to create a digital marketplace that incentivises households and businesses to generate and sell renewable energy resources to the energy network effectively and efficiently. The AEMC is participating in the reference group for this project.

B.2.8 Independent review into the future security of the National Electricity Market

At an extraordinary meeting on 7 October 2016, COAG Energy Ministers agreed to an independent review of the national electricity market to take stock of its current security and reliability and to provide advice to governments on a coordinated, national reform blueprint.

The Final Report for this review was presented to the COAG Leaders' meeting on 9 June 2017: *a Blueprint for the Future.* The blueprint focussed on delivering four key benefits to the electricity system: future reliability, increased security, rewarding consumers and lower emissions. The report used three pillars to achieve these outcomes: orderly transition measures, system planning and stronger governance.

At the 12th COAG Energy Council meeting on 14 July 2017, energy ministers agreed a series of actions in response to the Final Report of the Independent Review into the Future Security of the National Electricity Market.

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188 See: http://www.esc.vic.gov.au/project/energy/22790-inquiry-into-the-true-value-of-distributed-generation-to-victorian-customers/

189 See: https://www.distributedenergyexchange.com/

C Assessment framework

This appendix sets out the framework the Commission has used to consider:

- how distributed energy resources might drive an evolution to a more decentralised provision of electricity services at the distribution level
- the incentives or disincentives for business model evolution
- whether changes to the regulatory framework and market design are needed to enable this evolution to proceed in a manner consistent with the NEO.

C.1 The National Electricity Objective

The overarching objective guiding the Commission’s approach is the NEO. The NEO is set out in section 7 of the NEL, which states:

> “The objective of this Law is to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity with respect to:
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system.”

The NEO refers to the promotion of efficiency for the long-term interests of consumers. The availability and uptake of distributed energy resources is enabling electricity customers to make decisions that serve their own interests and what they value as a user, or producer, of electricity. These choices are driving investment in, and deployment of, particular technologies. The Commission considers that consumer choices should continue to drive the development of the energy sector, but that market design and regulatory frameworks may need to be modified to better align individual decisions with the long-term interests of consumers more generally. For example, to the extent that consumers make decisions regarding distributed energy resources that impose costs on others, those costs should be signalled to the consumer so that the costs can be internalised and incorporated in the consumer's decision-making.

In this way, energy market design should enable the efficient uptake and operation of existing and new energy technologies while facilitating technological innovation, competition and consumer choice. Where there are barriers or constraints to consumers exercising their choices, our preference is to address those barriers rather than using regulatory instruments to impose technology-based solutions on consumers. The rules the Commission makes, and the advice it provides, are therefore technology agnostic to the greatest extent practicable. The Commission's goal is to advise on and set a market framework that promotes consumer choice and can respond to any future scenario, including changes in technology.

C.2 Principles of good model design

The Commission developed a set of principles to guide its analysis of the technical and regulatory challenges raised by distributed energy resources, the possible models of future distribution system operation that may be available to address them, and their advantages and disadvantages. These principles were discussed in the approach paper, as well as the draft report, and stakeholders largely agreed with them.[190]

The Commission's principles of good model design are:

1. **Facilitate effective consumer choice.** Only a consumer itself knows its own preferences, and it expresses these preferences through its choices. Without consumer choice, there is no way for these preferences to be revealed and no way for the market to act on this knowledge. A market with consumer choice therefore promotes innovation and efficiency.[191]

2. **Promote competition.** Competition promotes efficiency - both in the short-term by encouraging suppliers to offer at prices that reflect production costs, and in the long-term by encouraging investment and innovation that will support the provision of cheaper or more attractive products and services. However, no market is perfectly competitive, and this must be taken into account. Similarly, it is important to consider those circumstances where the promotion of competition is impractical or not feasible. This principle was phrased as "promote competition where feasible" in the approach paper, but has been amended in response to stakeholder comment because the Commission agrees that feasibility is not the right criterion for determining how far competition should be pursued.

