ENERGY INSIGHTS

AEMC

AUSTRALIAN ENERGY MARKET COMMISSION

HOW DIGITALISATION IS CHANGING THE NEM

THE POTENTIAL TO MOVE TO A TWO-SIDED MARKET

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INQUIRIES

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ABOUT THE AEMC

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

OVERVIEW

1 Advances in technology, enabled by digitalisation, are changing electricity markets. The generation mix is increasingly renewable and dispersed, network companies are facing more dynamic two-way network flows and the nature of a 'consumer' is fundamentally changing.

2 Energy services in the future will be able to be bought and sold in a dynamic way, responding to consumer preferences and price signals, and new technology such as battery storage and electric vehicles will add another dimension to electricity usage.

3 Devices in our homes and businesses that use energy are increasingly digitally enabled. This is allowing greater flexibility in demand through the use of automation and other digital technologies. Over time, this creates significant opportunities to reduce system costs and therefore, consumer prices.

4 The future can have greater two-way trade of electricity in a wholly connected energy market. The energy market should be dynamic and consumers rewarded for buying and selling energy, demand management and other services to the parties who value them the most, in a way that benefits all consumers.

5 Parts of Australia are world leading in terms of their wind and solar penetration. However, the energy sector has had to play catch up to integrate them into the power system and account for the new challenges and opportunities that renewables bring.

6 Increasing digitalisation will facilitate more advanced engagement in energy markets through increased remote communication, control and automation of consumer devices. We have an opportunity to establish a fit-for-purpose framework ahead of the fundamental, consumer-led changes that follow. The sector should be considering changes to the market framework now in anticipation of these changes.

7 This paper sets out some future thinking on digitalisation and the potential to move to a two-sided market. Consumers are already starting to benefit from increased digitalisation in the energy sector. The reforms set out in this paper would seek to capture and extend the benefits of digitalisation to all consumers into the future. This is a natural progression of the market.

8 The Energy Security Board (ESB) is working closely with the Commission, the Australian Energy Regulator (AER) and the Australian Energy Market Operator (AEMO) on options for market design beyond 2025. The paper is intended to further discussion among stakeholders about the potential market design options that would yield the greatest consumer benefit in a digitally connected energy demand world. Further discussion and debate on this and other thinking helps inform part of ESB's work on the 2025 market design. We are not seeking submissions on this paper but invite stakeholders to draw on it when they engage in the ESB's 2025 work.

The case for change

9 Digitalisation is changing the way consumers can engage in the electricity market. These technological advances mean that consumers, instead of having to actively monitor the

electricity market and decide how or when to participate, can now 'set and forget'. Consumers, or someone acting on their behalf, can set batteries, pool pumps, smart air conditioners and any other number of devices to consume electricity at the cheapest times and export at the most expensive times (i.e when the power system needs it most). Consumers can capture the benefits of participation by taking advantage of new technological developments that require very little action on their part.

10 The market is already experiencing increased consumer participation, driven by a range of factors:

- there is a focus on the increasing cost of electricity
- digitalisation is encouraging consumers to maximise their return on buying new technologies and minimise the impact on their lifestyles
- the costs of digitalisation and new technologies that allow participation are falling substantially
- new energy products and services are becoming available to consumers.

11 However, while consumer participation is already growing, it is not transparent to the market operator or other market participants. As such, there are broader benefits of this increased participation that are yet to be captured.

12 When the national electricity market (NEM) started twenty years ago, the generation fleet provided information to the market operator in real time and all demand was forecast by the system operator, with some limited exceptions. This gave market participants (retailers and generators) a greater level of certainty about expected market outcomes ahead of time.

13 We now have a generation fleet that provides different degrees of information to the market about their operating intentions. Semi-scheduled generators (e.g. utility scale wind and solar) are not required to provide the same amount of information to the market that fully scheduled generators do.

14 The combination of an increasing uptake of distributed energy resources, more consumer participation from demand response, higher levels of weather-dependent renewable energy generation, and more extreme weather days will make forecasting increasingly difficult.

15 Also, there is a tighter demand-supply balance following the closure of several large coal-fired power stations in recent years. This means that the differences between forecasts and actual outcomes may have more significant consequences.

