Australian Energy Market Commission

Distribution Market Model

DRAFT REPORT
6 June 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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Reference: SEA0004

Citation

AEMC 2017, Distribution Market Model, Draft report, 6 June 2017, Sydney

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 asset 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. Currently, consumers might be able to benefit from one or two of the revenue streams that distributed energy resources can provide. However, in the AEMC's view, consumers (or their chosen energy service providers) should be able to access all possible revenue streams, if they choose. More generally, there is a need to facilitate cooperation between various parts of the supply chain to maximise the value of the multiple services that can be provided by distributed energy resources.

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. However, 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:

1. The **optimisation** of investment in, and operation of, distributed energy resources. That is, consideration of how to encourage consumer-led investment in distributed energy resources and to maximise the benefits of that investment by enabling consumers to, if they choose, receive the maximum possible benefit

of utilising and selling the full range of services that the asset is capable of providing, given transaction and information costs, and technical constraints.

2. The **coordination** of 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.

The draft 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. It 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, and identifies the barriers to this occurring. It presents an independent view of what future distribution network operation might look like, guided most strongly by the principles of competitive neutrality and consumer choice. The paper is not intended to be a prediction of, or pathway, for future regulatory reform, but rather an exploration of the key characteristics of a potential evolution to a future where investment in and operation of distribution energy resources is optimised to the greatest extent possible.

Nevertheless, we cannot know for certain what the future will look like. It may involve high levels of distributed energy resources. Alternatively, technology developments and climate change policies may result in a future with more use of grid-scale renewable generation and storage, rather than at consumer premises. Energy policy and associated regulatory frameworks need to be flexible and resilient enough to respond to whatever the future may bring in a way that is technology neutral, facilitates consumer choice and maximises efficiency. Where there are barriers or constraints to consumers exercising their choices, the Commission's preference is to address those barriers rather than using regulatory instruments to impose technology-based solutions on consumers.

This project is intended to be a forward-thinking, strategic piece to help inform the Commission's analysis of rule changes submitted to it by stakeholders in response to emerging issues, and guide its advice to governments. It forms part of the AEMC's technology work program, which seeks to explore whether the energy market arrangements are flexible and resilient enough to respond to changes in technology. It builds on the analysis undertaken by other projects in the technology work program, including the *Integration of storage* report,[1] which made a number of recommendations that were developed in response to stakeholder feedback. Some of those recommendations resulted in immediate rule changes, while others have led to rule changes that the AEMC is currently considering. As with that project, stakeholder input on the issues set out in this report has the potential to drive changes to the energy market arrangements.

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

A summary of this report is available in the form of a pre-recorded webcast on the AEMC website.[2] The Commission welcomes written submissions from stakeholders on any aspect of this draft report by 4 July 2017, as well as individual meetings with interested stakeholders. Feedback from stakeholders will be used to inform the development of a final report, to be published in August 2017.

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

Contents

1 Introduction

1.1 Objective of the project

This project forms part of the Australian Energy Market Commission's (AEMC or Commission) technology work program, which seeks to explore whether the energy market arrangements are flexible and resilient enough to respond to changes in technology.[3] 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.

The Distribution Market Model project is intended to be a forward-thinking, strategic piece. It will be used to inform the Commission's analysis of rule changes submitted to it by stakeholders in response to emerging issues, and its advice to governments. Its purpose 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, distribution system operation and 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 objective, the Commission will explore:

- 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 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

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

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 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, 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.

1.2 Progress to date

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 DNSPs is under the current 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 will be assessed through this project
- sought feedback from stakeholders on each of the above items.

24 submissions were received, and are available on the AEMC website.[6] A number of the comments made by stakeholders in those submissions have informed the development of this draft report, and are discussed and referred to where relevant.

1.3 Purpose of this draft report

This draft report:

- clarifies the project scope, key definitions and market design principles in response to stakeholder submissions on the approach paper
- sets 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

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

6 Ibid.

- identifies and assesses the barriers (if any) to these enablers
- seeks feedback from stakeholders on the materiality of any barriers, and possible ways to address them.

Input from stakeholders on this draft report will be used to inform the development of a final report. The next steps for the project, including the arrangements for consultation on this draft report, are set out in chapter 7.

1.4 Key terms

The approach paper set out the Commission's proposed definitions of some key terms, including 'distributed energy resources' and 'distributed generation'.

Our proposed definition of a distributed energy resource was "an integrated system of smart energy equipment co-located with consumer load." By 'smart', we meant that it had the ability to respond automatically to short-term changes in prices or signals from wholesale markets or elsewhere in the supply chain. The term 'energy equipment' was intended to include a range of technologies, including battery storage, electric vehicles, rooftop solar photovoltaic (PV) systems, or household appliances such as refrigerators and dishwashers.

As a result, energy equipment that operates passively, 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, was not captured under that proposed definition. The Commission decided to exclude such equipment from the definition of distributed energy resource because the mechanisms to address the issues raised by the passive operation of these technologies, such as tariff structures or export constraints on distribution networks, are limited in their ability to promote efficient coordination across all elements of the supply chain. Further, with the right incentives from market mechanisms and developments in the minimum technical requirements of electrical equipment (i.e. through standards), we expected that it would become worthwhile to make passive energy equipment 'smart'.

Our proposed definition of distributed generation - "smart energy equipment that is connected to the distribution network at a dedicated connection point" - sought to capture larger equipment, for example a solar farm or a large, grid-connected battery system.

A number of stakeholders disagreed with our proposed definition of distributed energy resources in their submissions to the approach paper.[7]

7 Submissions on approach paper: AEMO, p. 2; AGL, p 3; Ausgrid, pp. 1-2; Cambridge Economic Policy Associates, p. 3; Energy Consumers Australia, p. 18; Energy Networks Australia, p. 5; Energy Queensland, Attachment 1, p. 1; Origin Energy, p 1; Red Energy and Lumo Energy, p. 2.

Specifically, many considered that:

- 'passive' energy equipment should be brought within the scope of the definition, and therefore within the scope of the project, because it can also affect network operation and drive the need for evolution
- the same term being used by different organisations to describe different things is confusing - the industry-understood use of the term distributed energy resources includes what we proposed to separately define as distributed generation
- the use of the term 'smart' is potentially confusing and is not always seen in a good light
- the meaning of the term 'automatically' in the proposed definition suggests that the equipment responds without intervention - that is, without the consumer's knowledge or input.

Some stakeholders sought clarification on whether controlled load would be captured in this definition.[8]

In response to this feedback, the Commission has revised its definition of distributed energy resources to include distributed generation (i.e. not define it separately), given that many consider that the industry-understood use of the term includes such equipment. As such, the definition includes smart energy equipment of any size connected to the distribution network. It is also intended to capture controlled load, for example direct load control of pool pumps, hot water systems and air conditioning equipment.

However, the revised definition does not capture 'passive' energy equipment, and therefore such equipment does not directly fall within the scope of the project. As above, if the equipment is entirely unable to respond to external signals, then the ability of a 'market model' to address the issues it raises is limited. Further, we imagine that these sorts of systems 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. Nevertheless, we acknowledge that there is an existing amount of distributed energy resources that operates passively - for example, the majority of existing solar PV systems - which have the potential to create technical impacts and change the way we think about distribution network operation.[10]

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8 Submissions on approach paper: Ausgrid, p. 2; Energy Networks Australia, p. 6; Origin Energy, p. 1.

9 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.

10 The Commission acknowledges that there is a need to have better information about existing levels of passive distributed energy resources on the system. This need, and the existing processes underway to help achieve that, are discussed further in section 5.1.

The Commission's definition of smart retains the word 'automatically'. In this context, we use the word to describe the technical characteristics of the distributed energy resource - that is, it has the capability to respond automatically to short term changes in prices or signals. We do not intend it to mean that this response occurs without the input of the person who owns the device. The AEMC expects that any automatic response of a distributed energy resource would only occur where the customer has agreed to that response occurring, either through their original investment decision or subsequent arrangements they enter into regarding the control of that device.

Table 1.1 sets out the Commission's revised definitions of these key terms, and includes other key terms that are used throughout this report. 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. 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
Distributed energy resources	An integrated system of smart energy equipment that is connected to the distribution network.
Smart	The ability to respond automatically to short-term changes in prices or signals from wholesale markets or elsewhere in the supply chain.
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.
Optimise	To make efficient decisions about investment in and operation of a distributed energy resource, given any technical constraints.
Optimising function	The function of 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 on their behalf.
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 2.2.

Term	Definition
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 2.2.
Wholesale services	The services enabled by distributed energy resources that can be bought and sold in transmission-level markets, for example the provision of ancillary services to the Australian Energy Market Operator (AEMO), or the generation of electricity for participation in the national electricity market (NEM). These services are described in Figure 2.2.
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.[11]
Transmission-level markets	Markets for the provision of electricity services in transmission networks, including the NEM, the procurement of market ancillary services such as frequency control or the competitive procurement of services enabled by distributed energy resources for the purposes of managing network congestion.