3. **Promote price signals that encourage efficient investment and operational decisions.** Efficiency is promoted when prices reflect the marginal cost of the provision of a particular product or service, as well as any positive or negative externalities. Prices and other signals can be used to promote efficient optimisation of the services provided by distributed energy resources. The importance of the 'right' prices for distributed energy resources is particularly important because, by definition, they are 'smart' and so are able to respond to these prices. Distributed energy resources and the services they provide therefore create both opportunities and threats - the opportunity of distributed energy resources responding to the right prices and the threat of them responding to the wrong prices.

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190 Submissions on approach paper: AEMO, p. 7; AGL, p. 2; Ausgrid, p. 4; Cambridge Economic Policy Associates, pp. 5-6; Origin Energy, p. 3; Red Energy and Lumo Energy, pp. 2-3. Submissions on draft report: AER, p. 2; AGL, p. 1. These are also broadly consistent with the principles used by KPMG in the following report: KPMG, Distribution Market Models: Preliminary Assessment of Supporting Frameworks, Report for the Australian Energy Council, June 2017, p. 17.

191 Energy Networks Australia commented that this principle should be expanded to reflect efficient and fair outcomes for consumers. See: Energy Networks Australia, submission on draft determination, p. 17.

4. **Enable technological neutrality.** In a time of rapid technological change, it is particularly important to enable technology neutrality. Specifying arrangements for a particular technology in the regulatory framework may lock it in, whilst locking out evolving new technologies that might not even have been anticipated when the design was considered. This means that design should consider what is supplied rather than how it is supplied.[192]

5. **Prefer simplicity and transparency.** Investment in and operation of distributed energy resources will be predicated on consumer decisions. To make efficient decisions, the consumer must understand the impact of each decision. A framework that promotes simplicity and transparency is then able to support efficient decision making. Simplicity is also a way to keep transaction costs to a minimum.

6. **Regulate to safeguard the safe, secure and reliable supply of energy, or where it would address a market failure.** Any new market design must take into account the need to support the safe, secure and reliable supply of electricity to consumers. Regulation may be required to safeguard these outcomes. Regulation can also be used to address market failures. For example, if competition is not feasible, it may be necessary to regulate natural monopolies to encourage them to provide the services demanded by their customers at the lowest sustainable cost. Regulation will need to evolve over time as the market develops so that it is proportionate to the market failure it is designed to address.

Principles 1 to 5 are indicators of a well-functioning market. Principle 6 acknowledges that regulation may be required to improve the functioning of a market or where a market-based approach may not be possible or appropriate.

These principles informed the analysis and development of the recommendations in this final report. They are not new: these principles are inherent in the NEM's original design and have informed changes since then, as discussed in section 3.1.[193] With the creation of the NEM, market-based approaches were introduced to the wholesale and retail segments of the sector. Regulation of the electricity sector has therefore historically been limited to:

- ensuring the safe, secure and reliable supply of energy given the unique physical characteristics of electricity
- pricing of monopoly functions
- providing consumer protections in the retail market.

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192 City of Sydney noted that technology neutrality may be unrealistic, unless there is recognition of externalities like climate change. See: City of Sydney, submission on draft report, p. 5.

193 See: http://www.aemc.gov.au/About-Us/Engaging-with-us/Decision-making-process/Applying-the-energy-market-objectives.aspx

The existing electricity market design, and the regulatory framework that governs it, has historically been based on a linear supply chain: from generator -> transmission -> distribution -> consumer.

The availability and uptake of distributed energy resources is enabling electricity customers to make decisions that serve their own interests as a user, or producer, of electricity. The Commission has been amending the regulatory framework over recent years to reflect the changes brought about by distributed energy resources, including through the *Power of choice* reforms and rule changes relating to the connection of embedded generation.