Benefits of digitalisation and a two-sided market

16 There are significant benefits from digitalisation and a two-sided market where both sides (demand and supply) are actively engaged in scheduling and dispatch in the wholesale market:

1. digitalisation lowers the scale where participation by demand becomes economic, increasing participation and competition, putting more downward pressure on prices

2. retailers and aggregators who work to best understand their customers demand and preferences, and act in the interests of their customers become lower cost, and therefore able to offer better deals — and hence be rewarded with a greater market share
3. improved certainty associated with forecasts, which enhances the ability for market participants to make informed decisions and assist AEMO in maintaining the safe, secure and reliable operation of the power system
4. improved accuracy of forecasts by allocating forecasting challenges to the parties who can best manage them and have the strongest incentives to get it right
5. capturing the efficiencies of increased demand side participation in the wholesale market to the benefit of all consumers
6. reducing the complexities of cost reflective pricing as consumer preferences for how they use their electricity are automated to reflect their own individualised value of electricity.

Reforms to increase two-way participation

17 There are a number of market features that are affected by digitalisation. To create a framework for discussion, we have identified a spectrum of choice and developed the following six criteria for considering the form of a two-sided market that delivers on the national energy objective (NEO):

1. Participation: To what degree should supply and demand be required to bid into central dispatch in the same way as scheduled generation currently does? This may require some relaxation of the currently strict requirements on scheduled generators to create a more level playing field.
2. Dispatch horizon: Should dispatch instructions issued every five minutes consider multiple periods?
3. Locational pricing: Should we move to locational marginal pricing for non-scheduled participants over time, if this was found to be in the long-term interest of consumers?
4. Incentives for reliability: Digitalisation makes it possible for consumers to agree their own service levels, including the level of reliability with their retailer. However, there are barriers that would need to be removed before customers might be ready to choose the circumstances in which they could have their power switched off or reduced for short periods of time.
5. Settlement period and ahead markets: Would a multi-settlement system, establishing a market an optimal number of hours ahead, improve coordination of different resources and benefit consumers overall?
6. Sub-market optimisation: Digitalisation allows both a centralised and sequential approach to how distributed energy resources are dispatched. We would promote options that provide consumers greater choice while preserving necessary consumer protection and overall power system performance in relation to their energy supply and DER.
7. Incentives for security: As the market determines the need for security services, further assessment can be carried out on whether these could be operator procured or separately procured.

18 A summary of the initial assessment is provided in the figures below. These are designed to

show, at a high level, where either end of the spectrum is more likely to deliver on (via a 'tick') or less likely to deliver on (via a 'cross') the six criteria. A 'dash' indicates that that digitalisation makes either option is viable. The spectrum moves from stronger market signals (top figure) at one end to stronger control processes at the other (bottom figure).

19 We note that this assessment of options appears binary- that you can either land on one end of the spectrum or the other. However, the answer is not as certain, nor binary. There are many potential iterations along the spectrum of choice and multiple middle ground solutions to be considered. There are a number of options to explore for the transition to a two-sided market and this paper merely scratches the surface of what is a fundamental shift for the NEM.

20 The spectrum and the associated criteria are designed to highlight the types of outcomes you may see at either end of the spectrum, and to facilitate discussion. This is new territory to be explored both within the NEM, and internationally, and our approach is designed to enable a more in-depth and detailed discussion on harnessing the potential of digitalisation.

Figure 1: Initial assessment of design features

Stronger market signals

Design feature	End of Spectrum	Criteria: Competition and market signals	Appropriate risk allocation	Competitive / technology neutrality	Information asymmetry	Cross-market integration	Regulatory and admin costs
Participation	Compulsory	✓	-	✓	✓	✓	✗
Dispatch horizon	Single	✓	✓	✓	✗	✗	✓
Locational pricing	Nodal	✓	✓	✓	✓	-	✗
Incentives for reliability	Decentralised	✓	✓	✓	✓	-	✓
Settlement periods	Single settlement	✗	✗	✓	✗	✗	✓
Sub-market optimisation	Hierarchical	-	-	-	-	-	-
Incentives for security	Co-optimised	-	-	-	-	-	-

Stronger control systems

Design feature	End of Spectrum	Criteria: Competition and market signals	Appropriate risk allocation	Competitive / technology neutrality	Information asymmetry	Cross-market integration	Regulatory and admin costs
Participation	Voluntary	✗	-	✗	✗	✗	✓
Dispatch horizon	Multiple	✗	✗	✗	✓	✓	✗
Locational pricing	Regional	✗	✗	✗	✗	-	✓
Incentives for reliability	Centralised	✗	✗	✗	✗	-	✗
Settlement periods	Ahead settlement	✓	✓	✗	✓	✓	✗
Sub-market optimisation	Simultaneous	-	-	-	-	-	-
Incentives for security	Separate market	-	-	-	-	-	-

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1 THE VISION

1.1 Digitalisation of the energy supply

When electricity markets were first developed in the 1990s, the designers envisaged they would eventually share the characteristics of other commodity markets. That is, once technology was more advanced, there would be active participation from both the supply and demand side. However, the state of technology at the time meant the initial market design necessarily placed a greater emphasis on the supply side of the market.