1.5 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

11 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.

In submissions to the approach paper, stakeholders largely supported the Commission's proposed scope for the project, but asked that the AEMC also include consideration of other issues.[12] Table 1.2 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.

Table 1.2 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 the COAG Energy Council.[13]
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.

12 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.

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

Issue proposed by stakeholders to be included within scope	Included within scope? (Yes/No)	Reasoning
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. However, we also note that AEMO is considering such issues through its work on the visibility of distributed energy resources.[14]
Standalone power systems and micro-grids	No	These issues are being considered through the *Alternatives to grid-supplied network services* rule change.[15]
Environmental and social objectives	No	Consistent with the NEO and the Commission's approach to applying the energy objectives,[16] 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.

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.

1.6.1 Current AEMC projects

The Commission is currently considering a range of rule change requests and reviews that together contemplate changes to the economic regulatory framework that underpins the operation of distribution networks. Figure 1.1 groups these projects into topic areas. The Commission is closely managing the interactions between these various projects and sharing knowledge between internal project teams where

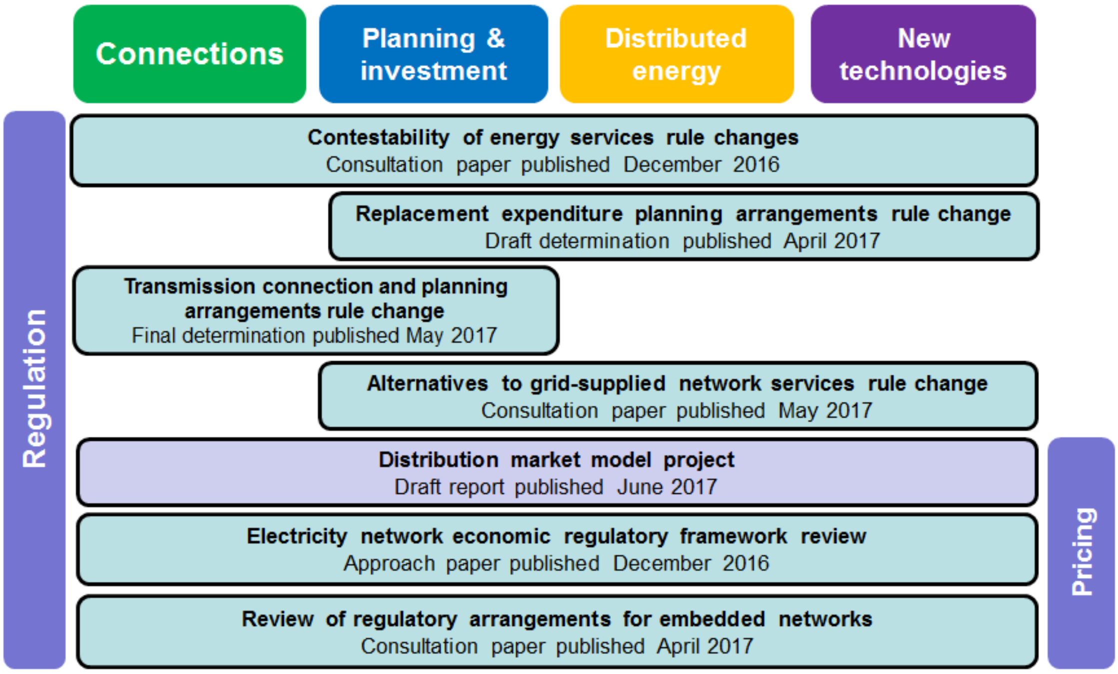
14 See: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Reports/AEMO-FPSS-program----Visibility-of-DER.pdf

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

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

relevant. A description of each project, and other relevant AEMC projects, can be found in appendix A.

Figure 1.1 Relevant AEMC rule changes and reviews



1.6.2 External projects

The Commission is also aware of, and participating in, a range of work streams being undertaken by other organisations in this space. A description of these projects can be found in appendix A.

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 describes the Commission's framework for how the technical impacts and associated regulatory challenges of increased uptake of distributed energy resources will be assessed through this project
- chapter 4 sets out indicative evolutionary path for future operation of the distribution system
- chapter 5 provides the Commission's preliminary views on the near-term 'market' enablers that will need to underpin any future design of distribution system operations

- chapter 6 provides the Commission's preliminary views on the near-term 'technical' enablers that will need to underpin any future design of distribution system operations
- chapter 7 sets out the Commission's next steps for this project.

2 Background

2.1 The 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
- increasing functionality of these technologies
- more sophisticated information and control technologies, and fast, cheap computing platforms
- changing consumer attitudes to electricity supply.

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:

- embedded solar PV uptake will triple by 2030, with 16GW of installed capacity across the NEM, which equates to approximately 50 per cent of projected average daytime demand[17]
- by 2035/36, nearly 4GW of this rooftop PV capacity will have integrated battery storage, providing 6.6 GWh of energy storage potential[18]
- the number of electric vehicles will significantly increase, from around 2,000 vehicles currently to around 255,000 in 2030, providing a total charging load of around 1,800MW.[19]

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.

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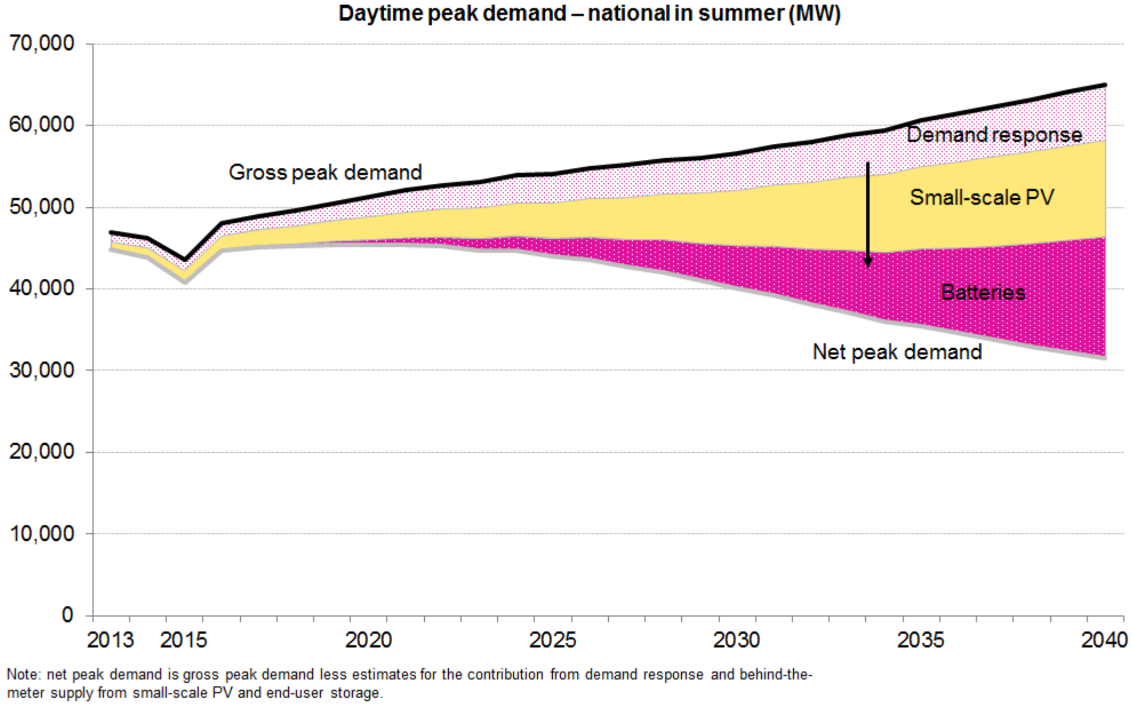
17 AEMO, National Electricity Forecasting Report, 2016.

18 Ibid.

19 AEMO, Emerging technologies information paper, 2015.

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.[20]

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

2.2 Distribution networks were not originally configured to deal with distributed energy resources

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 these networks generally have spare capacity and therefore have some ability to adapt to the technical impacts of distributed energy resources. However, distribution networks will likely experience a range of technical impacts as penetration levels increase, particularly if no action is taken to address them.

The approach paper published on this project set out the Commission's analysis of the key technical impacts that an increased uptake of distributed energy resources can present to distribution networks. These are summarised in Box 2.1. Stakeholders largely concurred with these technical impacts in their submissions to the approach

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

paper, but had different views about the scale of each impact and how each should be, or is already being, addressed.[21]

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 interface 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**.
- 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, for example depending on the network's size, topology and technical characteristics, the uptake of distributed energy resources and the impact of other factors, such as jurisdictional requirements, on the culture and practices of the DNSP.

21 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.