Consistent with the principles above, the Commission considers that consumer choices should continue to drive the development of the energy sector. However, more significant changes to this market design and the regulatory framework may be needed over the long term as the type and prevalence of distributed energy resources increases. These possible changes are discussed throughout this report.

D An evolution of distribution system operation

In order to inform the Commission's thinking, and that of others, we have developed an indicative evolutionary path for distribution system operation. An evolution, as opposed to discrete 'market design' options, allows us to assess what might be needed in order to facilitate the optimisation and coordination of investment in and operation of distributed energy resources across the whole electricity system.

This evolution is not intended to articulate a particular regulatory path or outcome, or predict the types or level of technology uptake in the future. We cannot know for certain what the future will look like. It is therefore unlikely that Australia's distribution networks will follow the evolutionary path as set out below - we could skip steps, stop at any point, or end up somewhere else entirely.

However, the Commission considers that any regulatory and market arrangements should be flexible and resilient to whatever the future may bring. The evolution set out below has three distinct stages, which allow us to explore:

- how regulatory, operational and market design changes may facilitate an evolution of distribution network operations
- what issues would need to be addressed in order to enable a progression through the stages of this evolution.

This appendix discusses the three stages of the evolution:

1. Minimal optimisation of distributed energy resources investment and operation.
2. Static optimisation of distributed energy resources investment and operation.
3. Dynamic optimisation of distributed energy resources investment and operation.

The first stage in this evolution is not intended to be a reflection of current arrangements. As set out in section 2.2, it is generally not clear how the operation of different distribution networks is evolving, and progress depends largely on the DNSP and various external factors. The stages speak in more general terms about the Commission's understanding of how the increasing uptake of distributed energy resources has changed how distribution networks are operated, and how distribution network operation might need to evolve to facilitate the optimisation of investment in and operation of distributed energy resources in the future.

Through the evolution, distribution network operations move from a world where there is limited optimisation of distributed energy resources (e.g. where few of the services they are capable of providing are being monetised) to one where the provision of all services provided by distributed energy resources is optimised across the whole electricity system. Over time, the AEMC expects that the market will evolve to a point where more real-time, dynamic information is available to participants that will allow them to more directly value the trade-offs between the different services capable of being provided by distributed energy resources. It is important to note that, while we see this market becoming more dynamic and operating on a more real-time basis, we do not envisage consumers being required to directly manage their energy in that way – it will be service providers doing that on their behalf, based on the preferences expressed by the consumer.

The stages in the evolution are summarised in Figure D.1 below.

Figure D.1 Evolution of distribution system operation

NO DIRECT INTERACTION WITH WHOLESALE VALUE OF ENERGY → FULL CO-OPTIMISATION BETWEEN WHOLESALE AND DISTRIBUTION MARKETS

STAGE 1: Minimal optimisation of distributed energy resources investment and operation	STAGE 2: Static optimisation of distributed energy resources investment and operation	STAGE 3: Dynamic optimisation of distributed energy resources investment and operation
DNSP owns, operates the network. No optimisation	DNSP owns, operates the network Optimisation function present	DNSP owns, operates the network Optimisation function present
Basic (mainly temporal) cost-reflective tariffs	Cost-reflective tariffs (both locational and temporal)	Dynamic cost-reflective tariffs (temporal and locational SRMC)
limited information on DER location, and network constraints	More information about DER use patterns, and network constraints	Real-time information about DER use patterns, and network constraints

D.1 Stage 1: Minimal optimisation of distributed energy resources investment and operation

In the first stage, relatively high-cost, limited functionality distributed energy resources are available in the market. Early adopters seek to install these technologies, likely in response to government incentives such as feed-in tariffs. The connection process and technical standards associated with connection do not contemplate such technologies, as historically they have not been installed on distribution networks at scale.