Changes in technology, enabled by digitalisation, are changing electricity markets. These changes provide for increased engagement in, and responsiveness to, the market for electricity production or consumption. These factors are challenging the assumptions underpinning the original market design.

As the national electricity market (NEM) goes through this significant rate of change the Australian Energy Market Commission (the AEMC or Commission) is prioritising five key areas of policy reform so that customers can access safe, secure and reliable energy at the lowest possible costs. One such priority is the *digitalisation of energy supply* (further information on our areas of priority can be found here).

The digitalisation of energy supply is:

> a power system and market that efficiently utilises digital technologies to make it easier to choose and control how, when and where power is generated, delivered and used, including to empower customers to optimise their energy use within their homes and businesses.

With digitalisation, energy services in the future will be able to be bought and sold in a dynamic way and new technology, such as digitally controlled energy consuming devices (e.g. smart air conditioning or pool pumps) will respond to consumer preferences and price signals. Battery storage and electric vehicles will add another dimension to electricity system usage. Digitalisation also provides the opportunity of managing reliability and offering new ways to manage security services and differentiated service levels.

It is critical to continue to consider the reform trajectory that will shift us closer to a two-sided market.

This paper addresses the digitalisation of the energy market by exploring future thinking on the changing electricity market and the potential to move to a two-sided market.

1.2 2025 market design

The energy market is undergoing a significant transformation involving all aspects of the market; retail, wholesale and networks (both distribution and transmission). Ensuring we continue to have a secure, reliable and efficient energy system, may require significant market reforms.

The vision for a two-sided market is a natural progression for the NEM. However, there are a number of questions to be explored when its comes to moving to a two-sided market and these need to be addressed in the context of other market reforms under way

The COAG Energy Council has tasked the Energy Security Board (ESB) with developing advice on a fit-for-purpose market framework to be in place for 2025. The ESB needs to recommend the necessary changes to the market, by the end of 2020.

The ESB is working closely with the Commission, the Australian Energy Regulator (AER) and the Australian Energy Market Operator (AEMO) considering options for market design for 2025. The paper is intended to further discussion among stakeholders about the potential market design options that would yield the greatest consumer benefit in a digitally connected energy world. This paper on the potential to move to a two-sided market therefore forms an integral part of the ESB's work.

We encourage further discussion and debate on this to form part of ESB's 2025 market design process. We are not seeking submissions on this paper, but rather request that stakeholders engage in the ESB's 2025 work and discuss the implications of digitalisation and the potential to move to a two-sided market within the construct of that work.

However, any other enquiries on this work should be addressed to Kate Wild on (02) 8296 6022 or kate.wild@aemc.gov.au.

1.2.1 Wholesale demand response mechanism

On 18 July 2019, the Commission made a draft electricity rule that would introduce a wholesale demand response mechanism. This mechanism would introduce a new participant category, a demand response service provider, and set up a framework for DRSPs selling demand response in the wholesale market.

In that draft determination, the Commission noted that it expected that over time the mechanism would be outgrown as more and more consumers looked to engage in demand-side participation. It suggested that the development of a two-sided market should start and in the meantime, a wholesale demand response mechanism could facilitate more wholesale demand response. The draft rule would assist in providing greater opportunities for wholesale demand response and promoting increased consumer engagement. This would subsequently allow for a transition to a two sided market when technology is mature enough and a clear path has been determined.

A final determination on the *Wholesale demand response mechanism* rule change request is due on 5 December 2019.

2 THE CASE FOR CHANGE

A substantial transition is under way across the energy sector. The generation mix is increasingly made up of a smaller number of resources (both renewable and batteries) which are geographically dispersed, network companies are facing more dynamic and two-way network flows and the nature of the 'consumer' is fundamentally changing.

There are already market reforms and initiatives under way to address the challenges and opportunities associated with the changing generation mix. However, these reforms and initiatives often do not occur ahead of the introduction of new technology.