As a result, 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. 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. There are 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.[22]

The Commission understands that the capability of Australia's DNSPs to recognise and resolve these impacts is currently low, given that the networks were not originally configured to deal with distributed energy resources. As a result, most existing, small distributed energy resources (<5kW) have been connected without detailed analysis of the incremental impact it 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. 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 and reliable supply of electricity to consumers. Distribution networks will therefore likely need to adapt to accommodate an increased uptake of distributed energy resources.

However, it is generally not clear how different distribution networks are evolving. Progress depends largely on the DNSP.[23] 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 and demand patterns at the wholesale level.

For example, AEMO considers that a high penetration of distributed energy resources will affect its ability to manage power system security.[24] AEMO manages power system security by balancing demand needs with available supply through the

22 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

23 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.

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

wholesale market dispatch process. It notes that distributed energy resources have common drivers 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 or less predictable in how they operate, 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 maximum demand is forecast to grow faster and become comparable to summer maximum demand from around 2030.[25] These changes will affect the operation of the NEM and the investment decisions of those participating in it.

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 electricity, 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. 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 2.2.
- DNSPs or TNSPs may procure the services enabled by distributed energy resources to help them provide common distribution or transmission services,

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

such as reducing peak load in order to defer network augmentation,[26] 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 2.2.

- 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 2.2.

- Other parties may use distributed energy resources to provide ancillary services, such as frequency control ancillary services, to AEMO. These services are described as 'wholesale services' in Figure 2.2.

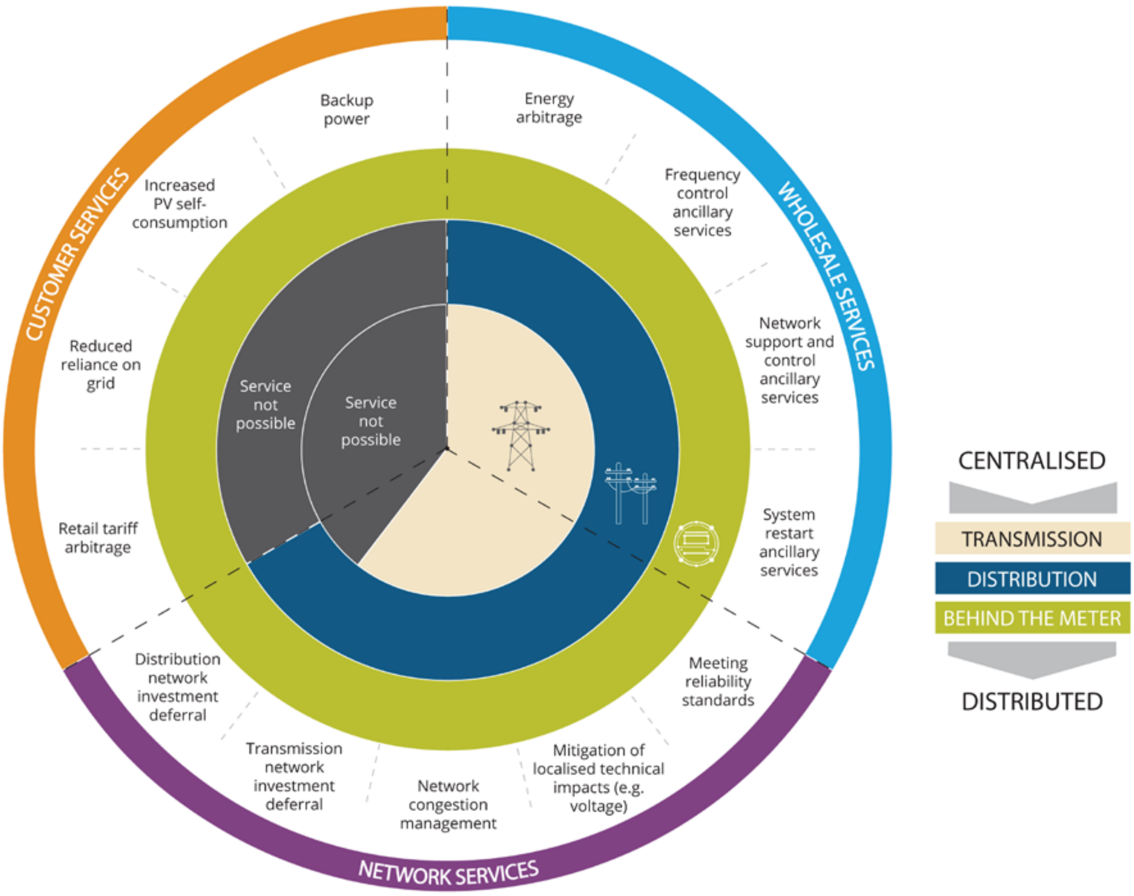
As shown in Figure 2.2, distributed energy resources are capable of providing a range of services to a number of different parties.

If distributed energy resources are 'smart', all of these services can be provided 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.[27]

26 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.

27 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.

Figure 2.2 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 coloured concentric circles in the centre illustrate where the asset is connected. The grey areas indicate where the physical location of an asset means it cannot provide particular services. For example, battery storage system connected at the distribution or transmission level cannot help an individual consumer reduce their reliance on the grid.

Each of these services is a potential source of revenue, but not all of them can be monetised together - that is, by the same asset 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, 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 is currently no way 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. Conversely, there is no way for the DNSP to send a real-time price signal to consumers with distributed energy resources that they need the services of a distributed energy resource. At the moment, a retailer could aggregate the combined capability of consumers' batteries to participate in the NEM, but this locks in the resource to only providing services to the wholesale market. Similarly, a DNSP may procure the services from a consumer's battery to help manage peak demand, but this too means the consumer is only benefiting from the value of that one service being provided. The AEMC sees a 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.[28]

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 asset 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. This optimisation process 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 asset 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 asset's operation on their behalf.

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 both a technical and regulatory sense, provide customer services, network

28 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 appendix A.2.7.

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.

Further discussion of these two issues is set out in the next section.

2.5 Ways to optimise and coordinate distributed energy resources

2.5.1 Optimising investment in and operation of distributed energy resources

When we talk about the 'optimisation' of the services provided by distributed energy resources, we mean making efficient decisions about investment in and operation of an asset, given any technical constraints. 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, for example the distribution networks themselves.

Optimisation is therefore likely to become increasingly valuable and important as the number of distributed energy resources installed increases. However, the task of optimising the services provided by distributed energy resources is highly complex, given their number, the range of services they are capable of providing, and the differing values that consumers place on utilising or providing those services, as well as the fact that not all services can be provided at the same time.

Further, the task of optimising the services provided by distributed energy resources may not be performed by one party alone. The future may see the emergence of a range of business models that seek to maximise the full value of services provided by distributed energy resources on consumers' behalf - each interacting individually with the local DNSP and transmission-level markets to settle arrangements regarding the buying and selling of particular services. A workably competitive market will determine whether this optimising function is most efficiently achieved by multiple parties or by one party across a particular geographic region (which may or may not be a current distribution network), or indeed via multiple parties responding to an 'invisible hand'. This report does not express a preference for any particular outcome, but rather seeks to promote the development of a competitive market for the provision of services enabled by distributed energy resources so that markets, in response to consumer decision-making, can determine the most efficient outcome.

There is a range of ways to maximise the value of investing in and operating distributed energy resources, including 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 would allow for an orderly rollout of distributed energy resources, and is consistent with the fact that 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 who 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. However, such an approach will likely foreclose the considerable potential benefits of a well-functioning market, and may result in trade-offs being made between different objectives 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".[29]

In the Commission's view, 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. 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.

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. 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

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

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 network pricing arrangements and feed-in tariff structures, consumers benefitted more from facing them north and therefore had no incentive to face their solar panels west.[30]

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
- 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.

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 5, cost-reflective price signals are an important precursor to efficient investment in and operation of the services provided by distributed energy resources.

A market-based approach to optimisation of distributed energy resources

Unlike the networks used to transport electricity, the generation of electricity does not exhibit substantial natural monopoly characteristics. The NEM was established to facilitate inter-regional trade and to introduce competition in electricity generation. It decentralised operational and investment decisions in generation to commercial parties who have stronger incentives to make efficient decisions and are better placed to manage the risks of those decisions.

The objective of those who designed the NEM was to facilitate competition between electricity generators across the interconnected system and trade with retailers. Importantly, this allowed future investment in generation to be determined by market participants on the basis of signals from the market: expectations of future spot prices (ultimately determined in part by consumer demand) and retailers' willingness to enter into contracts to hedge against future price risk. Box 2.2 sets out how AEMO operates the NEM.

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

Consumers are now - more than ever - driving the transformation of the energy sector through the decisions they make about their household and business energy needs. The AEMC’s *Power of choice* review, which concluded in November 2012, found that most consumers were not paying prices that reflected the underlying costs of supplying them with electricity. The review recommended a package of changes to provide households, businesses and industry with more opportunities to make informed choices about the way they use electricity and manage expenditure.