The majority of the distributed energy resources are only being installed to provide services to, and so benefit, one party. That is, they are only monetising the value of services to one beneficiary. For example, a DNSP may contract with consumers to provide direct load control in order to manage peak demand issues in its network. Or, a customer may install a solar PV + battery system in order to reduce its retail bills. As a result, the party who *controls* the distributed energy resource is acting independently in accordance with its own interests (e.g. the DNSP or the customer). As a result:

- the full capability of the distributed energy resource is not being used because its control lies solely with one party, who wants that capability 'on hold' for when it wants to use it
- there is little incentive on the controller to provide services to other parties, because it is only considering the maximisation of the benefits from the

distributed energy resources to itself, rather than the maximisation of the benefits to the electricity system as a whole.

A lack of knowledge about the existing technical characteristics of the lower levels of distribution networks, and the impact of the distributed energy resources connected there, means DNSPs have limited ability to develop fully cost-reflective network tariffs. A lack of exposure to these costs means that some customers are making inefficient decisions about where to connect and when to use distributed energy resources.

Since, at this stage, distributed energy resources are relatively new technologies, DNSPs have limited experience in processing connections for them and in understanding their technical impacts. This may mean that DNSPs place limitations on the installation or operation of distributed energy resources as a means to manage the risks of any technical impacts of those technologies on distribution networks. DNSPs may also not have developed confidence in the firmness of response from distributed energy resources for the services they provide to be considered a viable alternative to traditional network investment.

However, over time, the costs of distributed energy resources decline, and their functionality increases. As a result, more parties offer distributed energy resources, related technologies and services, and more consumers take them up. This leads to calls (from both retailers and consumers) for more cost-reflective network tariffs so that consumers can better understand the costs and value of the services provided by distributed energy resources. DNSPs start to set basic cost-reflective network tariffs, which, over time, are reflected in consumers' retail offerings. With this, consumers start to make more efficient decisions about investing in and operating distributed energy resources.

As set out in chapter 2, distribution networks were originally designed to accommodate one way flows of electricity from large, transmission-connected generators to distribution networks via transmission networks. As there is, generally, plentiful spare capacity in distribution networks, and so distributed energy resources essentially have free 'access' to the distribution network, and so to transmission-level markets. However, the majority of distributed energy resources are still being controlled by one party, acting independently, for their benefit alone. That is, distributed energy resources are in most cases being installed to provide services for only customer benefits, retail benefits or network benefits. This results in a limited ability or incentive for the full value of distributed energy resources to be maximised.

As distributed energy resources become more widespread, DNSPs start to see the services that distributed energy resources provide as a viable alternative to investment in traditional network assets, and become more comfortable with the 'firmness' of response that they are capable of providing. As DNSPs start to procure more of these services, the aggregator business model strengthens and more providers emerge. This business model initially seeks to provide value to customers by monetising both the network services and services to the consumer itself.

In some cases, consumers may be able to meet their energy needs without relying on large-scale generation via networks. In such examples, distributed energy resources technologies become competitive with traditional network investment, most likely at the fringes of distribution networks where the cost of providing network capacity is highest. Here, distributed energy resources are deployed as an alternative to network expansion or replacement, and the remaining network assets are left to age.

With distributed energy resources becoming more prevalent, standards and connection processes are revised to accommodate their connection and use. This gives consumers and other investors in distributed energy resources better information with which to make investment decisions, and means that DNSPs have less need to place limits on the connection and use of distributed energy resources. Some distribution networks start to experience technical impacts as a result of higher levels of distributed energy resources, such as those set out in Box 2.1, which drives DNSPs to consider upgrades to communication and legacy control systems in order to have better information about, and manage, their network. Accordingly, DNSPs start to operate their networks much more actively than they have historically.

At the end of this stage:

- The costs of distributed energy resources are decreasing. Consumers have increasing needs and desires for distributed energy resources and the services they provide. The economics of these technologies means more consumers take them up, and DNSPs start to consider ways to use the services provided by distributed energy resources as an alternative to traditional network investment.