Parts of Australia are world leading in terms of their wind and solar penetration. On 10 November 2019, South Australia's operational demand reached an all time low of 458 MW while rooftop PV output was over 830 MW.[1] While Australia is world leading in this regard, the energy sector has had to play catch up to account for the challenges and opportunities that have come with renewables.

There is window of opportunity to establish a fit for purpose framework ahead of fundamental, consumer-led changes. The sector should be considering changes to the market framework in anticipation of digitalisation. This paper attempts to set out what these changes might be.

Consumers are already starting to benefit from increased digitalisation in the energy sector. The reforms set out in this paper would seek to capture and extend the benefits of digitalisation to all consumers into the future.

This section of the paper elaborates on:

- what is a two-sided market
- why the wholesale market was originally designed with a focus on the supply-side
- how digitalisation is reducing costs of participation
- the opportunity to move closer to a two-sided market.

2.1 What is a two-sided market?

A two-sided marketplace is a business model that promotes direct interaction between suppliers and customers. Most traditional markets are two-sided. Examples include commodity markets and agricultural markets. New two-sided markets, supported by technological developments, are also opening up under the sharing economy such as Airbnb, Uber and Ebay.

This paper therefore focuses on the development of a two-sided market at the wholesale, centralised level which is one that is informed by quantity and price inputs from both consumers and producers of electricity. This would represent an evolution from the largely supply-side market that has characterised the NEM to date.

1 AEMC analysis of NEOpoint data, 13 November 2019.

2.2 Focus was originally on suppliers of electricity

In order for the electricity system to operate securely, the generation and consumption of electricity must be in balance near instantaneously. It is for this reason that electricity is priced in the wholesale market every five minutes. The short pricing intervals and sharp price changes send signals about what the system requires at that particular point in time, and so encourages decisions that maintain the supply-demand balance.

The original NEM market design recognised that generation must be dispatched to match demand. The demand side was not obligated to actively participate in the wholesale market for three reasons:

1. **Demand was hard to measure in real time**. Responding to short-term price signals requires real time measurement of consumption and generation. These measurements also need to be communicated to AEMO in close to real time so that AEMO can operate wholesale market dispatch. It was economically feasible for large generators to meter information in real time and provide it to AEMO but it was technically infeasible (and cost prohibitive) to meter every consumer of electricity at a high level of frequency and accuracy, and collate this information for central dispatch.
2. **It was hard for most consumers to respond to market signals**. Active participation in central dispatch comes from responding to wholesale prices. Even when consumption could be measured for each customer, the large majority of consumers (i.e. the demand side) were unable to respond effectively to wholesale prices.
3. **Consumers had less dynamic load and it was assumed to be relatively price inelastic**. It was assumed that consumers place a higher value on consuming electricity than its cost meaning that, for the vast majority of pricing intervals, the value they place on consumption exceeds the wholesale price, and they would not want to adjust their consumption even if exposed to the wholesale price. Historically, consumers had limited options for reducing power consumption (hot water load being the primary one) in a way that has minimal impact on their well-being.

Large-scale generators and batteries are required to provide information to AEMO and the rest of the market about their availability well in advance of real time. They also receive targets instructing them to generate at a level determined by AEMO every five minutes.

The vast majority of loads do not participate in the same manner as generation. Under the current framework, individual loads are not required to bid in the market and do not receive a target from AEMO to consume at a set level. Instead, AEMO makes short-term forecasts of demand for the purposes of dispatch and assumes that all demand is willing to consume at the market price. AEMO also makes forecasts of demand to inform planning and investment decisions.

In summary, the approach embedded in the market design has been to alter supply to meet *expected* demand based on forecasts.

2.3 Digitalisation reduces barriers to greater two-way participation

The changing context of the electricity market and changing nature of electricity consumers are challenging some assumptions underpinning the original market design. The technological barriers to greater consumer participation that existed at the inception of the NEM are continually reducing. Further, the nature of the supply mix is becoming increasingly variable.

Responding to wholesale prices has historically posed a challenge to most consumers. To respond, consumers have generally needed:

1. To be technically equipped to respond, which involves having the appropriate pricing information, metering and tools to make it economic for them to alter their consumption. Without digitalisation, consumers would have to manually change their consumption, which required sufficient notice of high price periods.
2. An incentive to respond to wholesale prices. Consumers who are unable to capture the benefits of responding to wholesale prices would not do so.
3. A desire to engage in the market and respond to wholesale price signals. Consumers have needed the appetite to actually engage and respond.