Since 2013, a number of rule changes originating from the *Power of choice* review have been, or will soon be, implemented.[31] These include changes to the principles for distribution pricing, new metering frameworks, measures to improve access to consumers’ data, improvements in demand side participation information provided to AEMO, and demand management incentives. Such regulatory changes, along with developments in technology and changing consumer preferences (as discussed in section 2.1), have encouraged investment in distributed energy resources that have the potential to bring substantial benefits to consumers in terms of the cost of, and choice in, their energy service offerings. These investments look set to continue as the cost of distributed energy resources continues to fall.

As noted in section 2.5, the task of optimising investment in and operation of distributed energy resources in both the short- and the long-term is highly complex. However, while complex, it is likely to become increasingly important as the number of distributed energy resources in the market increases.

Box 2.2 AEMO's role in the NEM

Most goods and services in the economy do not require an individual organisation to be responsible for optimising the provision of those goods and services. Instead, choices are made directly by market participants acting in response to the prices of those goods and services, and in accordance with the value they place on those goods and services.

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. Scheduled generators do not directly make decisions as to whether they are dispatched to meet demand in a particular dispatch interval. Instead, their offers to sell electricity are taken into account by a process run by AEMO - the 'NEM dispatch engine'. The dispatch engine also takes into account the physical characteristics of the system to make sure the safe, secure and reliable flow of electricity when determining which generators are dispatched.

If there was no coordinated dispatch, and price signals were to be relied upon exclusively, it is unlikely that the safe, secure and reliable flow of electricity would be achieved given electricity's exacting physical characteristics. The acute

31 See: http://www.aemc.gov.au/Major-Pages/Power-of-choice

need to always balance supply and demand, and manage the limitations on the transmission system, on an instantaneous basis demands this approach.

During every dispatch interval of the market, the dispatch engine must also enable a sufficient amount of frequency control ancillary services to meet the frequency regulation or contingency needs of the system. During periods of high or low demand, it may be necessary for the dispatch engine to move the energy target of a scheduled generator or load in order to minimise the total cost of energy and frequency control ancillary services to the market. This co-optimisation process is inherent in the dispatch algorithm.

AEMO's dispatch engine therefore 'optimises' the provision of electricity by competing parties at least cost, taking into account the physical constraints of the system and ancillary services requirements.

A competitive market for the services capable of being provided by distributed energy resources is in theory possible for the same reason as that for generation in the NEM: in neither case do the services exhibit substantial natural monopoly characteristics. Consequently, the underlying rationale for enabling the competitive provision of the services provided by distributed energy resources is the same as for the introduction of the NEM.[32] In both cases, the complex task of optimising investment and operational decisions is best handled through disaggregated decision making in the market. The Commission considers that well-functioning markets are the best means to manage the complex task of optimising investment in, and operation of, distributed energy resources.

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

1. As set out in Box 2.2, 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.

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.

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

32 We use the term 'competitive provision' 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.

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.

2.5.2 Coordinating the operation of distributed energy resources

In order for a market-based approach to optimisation to be effective, and for the full wholesale benefits of distributed energy resources to be realised, the operation of distribution energy resources would benefit from being coordinated with the wholesale market, and vice versa.

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 in Figure 2.2. However, for a distributed energy resource (presumably in aggregate) to provide wholesale services (i.e. those set out in Figure 2.2), it must first access the transmission network via the distribution network. While there are not currently many technical constraints on distribution networks to prevent this from occurring, if this becomes the case in future, the operator of a distributed energy resource (or its agent) may be unable to maximise the full value of that asset because it is unable to access transmission-level markets due to physical constraints on the distribution network.[33] Distribution networks must therefore enable access by distributed energy resources to transmission-level markets so consumers can make efficient trade-offs between the utilisation and provision of all the services that the distributed energy resources are capable of providing.

Further, if a consumer who operates a distributed energy resource is exposed to accurate wholesale electricity prices but to charges for the common distribution service that are not reflective of underlying costs, it may choose to operate its distributed energy resource in a way that maximises its own value in the wholesale electricity market, despite the fact that this may impose additional common distribution service costs on others. On the other hand, if a distributed energy resource is active only at the distribution-level, and not in transmission-level markets, its activity at the distribution level will have an impact on the latter. This may create issues for transmission-level markets that may need to be addressed.

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 effective 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. As is discussed in chapters 2 and 4, this coordination role need not be carried out by one party, and there are a range of ways in which this could occur.

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33 It is worth noting that AEMO is starting to implement constraint equations in NEM dispatch engine to manage distribution network limits in certain areas of the NEM.

3 Assessment framework

This chapter sets out the Commission's framework for considering:

- 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.

3.1 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.

3.2 Principles of good model design

The Commission has 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, and stakeholders largely agreed with them.[34]

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.

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.

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.

34 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.

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 have informed the analysis and development of the recommendations throughout this paper. They are not new: these principles are inherent in the NEM's original design and have informed changes since then, as discussed in section 2.5.1.[35] 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.

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. As noted above, 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.

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

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 in the following chapter.

4 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 chapter discusses the three stages of the evolution:

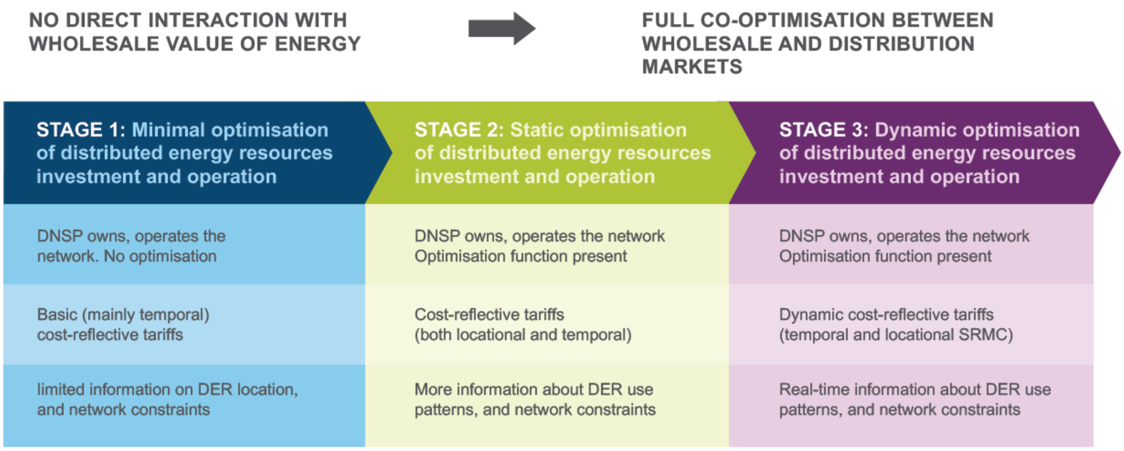
1. Minimal optimisation of distributed energy resources investment and operation.
2. Static optimisation of distributed energy resources investment and operation.
3. Dynamic optimisation of distributed energy resources investment and operation.

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 4.1 below.

Figure 4.1 Evolution of distribution system operation



4.1 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.

4.2 Moving from stage 1 to stage 2

4.2.1 Establishing a level playing field for market participants

A key principle of the current energy markets is that consumers are at the heart of the system, and are driving change. At its most basic level, market development means enhancing consumers' ability to decide when the value of energy services to them is greater than the efficient costs of providing these services. The increasing functionality and types of distributed energy resources that exist means that the range of energy services that is available to consumers is expanding. 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 asset at the same time.

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.

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 this innovation through to consumers, either through lower prices, higher service levels of different service offerings.

If competition for the provision of the services provided by distributed energy resources does not occur, this will:

- drive otherwise competitive businesses out of the market
- create barriers to entry for prospective new entrants
- in turn, reduce the competitive pressure on the remaining service provider(s) to provide valued services at competitive prices, and to innovate.

4.2.2 To assure a level playing field, an 'optimising' function may need to be created

As set out previously in this report, 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, for example the distribution networks themselves. Optimisation is therefore likely to become increasingly valuable and important as the number of distributed energy resources installed increases.

This clear creation of an 'optimising' function is an important precursor to the next stages in this evolution, set out below.

A key question is who would perform this function, and how. The evolution set out in this report does not seek to answer this. The function could be carried out by multiple parties, or simply by market participants themselves (e.g. consumers or their chosen energy service providers) responding to price signals. It may also eventuate that this function is performed by just one party within a particular network area as a result of a competitive process that sees one business model prevail over others.

In the Commission's view, energy market arrangements should enable consumers to monetise the value of as many of the services capable of being provided by distributed energy resources as possible, and this is best achieved when there is a level playing field for the provision of those services. A level playing field for the buying and selling of the services capable of being provided by distributed energy resources means all parties operating in that market have a fair and equal chance to participate. In the Commission's view, a level playing field for the optimisation of investment in, and operation of, distributed energy resources is created if the following conditions are satisfied:

1. The optimising function is carried out by a party who does not have a specific interest in one or more of those services being provided, or in a particular way. That is, it is **independent**. If the optimising function is taken on by a party who has a particular financial or 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 asset being maximised.