- The functionality of distributed energy resources is improving. DNSPs are getting more confident in procuring services provided by distributed energy resources as a means to provide common distribution services. Distributed energy resources are becoming increasingly able to be controlled in real time, or near real time. This increases their ability to interact with the wholesale market, where being controllable or dispatchable is key.

D.2 Stage 2: Static optimisation of distributed energy resources investment and operation

In stage 2, the costs of distributed energy resources continue to decline and their functionality continues to improve.

As noted above, the Commission considers that, in order for a level playing field for the provision of services from distributed energy resources to be achieved, there needs to be clear optimisation of distributed energy resources, and it is best if regulated DNSPs do not provide such a service. If a competitive market for optimising services exists, the Commission expects that the 'market' for the provision of distributed energy resource services will continue to grow - with business models seeking to maximise the value of distributed energy resources for consumers by providing services to others on the consumer's behalf.

The emergence of a competitive market for optimising services, combined with greater uptake of distributed energy resources, sees trials of 'markets' to enable the buying and selling of services provided by distributed energy resources; as well as the rise of the aggregator business model to manage interactions between consumers, and the provision of network and wholesale services.

Due to the incentives placed on them in stage 1, the DNSP has installed better communication and monitoring equipment across its network. As a result, it has more information about the technical characteristics of its network, including network constraints. This information enables the DNSP to plan its network more efficiently and effectively, and in shorter timescales. This information, and the emergence of new business models seeking to sell network services from distributed energy resources to DNSPs, sees DNSPs contracting for the provision of services by distributed energy resources as a substitute for traditional network investment on a wider basis than in stage 1.

The DNSP can also make this information available to enable greater optimisation across its network, for example information about network constraints. This means that price signals have been developed that provide information on where and how to invest in distributed energy resources and operate them in a way that maximises value to them and to those parties who procure the services (including DNSPs). This also provides the ability to more actively control and coordinate the distributed energy resources to support contracts with DNSPs to mitigate the technical impacts that arise from the use of such resources.

The value of distributed energy resources is therefore starting to be maximised due to the closer interaction between the value of distributed energy resources to consumers, DNSPs and transmission-level markets. This results in a better understanding of when distributed energy resources provide benefits to the wholesale market, versus the distribution and transmission networks, versus customers. This information supports decision-making about where investment in distributed energy resources provides value and which services generate the most value at any point in time.

D.3 Stage 3: Dynamic optimisation of distributed energy resources investment and operation

In this final stage of this evolution, any party who takes on the optimising service has both the incentives and the data to provide more dynamic price signals to the owners of distributed energy resources, for example about the value of providing network services. More dynamic pricing of the value of network services means consumers face stronger, more accurate signals regarding investment in, and use of, distributed energy resources. Responses to these signals help DNSPs better (e.g. more actively) manage the network, which supports more efficient operation of, and integration with, the wholesale market.

As data and technology becomes more sophisticated, so do the prices that consumers are exposed to. The costs of using the network are now much more reflective of the temporal and locational demand for the network service. This enables:

- more efficient installation and use of distributed energy resources by consumers
- parties to rely on pricing to reveal responses from participants, which, among other things, can help the DNSP operate its network more safely and reliably, rather than relying on strict, regulatory controls.

Given the advances with pricing, contracts that were envisaged earlier become more refined - in the long-term potentially even becoming real-time in response. DNSPs can now make procurement decisions in real-time to address the impact or utility of distributed energy resources on the network. This results in more efficient investment in and operation of the network - however, parties are exposed to increased basis risk, so thought would need to be given as to how parties might hedge against such risks.

Aggregator business models are further developed to maximise participation of distributed energy resources in all the various markets. This enables a closer interaction between the provision of services to distribution-level markets to transmission-level markets, including the NEM. Therefore, the value of investing in and operating distributed energy resources is more co-optimised across the whole system than in the earlier stages. This should result in efficient co-optimisation of all of the value streams from distributed energy resources.

D.4 Conclusion

The evolution described in this appendix sets out one of many pathways that the operation of the distribution system could follow as the uptake of distributed energy resources increases. The exploration of this particular pathway allows us to assess the key transformation issues and so determine what 'market design' changes may be needed to progress through the stages of this evolution. The Commission's preliminary conclusions, following consideration of this particular evolution, are that:

- The provision of the services provided by distributed energy resources in response to market-based signals has a number of benefits. The installation, connection, optimisation and control of distributed energy resources should therefore, except for system security and safety reasons, be determined through market-based signals, not regulation. This approach will most likely lead to efficient outcomes because it promotes consumer choice while providing a level playing field for market participants.
- The interaction between the provision of network services and services to the wholesale market is likely to increase over time. Therefore, for the full value of distributed energy resources to be maximised, these segments of the market will need to become increasingly integrated.

We have also considered that, while unlikely, the penetration of distributed energy resources may plateau if grid-scale technologies make centralised electricity generation more cost-effective. Our view is that the conclusions set out above are still relevant in such a future. This is because:

- a greater level of optimisation across the distribution network and coordination with transmission-level markets is arguably already required with existing levels of distributed energy resources
- there will always be a significant amount of distributed energy resources, and without integration the value from these devices would not be fully realised.

Chapters 4 and 5 set out the Commission's views on the nearer term market and technical enablers that are needed to advance the development of distribution system operation, and more readily incorporate distributed energy resources into our markets, and recommendations for further work or action to overcome any barriers to these enablers being implemented.

E 2017 *Energy sector strategic priorities* terms of reference

Project ID .... RECEIVED 13 JAN 2017

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COAG
Energy Council
Chair

Mr John Pierce
Chair
Australian Energy Market Commission
PO Box A2449
SYDNEY SOUTH NSW 1235

Dear Mr ~~Pierce~~ John

You would be aware that in December 2015, in response to the *Review of Governance Arrangements for Australian Energy Markets*, the Council of Australian Governments (COAG) Energy Council (the Council) agreed to task the Australian Energy Market Commission (AEMC) with providing targeted strategic advice to inform the Council's energy market strategy and priority setting.

I want to thank you for your considered engagement since that time and for your suggestions to amend the national energy laws in relation to this important strategic advice role. As the Council has resolved to rely on the existing national energy law framework, rather than make further legislative amendments, the attached Terms of Reference has been developed with the aim of formalising the provision of this advice.

The Council is seeking a report that informs key issues that could impact on its efforts in determining and setting strategic priorities in the Australian energy sector and markets. The report is intended to be a brief, broad, and high-level analysis of issues drawing on the AEMC's daily experience of the sector and its institutional interactions. It will form an important contribution to Council deliberations in the coming years, and it is intended that the outcome of those deliberations will be published on the Council website as a means of providing guidance to the energy community and its institutions, including the AEMC. Importantly, as this tasking is an ongoing triennial process, each advice and subsequent response of the Council is intended to build upon the former, with the aim of providing a body of work to assist decision makers into the future – it will act as a transparent reflection of the evolution of the Council's priorities over time.

If you require further information please contact Mr Brenton Philp, A/g First Assistant Secretary, Energy Division on (02) 6275 9026.

Yours Sincerely

The Hon Josh Frydenberg MP
Chair
COAG Energy Council

December 16

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Terms of Reference

Request for advice: Energy Sector Strategic Priorities

Context

On 4 December 2015, the COAG Energy Council (the Council) published its response to the *Review of Governance Arrangements for the Australian Energy Markets* (the Review). In its response, the Council affirmed that it is the primary entity responsible for setting strategic direction in the energy sector and in relation to energy market reform. Critical to this is the identification of emerging circumstances (or the potential for such circumstances) that could transform the energy sector. The Council's role is to provide leadership and strategic guidance about how such structural changes should, if at all, be accommodated within the national energy frameworks.