2. The optimising function is carried out 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 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.

Independence

In the Commission's view, it would not be appropriate for a DNSP to take on an optimising function 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. The role of a DNSP is set out in more detail in Box 4.1 below.

Box 4.1 The role of a DNSP

DNSPs are responsible for the provision of common distribution services - that is, the suite of services and activities involved in operating and distributing electricity to customers safely and reliably in accordance with the regulatory framework to meet network demand.

DNSPs make decisions about how to provide common distribution services in a way that enables them to meet their regulatory obligations to provide a safe, reliable and secure supply of electricity to consumers. These obligations are a function of jurisdictional legislation as well as the NEL and NER. This includes decisions about the inputs they will use to provide common distribution services, for example decisions about whether to build additional network infrastructure or procure services provided by other parties to manage network congestion. These decisions are made under the current economic incentive regulatory framework, which:

- creates incentives for, and a framework within which, DNSPs can consider potential non-network solutions to network constraints or limitations
- establishes clearly defined planning and decision making processes to assist DNSPs in identifying the solutions to network problems in a timely manner
- provides transparency on network planning activities to enable stakeholder engagement with those activities in order to support the efficient investment in the network.

The Commission is of the view that, in a future where the penetration of distributed energy resource is high, allowing regulated DNSPs to take on a role in optimising investment in and operation of distributed energy resources would not provide a level playing field for market participants. The DNSP, as discussed below, will have the ability to exert control over the distributed energy resources and foreclose access. This is because:

- The DNSP has an incentive to focus on the network benefits of distributed energy resources only. Ideally, optimisation should make sure that individual issues or system needs are looked as part of the whole picture, rather than solely from a distribution or transmission system perspective. As set out in section 2.4, distributed energy resources are capable of providing a range of services to a number of parties including DNSPs, for example services to address localised technical impacts or defer investment in network assets. DNSPs therefore have a specific interest in procuring, or directing the provision of, network services. However, this may come at the expense of a lack of consideration of the additional benefits or services that the asset could be providing to its owner or to the electricity system as a whole. For example, the DNSP may require a battery to be fully charged at all times in order for it to be used to alleviate peak demand when the need arises, but that battery could, at times, have also been used to provide frequency response to the wholesale market.

- The DNSP may have a limited incentive to share some or all information about constraints or limitations on its network, or where investment in the network may be valued, unless required to do so.[36] Other parties therefore might not receive the information they need to help them make investment decisions and manage risk. A lack of this type of information could result in inefficient investment (either too much or too little) in the quantum and location of distributed energy resources.

- The DNSP may have less of an incentive to establish effective price signals to show the highest value use of distributed energy resources, which means that the full range of services that can be provided by distributed energy resources is unlikely to be optimised.

- As discussed in section 2.5, in order for a market-based approach to optimisation to be effective, and for the full wholesale benefits of distributed energy resources to be realised, there is value in the operation of distribution energy resources being coordinated with the wholesale market. For the reasons set out in the dot points above, the regulated DNSP may have an incentive to limit access by distributed energy resources to transmission-level markets, for example to prioritise their network benefits.

The interests of a party who is responsible for providing common distribution services (i.e. a DNSP) are therefore unlikely to be independent from the function of optimising the various services that can be provided by distributed energy resources. Incentive-based regulation may provide some ability to for DNSPs to consider the value of the provision of those services to other parties. Fundamentally however, for the reasons set out in the above dot points, the incentives on a DNSP may never be strong enough to allow it to generate benefits for other parties over its own operations.

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.

Ring-fencing arrangements can be used to separate the competitive and regulated arms of a DNSP to mitigate the risks of it engaging in the following behaviours:

- A DNSP potentially has the ability to cross-subsidise the provision of competitive services enabled by distributed energy resources from its regulated activities. This would reduce the DNSP's costs in providing distributed energy resources,

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36 We note that, under the existing regulatory framework, DNSPs are required to share some of this information through their annual planning reports, and will be required to share certain information through an annual system limitation report. See: http://www.aemc.gov.au/Rule-Changes/Local-Generation-Network-Credits#. However, in a future with a high penetration of distributed energy resources, consideration may need to be given as to whether these mechanisms remain appropriate.

which would undermine third party provider's ability to provide such resources and so impede the competitiveness of the market.

- A DNSP may, in the course of performing its regulated activities, acquire commercially sensitive information that could provide it with advantage in a competitive market e.g. metering data or load profile data.
- There may be concerns about the DNSP having control of distributed energy resources that are capable of providing services in transmission-level markets. Vertical unbundling is a key measure in deregulating electricity markets, where competitive sectors (i.e. generation) are disaggregated from monopoly elements (e.g. distribution). If a DNSP owns distributed energy resources that can participate in the competitive generation market, it may have the power and the incentive to discriminate in favour of its downstream distributed energy resources and/or against its distributed energy resources' competitors.

In November 2016 the AER completed the revision of the distribution ring-fencing guideline.[37] This new guideline imposes obligations on DNSPs to separate the legal, accounting and functional aspects of regulated distribution services from other services provided by a DNSP or an affiliated entity. Effective monitoring and enforcement of compliance with this guideline is 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.

However, ring-fencing arrangements may not be able to successfully address these risks in a future where the penetration of distributed energy resources is high and the range of services capable of being provided by means of those assets has increased.

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.[38] 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.

A related issue is whether there are appropriate incentives on DNSPs to choose equally between using capital expenditure or operating expenditure to meet its relevant

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

38 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 operate 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.

regulatory obligations.[39] For example, a prioritisation of capital expenditure over operating expenditure does not enable a level playing field and may hinder the development of a market for the provision of non-network solutions, including those using distributed energy resources. This issue was recognised and discussed by the Commission in the *Integration of storage* report.

The Commission considers that it is important to explore near-term actions that could help to address this, for example the introduction of 'totex'. Totex seeks to equalise any incentive a DNSP may have to choose capital expenditure over operating expenditure to address a network need - for example, a DNSP's choice between investing in network infrastructure or procuring network services from the owners of distributed energy resources.

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.

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 can respond to financial incentives. Therefore, the Commission considers that this is a key consideration in thinking through the optimising function.

Conclusion

The Commission considers that the optimising function is best carried out by a party that does not have a financial or regulatory interest that would result in them favouring the provision of one service over another, other than in response to efficient price signals. As set out above, the Commission does not consider it appropriate for the party who is responsible for providing common distribution services (i.e. a DNSP) to take on the function of optimising investment in and operation of distributed energy resources and the services that they provide.

The Commission also considers that such a party should be exposed to financial incentives.

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39 In 2015, the AEMC made a rule to help balance the incentives on DNSPs to make efficient decisions in relation to network expenditure, including investment in demand management. See: http://www.aemc.gov.au/Rule-Changes/Demand-Management-Embedded-Generation-Connection-I#

Such an approach is likely to enable a truly competitive market to be established, and for the full value of distributed energy resources to be realised - that is, the benefits to consumers, networks and the wholesale market.

4.3 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 take on such a function. If a clear optimising function is created, 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 the optimising function, 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.

4.4 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 function 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.

4.5 Conclusion

The evolution described in this chapter 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.

Based on the above discussion, we have considered what the 'enablers' of such an evolution are. We have also considered the existing or possible barriers to those enablers that may need to be addressed to support a progression through the stages of this evolution. These are discussed in the following chapters: chapter 5 focuses on the 'market aspects' and chapter 6 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.

5 Market enablers

This chapter sets out the Commission's preliminary views on the near-term enablers that may be needed to underpin any future design of distribution system operations in a way that meets the objectives set out in chapter 3. This chapter focuses on the 'market enablers', specifically:

- information
- network tariffs
- network access
- connection charges.

5.1 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 co-optimisation and the competitive provision of the services enabled by distributed energy resources.

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

- 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
- the technical impacts of distributed energy resources installation and operation on the network, both at a localised level and across the network as a whole.

The Commission considers that there are three main categories of information that can be used to inform decisions about the above:

1. The technical capability and requirements of distribution networks.
2. What distributed energy resources are installed on distribution networks, and where.

3. How those distributed energy resources are being operated.

Each of these is discussed below.

5.1.1 The technical capability and requirements of distribution networks

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 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.

The Commission understands that most DNSPs currently lack sufficient visibility of the technical capability and characteristics of lower levels of their networks – although this does vary across networks. 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 levels of their networks to better inform how they operate and invest in those networks.

Investment in new equipment and smart IT/communications infrastructure is likely to be needed to support this level of data collection. 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. DNSP’s would seek a capex 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.