To assist in the Council's understanding of the changing environment in and around the energy sector, and ultimately in determining strategic priorities, it is necessary to seek advice from a range of expert sources. An important part of this is to draw on the Australian Energy Market Commission (AEMC), and its understanding of the detailed frameworks set out in the national energy rules, to highlight major issues currently facing the energy market and circumstances that could arise in the in the future that may require further analysis.

Energy Council Directed Review

The Council comprises Ministers responsible for Energy matters. These Ministers comprise the membership of the legally enduring Ministerial Council on Energy (MCE). Pursuant to section 6(b) of the *Australian Energy Market Commission Establishment Act 2015*, the MCE requests the AEMC to provide advice on current and future challenges and opportunities facing Australia's energy sector and energy markets.

This Terms of Reference (ToR) is an ongoing tasking of the AEMC. Future advices are intended to build on previous work to provide a useful body of work against which current strategic priorities may be referenced.

Content of the Report

The Council seeks a report that sets out the key issues that could impact on the Council's efforts in determining and setting strategic priorities in the Australian energy sector and Australian energy markets. Broadly, the report should cover significant current and potential challenges, risks and opportunities relating to the energy policy, regulatory or operational environment.

It is intended that this advice be a broad, high-level analysis rather than a detailed examination of individual issues. More specifically, the report should concisely highlight:

- major challenges, risks and opportunities currently facing the energy sector and energy markets;
- any current or potential future energy sector related developments that could impact on the national energy regulatory frameworks and their capacity to deliver:

- the statutory objectives articulated in the NEL, NGL and NERL;
  - the objectives articulated by COAG in the Australian Energy Markets Agreement;
- the current work being progressed by the AEMC, inclusive of reviews and rule change requests, that are relevant to the matters listed above;
- from a high-level, issues-based perspective, matters covered under the national energy rules that may require further consideration.

The advice should be developed in the context of any matters that could impact on national energy policy, including the delivery of the National Electricity Objective, the National Gas Objective and the National Energy Retail Objective.

Process and deliverables

The AEMC will provide its detailed advice, in the form of a report to the MCE by October every three years. In the intervening years, the AEMC is to annually provide updates on its previous detailed advice to the MCE by October. Unless determined otherwise, the Report will be published in mid-December following the provision of advice to the MCE in October.

In addition to its existing consultation activities, in developing the advice and the updates, the AEMC must consult with:

- the Standing Committee of Officials (SCO) on an ongoing basis; and
- the other market institutions (the Australian Energy Regulator, Australian Energy Market Operator and Energy Consumers Australia).

The process is expected to take about one year from commencement of the work until the consideration of the advice by the COAG Energy Council. A timeline for the provision of advice is set out below:

Activity	Due by
Terms of Reference issued to the AEMC	The second half of year 1 (initially 2016).
Development of detailed approach	December – year 1 (and in December each year before the next advice is to be provided).
Delivery of advice to Council Secretariat	September/October – year 2 (initially 2017, and every three years thereafter).
Workshop with SCO; consideration of advice	Late-October – in each year following receipt of the advice.
COAG Energy Council publishes its strategic priorities	December – in each year following receipt of the advice.

The full process for developing the detailed advice will be conducted every three years. In line with this, it is expected that the AEMC will provide detailed advice in October 2017, 2020, 2023, etc.

The AEMC must publish a statement of approach setting out how the advice will be developed, including the process for consultation with all stakeholders.

Future variations to the Terms of Reference

As with all advice requested by the MCE, the Council recognises it may be necessary to vary this ToR to reflect changing priorities, experiences over time with the type or frequency of advice or, if necessary, to terminate this request for advice. Additionally, supplementary ToR for future triennial reviews may be issued to focus upon specific areas of national policy interest.