This information may also be of use to other parties, and for other purposes. For example, an increased penetration of distributed energy resources has the potential to affect broader power system operations, which means AEMO may have an interest in accessing aggregated data about the technical capabilities of distribution networks. 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.[40] 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.

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 renewable energy industry is collected and managed by different parties, not centralised in a single location.[41]

The mapping tool consolidates data from a range of organisations to support “developers, financiers and policy makers in evaluating spatial renewable energy information”.[42] 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.

5.1.2 What distributed energy resources are installed on distribution networks, and where

An understanding of what distributed energy resources are installed and where requires information about distributed energy resources being collected when it is 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.[43] 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

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

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

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

43 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.

Customers may also wish to modify an existing connection to include distributed energy resources. For example, they may wish 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; and
- inform either the retailer or the DNSP of any permanent material change to the energy load or pattern of usage at the premises.[44]

However, the Commission understands that customers (or their agents) do not always inform the local DNSP of modifications to existing connections, or may not have an incentive to do so (for example, if to do so would result in them having more regulatory obligations due to upgrading equipment). Appropriate compliance or enforcement measures may therefore be needed to make sure that this occurs, and in a consistent manner across distribution networks.

DNSPs collecting information about distributed energy resources when processing new connections or modifying existing ones are the most obvious means by which information about the type and location of distributed energy resources being installed can be collected. However, there are other means by which this information will, or is proposed to be, collected. These are set out below.

Energy storage register

In August 2016, the COAG Energy Council published a consultation paper on energy storage registration.[45] The paper sought stakeholder views on whether it is necessary to establish an energy storage register so that relevant authorities and organisations have access to critical data to fulfil their regulatory obligations. If this proposal is adopted, DNSPs would have access to the information in the register, which is proposed to include static data about storage devices, such as capacity, manufacturer, make, model number, and trip settings, and more dynamic data (discussed in the next section). In its submission to this process, the AEMC recommended further consideration of whether information to be included in any proposed register could already be obtained under the existing regulatory framework, and suggested that any new data collection requirements should be specified in a technology neutral way (i.e.

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

45 See: http://www.coagenergycouncil.gov.au/sites/prod.energycouncil/files/publications/documents/Energy%20Storage%20Registration%20Consultation%20Paper%20-%20August%202016.pdf

not just specific to storage) in order to accommodate future technologies that have similar characteristics.[46]

The COAG Energy Council released a draft report and consultation paper on the findings of a cost/benefit analysis on the development of a national energy storage register in May 2017.[47]

Demand side participation information guidelines

In March 2015, the AEMC made a rule determination that provides a process by which AEMO may obtain information on demand side participation from registered participants in the NEM.[48] In April 2017 AEMO published a final report and determination on these guidelines.[49] The demand side participation information guidelines specify information that registered participants must provide to AEMO for it to use when developing or using electricity load forecasts, with the objective of giving AEMO better quality information to develop and improve its load forecasting. The guidelines require registered participants to submit demand side participation data annually at the national metering identifier (NMI) level from April 2018, including:

- for all connections, information about whether the NMI is on a time-of-use tariff, whether it has controlled load, whether it has energy storage, whether it is exposed to the spot price, whether it is on a 'network event' tariff, whether the customer is on an alert list (e.g. a warning about when prices are expected to be high as an incentive to reduce demand), and lists of any future demand side participation deployment programs for those NMIs where potential demand side participation response exceeds 1 MW

- for large connections, or programs where the total possible demand side participation is over 1MW, information including the NMI, the meter configuration, name, address, demand side participation program, available load reduction, demand side participation type (e.g. energy storage, load reduction), what price (trigger/tariff) the response is driven by, who controls the response, what the control algorithm is, the type of energy storage, if any (capacity, purpose, installation date, whether export is permitted, inverter make and model), information about historical response, how the demand side

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46 See: http://www.aemc.gov.au/getattachment/bd069bfb-04e4-43ee-b765-2fbff86ab110//About-Us/Resources/Corporate-publications/AEMC-Submission-on-energy-storage-registration-con.aspx

47 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

48 See: http://www.aemc.gov.au/Rule-Changes/Improving-Demand-Side-Participation-information-pr#

49 See: https://www.aemo.com.au/Stakeholder-Consultation/Consultations/NEM-Demand-Side-Participation-Information-Guidelines-Consultation

participation is monitored, seasonal variation, temperature restrictions and when the demand side participation program ends.

The guideline requires registered participants to provide information that is obtainable with current processes/systems and only once a year. However, AEMO expects that registered participants will develop their processes and automated systems so that data submission could become more frequent in the future.[50]

The rule requires AEMO to publish information no less than annually about the extent to which the information it receives informs its development or use of load forecasts,[51] and to have regard to the reasonably costs of efficient compliance by registered participants compared to the likely benefits from the use of the information.[52] In the guideline, AEMO notes that it publishes a number of reports that address the forecasting of load, and that it will include a discussion on the extent to which the information obtained informed its load forecasts at least once a year.[53]

Visibility of distributed energy resources

In January 2017, AEMO published a paper on the visibility of distributed energy resources. In it AEMO explains that it has been able to operate the power system in a secure and reliable manner without visibility of distributed energy resources below five MW because these systems have historically constituted a small component of the whole power system. However, it is now seeing the traditionally passive demand side become more active through a significant uptake in distributed energy resources, which can have a material and unpredictable impact on the power system and its dynamics due to their cumulative size and changing characteristics.

AEMO noted that if the opportunities presented by distributed energy resources are not taken up in a coordinated way, large penetrations of distributed energy resources installed on customers' premises are likely to be "invisible" to AEMO, which affects AEMO's ability to quantify and manage the operational impacts of distributed energy resources on the power system.[54] The paper states that AEMO requires static data on the location, capacity, and technical characteristics of distributed energy resources systems, in particular the inverters interfaced to the network, as well as operational data (discussed in the next section).

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50 AEMO, Demand side participation information guidelines consultation, draft report and determination, 20 February 2017, p. 9.

51 See clause 3.7D(d) of the NER.

52 See clause 3.7D(f)(1) of the NER.

53 See: https://www.aemo.com.au/-/media/Files/Stakeholder_Consultation/Consultations/Electricity_Consultations/2017/DSPIG/Demand-Side-Participation-Information-Guidelines.pdf

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

5.1.3 How distributed energy resources are operated

Efficient investment in and operation of distributed energy resources relies on relevant parties having access to information about how distributed energy resources are being operated, for example how much it is exporting or importing and when.

More information about how distributed energy resources are being operated allows DNSPs to better understand the localised technical impacts, if any, distributed energy resources are having on their network. Each DNSP has a threshold system size under which systems are automatically pre-approved for connection to the network. Therefore, most small distributed energy resources (<5kW) is connected without detailed analysis of the incremental impact on the capacity of the network. The level of the threshold differs between DNSPs and also depends on the type of line a customer is connected to.[55] 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.[56]

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 fully granular data on the operation of distributed energy resources down to the household level. For example, from a power system security point of view, information is likely only needed 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 is the best energy service offering for them.

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.

There may not be the equipment or systems in place to support the creation or collection of this granularity of data. For example, most residential and small business consumers in Australia have accumulation meters, which cannot measure consumption in intervals and cannot be accessed remotely.[57] The majority of

55 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.

56 Distribution network tariffs are discussed in section 5.2.

57 The exception is in the state of Victoria, where the government mandated the rollout of advanced meters to all Victorians consuming up to 160 megawatt hours of electricity per annum. The program is now effectively complete with approximately 2.8 million advanced meters installed across the state.

distributed energy resource technologies, including inverters, installed to date do not have remote communications capability. Investment in new equipment and systems may therefore be needed to support this level of data collection.

In November 2015, the AEMC made a rule to enable the competitive provision of advanced metering services for residential and small business consumers.[58] Depending on the functionality of the meter, the ability to send and receive data remotely enables data on electricity consumption, electricity outages and other information on the performance of the distribution network to be obtained almost instantaneously. Advanced meters may also provide retailers, DNSPs and energy service companies the opportunity to provide and access services that support the efficient operation of the electricity system, allowing them to provide lower cost and higher quality services to consumers.

The rule change is supported by amendments to the NER electricity B2B communications framework.[59] This new framework will better suit the wider range of services that are likely to be made available by advanced meters and the wider range of parties that are likely to be interested in accessing or offering those services. It is expected to improve interoperability, reduce barriers to entry for new participants, support innovation in new services and reduce the costs of providing those services.

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.

Another possible reason why information about how distributed energy resources are being operated is not widely available is that 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,[60] 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.

5.1.4 Issues to be addressed

As set out above, the collection and dissemination of information about the technical capability and requirements of distribution networks, what distributed energy resources are installed on distribution networks and where, and how those distributed

58 See: http://www.aemc.gov.au/Rule-Changes/Expanding-competition-in-metering-and-related-serv

59 See: http://www.aemc.gov.au/Rule-Changes/Updating-the-electricity-B2B-framework

60 See section 2.1.

energy resources are being operated should help parties make decisions about how to manage, invest in and operate distributed energy resources.

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. In the Commission's view, there remain a number of questions about how the collection, management and dissemination of data under any mandated process should be managed in order to make sure that the benefits 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?

As explained above, a number of organisations are already 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. The COAG Energy Council’s energy storage register proposal, AEMO’s DSP information guidelines, and AEMO’s paper on the visibility of distributed energy resources all propose to collect data about the installation and operation of distributed energy resources, including output data in real time.

5.2 Network tariffs

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 distribution network operators 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 network businesses' 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
- distribution network operators 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 may incentivise consumers in particular areas to invest in distributed energy resources and/or provide network services.

The Electricity Network Transformation Roadmap produced by Energy Networks Australia and the CSIRO also 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.[61] 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 can and does provide network value, including through reducing network congestion, which can potentially defer network augmentation and thus reduce network costs.[62]

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 costs and value 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.

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.[63] It uses these criteria to put a price on 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. For example, 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 adopted an opt-in approach to distribution network tariffs. 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 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.

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

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

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

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 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 may not 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.

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.[64] This is intrinsically linked to the discussion of access in section 5.3 below. At the moment, only one of four values/costs is priced: the costs associated with using the network to consume electricity. Consumers are not paid for the benefits the provision of services from their distributed energy resource may have on the distribution system. And, as discussed below, generators do not pay any charges beyond connection costs, or receive any payment for benefits of the services that they provide.

5.2.1 Issues to be addressed

The new network pricing rules are now being implemented. DNSPs, retailers, governments and consumer groups must now work together to implement them. However, while the NER are sufficiently flexible enough for DNSPs to develop fully cost-reflective tariffs (i.e. comprising both temporal and locational components), ensuring that consumers have visibility of the signals being sent through these tariffs relies on:

- retailers passing them on through their retail offerings in a way that accommodates the needs of their customers
- these signals not otherwise being distorted.

64 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

Question 1	Do stakeholders consider that there are any other barriers to the development and implementation of cost-reflective network tariffs? How material are these barriers? Are there other means for them to be addressed?

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, flicker. For some of these impacts, a market already exists to enable the procurement of services to address that impact. For example, frequency control ancillary services 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.

However, 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 tariffs should be introduced to recover 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.

Question 2	Do stakeholders consider that there are any 'missing markets' or 'missing prices' beyond those that will be implemented through cost-reflective network tariffs? If so, what are these?

5.3 Network access

5.3.1 Open access for market generators

Access means different things to different people, in different contexts. Here, we refer to getting access to use the distribution network. Access is important to distributed energy resources. They are connected to the distribution network and so, physically at least, can provide services to parties seeking to procure them at the distribution network level, for example through a RIT-D for network support services. However, for a distributed energy resource to participate in transmission-level markets, it must first access the transmission network via the distribution 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 load 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 is no inconsistency between the transmission market itself, and no constraint costs are incurred by 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.

All transmission and distribution networks in the NEM currently operate under an open access regime for the connection of generation. Box 5.1 describes the history of these arrangements in relation to the NEM's transmission networks.

Box 5.1 Open access in transmission networks

Transmission and distribution networks in the NEM operate under an open access regime in which parties 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.[65] 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 deleted rule 5.4A, making it clear that the NEM operates under an open access regime.[66]

As in transmission networks, the open access regime that applies to market generators[67] connected to the distribution network is confused by rule 5.5 of the existing NER (the distribution equivalent of rule 5.4A), which describes an ability for generators to negotiate a form of firm financial access with the DNSP and seek compensation from the DNSP in the event that it is constrained on or off, in return for an access charge. While there is nothing in the NER that prevents a DNSP from offering access, it is difficult to see how this could be made to work in practice, as there is nothing to compel a second generator to compensate another generator.

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

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

67 A market generator is a generator whose sent out output is not purchased in its entirety by a local retailer or by a customer located at the same network connection point.

The Commission understands that some DNSPs are exploring ways to offer firm network access arrangements with generators that are connected to it. The Commission is of the view that this is inconsistent with the current framework that is set out in the NER.

As noted above, in May 2017 the Commission deleted the transmission-equivalent rule (5.4A) in the *Transmission connections and planning arrangements* rule change, putting it beyond doubt that the NEM operates under an open access regime.

5.3.2 Access for distributed energy resources

In contrast, the majority of the operators of distributed energy resources are not market generators, but rather sell electricity and other energy services to an energy service provider or to the DNSP directly. What these parties get paid is determined by whatever arrangement they enter into with an energy service provider or the DNSP.

As more distributed energy resources are installed, distribution networks may not continue to operate on an unconstrained basis as has historically occurred.[68] For example, some consumers may invest in distributed energy resources in order to be able 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 fair or appropriate for consumers who made an investment decision assuming that they would be able to use that asset in a particular way to be 'constrained off' with no compensation, which is what occurs under an open access regime. 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.

Under an open access framework, consumers in increasingly constrained networks may need to be made aware when making decisions about investing in and operating distributed energy resources that they could be 'constrained off'. Apart from through tariffs (discussed in section 5.2), if the DNSP wants to make use of the distributed energy resource's responsive capabilities to help manage congestion on its network, it must agree special terms with the party who owns that asset, for example through a contract under which the DNSP or the energy service provider can control the distributed energy resource. Essentially, the distributed energy resource is constrained on or off by the party who has control, that is - the DNSP or energy service provider. Therefore, these arrangements are likely to be ad hoc, focus on one value stream, and may result in inefficiencies.

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

Further, under the existing NER, the DNSP is required to make an offer to connect to consumers who request it, including those with distributed energy resources. However, anecdotally, the AEMC understands that some DNSPs are refusing 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.[69]

There are differences between generators and 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.

In a future where the patterns of investment in distributed energy resources and flows across distribution networks are much more uncertain, an access regime that provides greater flexibility may be required to facilitate more efficient coordination between these two types of investment.

5.3.3 Conclusion

The Commission is interested in stakeholder views on whether an open access regime should continue to apply at the distribution level, or not. The Commission considers that it would beneficial to undertake a holistic assessment of such issues as soon as possible, before DNSPs start to develop solutions themselves, which may occur on an ad hoc and inconsistent basis, creating inefficiencies in the use of distributed energy resources. Views on this are important since the type of access regime that applies at the distribution level drives decision-making on other aspects of the regulatory framework, including network tariffs, network investment and operational decisions, and connection charges (as discussed below).

If stakeholders consider that an open access regime should not continue to apply at the distribution level, it would be worthwhile exploring other ways that distributed energy resources could gain access to the distribution network. In particular, the Commission is interested in understanding what stakeholders see as the opportunities and challenges related to accessing the distribution network, and what principles stakeholders consider should apply to such a framework.

If stakeholders consider that it remains appropriate for an open access regime to apply to distribution networks, the Commission considers that it would be worthwhile exploring the workability of rule 5.5 of the NER to determine whether similar

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

conclusions as for the equivalent rule at the transmission level can or should be made for access at the distribution level.

Question 3	Do stakeholders consider that an open access regime will continue to be appropriate in an environment of increasing uptake of distributed energy resources and more constraints on distribution networks? If not, what principles or considerations should be taken into account in determining whether a different access regime is more appropriate?

5.4 Connection charges

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 import less electricity from grid, since some of their energy consumption would be supplied by their PV system, and the retailer would purchase less electricity from the NEM, which would, in turn, reduce the household's electricity bill.

However, the direction of electricity flows on distribution networks is changing, and switching more often, as more distributed energy resources are installed. This is imposing new costs.

5.4.1 Distributed energy resources currently only pay connection charges

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, as discussed above. 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.

Under the current NER, the DNSP has no rights to tell a consumer with a distributed energy resource when it can, or cannot, import energy and how much. Apart from through tariffs (discussed in section 5.2), if the DNSP wants to make use of the distributed energy resource's responsive capabilities to help manage congestion on its network, it must agree special terms with the party who owns that asset, for example through a contract under which the DNSP can control the distributed energy resource. Essentially, the distributed energy resource is now being constrained on or off by the DNSP. However, as discussed in chapter 4, it is likely not appropriate for the DNSP to take on this function because it may manage and dispatch the distributed energy resources to the extent necessary to meet its own obligations. This would be inefficient, since the full capability of the distributed energy resources is not being optimised across its various value streams, but rather used solely for network benefits.

5.4.2 Only paying a connection charge may no longer be appropriate

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.[70]

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."[71] Therefore, the Commission's preliminary view is that one-off connection charges may not be appropriate when there are large amounts of distributed energy resources connected to a network, because the costs caused and benefits created by those assets are variable, depending on where they are connected and when they are being used.

5.4.3 What are the alternatives?

Currently, clause 6.1.4 of the NER prohibits a DNSP from charging a distribution network user (such as an owner of a distributed energy resource) distribution use of system charges for the export of electricity by that user to the distribution network. There may be cause to revisit this clause if DNSPs incur costs (and benefits) due to the export of energy from distributed energy resources (or passive solar PV systems) that are not appropriately reflected in connection charges and where these costs (and benefits) increase (albeit not necessarily proportionately) with the volume of injections.

The Commission therefore considers that there may be benefits in exploring the deletion of clause 6.1.4 of the NER, and what possible alternatives there are.

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

71 Essential Services Commission 2016, The Network Value of Distributed Generation: Distributed Generation Inquiry, Stage 2 draft report, October 2016, p. xxvii.

Question 4	Is there support for the Commission's proposal that the deletion of clause 6.1.4 of the NER be explored?

6 Technical enablers

There is no point in developing cost-reflective distribution tariffs, or the distributed energy resources optimisation market sending signals about the value or impact of distributed energy resources if participants do not have the capability to respond to those signals. An efficient market for the optimisation of distributed energy resources therefore relies on participants having the technical capability to respond to those signals on an operational timescale. It is also important that this technical capability can be used, and that appropriate incentives are in place to support its use, so that the full value of distributed energy resources and related technologies can be realised.

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

This chapter sets out the Commission's preliminary 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 chapter 3. This chapter focuses on the 'technical' enablers, specifically:

- standards
- connection processes.

6.1 Australian standards

Australian 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.

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. As such, 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. New energy technologies and services are allowing consumers more choice and control over how their electricity is delivered and used. Consumers are making decisions that align with their own interests and what they value as a user, or producer, of electricity. It's these choices that are driving investment in, and deployment of, particular technologies. These choices should continue to drive the development of the energy sector. So, while standards are important to mandate minimum technical requirements, they shouldn’t be used to resolve issues that may be better addressed using market signals.

Standards should therefore be forward looking and fit for purpose. 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 distributed energy resources owners to participate actively in the energy market.

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. A number of committees have been updating and creating new standards to accommodate the rapid uptake of distributed energy resources and related technologies, including in relation to inverters, battery storage and demand response.

In its submission to the approach paper, some stakeholders noted that, since October 2016, all inverters have been required to meet Australian Standard 4777.2:2015 Grid connection of energy systems via inverters – Inverter requirements.[72] 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. The Clean Energy Council submitted that these capabilities mean that distributed energy resources utilising smart inverters can provide services to the network, but that this is not occurring in practice due to the absence of markets or other incentives for the provision of these services.

6.1.1 Issues to consider

As set out above, a range of projects are underway to support the development of standards for distributed energy resources and related technologies. The AEMC has no direct involvement in the development of standards, but recognises their ability to support the development of a consumer-driven energy market. The AEMC encourages committee members and others involved in the standards development process to consider the implications for competition and consumer choice when developing and commenting on standards.

Question 5	Are there any other aspects of the development of Australian standards that are relevant and should be considered?

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

6.2 Technical requirements and connection arrangements

The Commission considers that the installation, connection, optimisation and control of 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 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 resources 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 system. In order for the DNSP to meet its responsibilities regarding the safety and reliability of its network, it necessarily needs to put in place some minimum requirements on the technical characteristics of distributed energy resources connected to its network. In addition to the requirements set out in the NER, distribution connection applicants may have specific processes or technical requirements placed on them by their connecting DNSP before they can connect distributed energy resources to the network. For example, a connecting DNSP might undertake a technical assessment of the size and intended operation of the distributed energy resources to determine whether the local network is able to accommodate it.

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 and/or
- constitutes part of an existing generating system (e.g. retrofitting an existing solar PV system with storage capability).

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 installed and how it will be operated. Overly onerous technical requirements are likely to increase the costs of connection, 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 views were expressed in an assessment by The Customer Advocate on the solar PV connection framework in Queensland,[73] 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. These stakeholders were of the view that standardisation would:

- simplify the connection process for parties operating within or across distribution areas (for example, retailers or storage system installers);
- reduce administrative burden on DNSPs;
- provide transparency in the connection process; and
- support a level playing field for the provision of storage and the services it enables.

The process for connecting to the network should also be clear 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.

6.2.1 Issues to consider

While these comments above were made in the context of storage technologies, the Commission considers that they are equally relevant to all types of distributed energy

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

resources. 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 sees value in reviewing the technical requirements that apply to the connection of distributed energy resources, particularly small-scale, residential/small business systems, to assess their appropriateness, potential for standardisation and how they affect the DNSP's ability to control what is connected to their network.

Similar sentiments have been expressed by other stakeholders recently, for example in its submission to the directions paper on the AEMC's *System Security Market Frameworks Review*, Energy Queensland stated that it is timely to undertake a comprehensive review of the process to connect and manage generators in light of the new generation technologies that have become commonplace in the network.[74][75]

Question 6	**Do stakeholders see value in the AEMC (or other party) reviewing the technical requirements that DNSPs apply to the connection of distributed energy resources?**

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

75 The Commission has recently undertake a comprehensive review of the transmission connection process through the *Transmission connections and planning arrangements* rule change request. The final rule set out significant changes to the arrangements by which parties connect to the transmission network to improve the 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

7 Submissions and next steps

7.1 Submissions and stakeholder consultation

A summary of this report is available in the form of a pre-recorded webcast on the AEMC website.[76]

The Commission invites written submissions on the questions set out in this draft report, or any other aspect of it, by **4 July 2017**. The Commission also welcomes one-on-one meetings with interested stakeholders in lieu of, or in addition to, a written submission. Please contact Claire Richards, (02) 8296 7878, if you would like to arrange a meeting.

7.2 Final report

The Commission intends to publish a final report on this project in August 2017. The final report will draw on stakeholder input received on this report and, where relevant, set out recommendations on possible ways to address any identified barriers to the development of a market-based approach to the optimisation of distributed energy resources.

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

A Related projects

A.1 AEMC projects

A.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, with the first report due on 1 July 2017.

The Commission published an approach paper on 1 December 2016 setting out how it intends to conduct the task and its proposed information sources.[77] The paper also sets out the Commission's preliminary views on the areas that will be the focus of the 2017 report, which are:

1. continued implementation of network pricing reform;
2. the ability of networks to utilise increasingly diverse supply options; and
3. different network operating models, i.e. this project.

The 2017 annual monitoring report will draw on findings of this project to support its analysis of the third focus area.

A.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".[78] 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".[79] 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.

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

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

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

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

A.1.3 Replacement expenditure planning arrangements rule change

On 11 April 2017, the AEMC made a draft rule to increase the transparency of network service provider decisions on investment in network assets.[80]

Made in response to a rule change request submitted by the AER, the draft 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 draft rule.

The AEMC is currently consulting on the draft rule. Stakeholder submissions closed on 6 June 2016.

A.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."[81] The Commission will commence public consultation on this rule change request in June 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.[82]

A.1.5 Review of regulatory arrangements for embedded networks

In December 2015, the AEMC made a rule to clarify the arrangements under the NEL and NER for consumers in embedded networks.[83] 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.[84] 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

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

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

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

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

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

related to embedded networks in the NEL, NER, National Gas Law, National Gas Rules and jurisdictional instruments.

A.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.[85] 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.

A.1.7 System security work program

The Commission initiated a review into system security in July 2016, and is considering a number of rule change requests on aspects of power system security.[86] The Commission is working with stakeholders and AEMO to develop a comprehensive set of potential solutions to address identified issues.

A directions paper for the review was published on 23 March 2017. The directions paper proposes a number of complementary measures to maintain control of power system frequency following a contingency event and to manage declining fault levels.

A.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.[87] The Commission commenced consultation on this rule change request in March 2017. A draft determination is due to be published on 20 June 2017.

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

86 See http://www.aemc.gov.au/Major-Pages/System-Security-Review

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

A.2 External projects

A.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.[88] 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.

A.2.2 AER: National distribution ring-fencing guideline

The AER published a national electricity distribution ring-fencing guideline on 30 November 2016.[89] 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 was developed in collaboration with the AEMC and in consultation with relevant stakeholders.

A.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."[90] As part of this program, the COAG Energy Council has 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.[91] In May 2017 the COAG Energy Council released a draft report and consultation paper on a cost/benefit analysis for the

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

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

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

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

development of a battery storage register.[92] The issues and solutions raised through the market transformation program are relevant but separate to this Distribution Market Model project.

A.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.[93] 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[94] and energy storage.[95] The Commission was involved in the development of these roadmaps, and will continue to be involved in their implementation.

A.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.[96] The Commission is working with AEMO and stakeholders to develop a comprehensive set of potential solutions that take into

92 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

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

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

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

96 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.

A.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.[97] 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.

A.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. The project seeks to create a digital marketplace for energy generated by solar PV systems and stored using batteries to enable households and small entities to 'rent' their distributed energy resources to the grid, providing demand response and ancillary services such as frequency control. The AEMC is participating in the reference group for this project.

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