Digitalisation is changing what it means for a consumer to engage in the market.

Historically, a consumer actively participating in the market would need to make real time considerations about how and when to respond. This means constantly making assessments about the cost/benefit trade off of changing how much electricity is being consumed. Sophisticated metering was also required.

The consumer had to decide whether the effort was worth the potential pay-off, meaning the participating consumers were likely to be large and sophisticated. However, most electricity consumers are not large and spend little time thinking about their electricity consumption. As such, the majority of consumers have not historically been able to capture the benefits of being price responsive. However, this is now being resolved through digitalisation.

Technological advances will mean consumers will no longer need to monitor electricity prices and decide how or when to participate as these decisions could be set up to happen autonomously. Even now, new equipment, appliances and software are available that use digital technologies to save energy and seek out the lowest rates. Specific loads such as electric hot water, pool pumps and air conditioners can be set and controlled remotely to consume electricity at the cheapest times and export it (in the case of solar PV and batteries) at the most expensive times without impacting consumers.

These trends will be accelerated by the entrance of new services providers marketing home energy management services. This is analogous with the existing controlled load circuits that have been a common part of the electricity system for decades, but takes it further into the home and can be done in a way to suit each customer's preferences and lifestyles. Consumers can capture the benefits of active participation by taking advantage of new technological developments with much less effort on their behalf. Examples of this are provided in Box 1.

The market is already seeing increased consumer participation. This is being driven by a range of factors:

- **There is a focus on the increasing cost of electricity**. Increased awareness of electricity costs have driven consumers to seek to address these costs, leading to uptake of distributed energy resources (DER), demand side flexibility and energy efficiency.
- **Digitalisation will enable consumer participation to maximise return and minimise impact**. Most consumer participation previously involved manual changes but advances in technology are providing consumers the opportunity to participate with little to no tangible impact on their well-being. These trends will be accelerated by the entrance of non-traditional energy players or even non-energy players, such as Samsung, which is marketing a home energy management service (see Box 1 below).[2]
- **The costs of these technologies are falling substantially**. Previously, distributed energy resources were inaccessible to most consumers due to high upfront costs. However, as these technologies enter the market and mature, they come down the cost curve and become increasingly affordable. The proliferation of 'smart devices' means the technology to respond to price signals will be increasingly ubiquitous.
- **Consumers have demonstrated a desire to align consumption of electricity with the output of renewable energy sources**. For example, residential consumers with solar rooftop PV change their consumption of electricity to better take advantage of the output of their solar panels. In addition, entities that have signed corporate power purchase agreements (PPAs) are incentivised to align their consumption with the output of the seller of the PPA. This is driving consumer interest in batteries and demand flexibility.
- **New products and services are becoming available to consumers**. As more devices become available to end-consumers, a range of new products and services are emerging that are redefining the way in which electricity is supplied to consumers, how consumers engage with the market and how and when electricity is used. For example, the emergence of Flow Power and Amber Electric have demonstrated a change in the 'typical' retailer service. These retailers pass the wholesale electricity price directly to consumers and encourage them to respond to these signals.[3]

As consumers increasingly engage in the market, the market should be altered to accommodate and fully capture the efficiencies arising from this engagement. The future development of a two-sided market would be able to address challenges associated with the changing nature of the wholesale market, and more readily capture the efficiencies of greater consumer participation. AEMO has also previously expressed support for a customer-focussed two-sided NEM, and we are continuing to work within them and the other market bodies on the implications of new technology for market design.[4]

2 For more information, see: https://www.samsungsds.com/global/en/solutions/off/hms/SamsungSmartHome.html.

3 More examples of developments in retailer models and service provision to consumers can be found in chapter 2 and in the Commission's 2019 *Retail energy competition review*.

4 AEMO, submission to *Wholesale demand response mechanism* draft determination, p. 1.

Importantly, while consumer participation is already growing, it is not transparent to the market operator or other market participants. As such, there are broader benefits of this increased participation that are yet to be captured.

BOX 1: EMERGING HOME ENERGY MANAGEMENT SOLUTIONS

Over the past several years, the market has seen the emergence of new energy service providers who work in competition with retailers, in partnership with retailers or standalone services to help customers better manage their energy use.

Reposit

A Reposit box is a hardware product for consumers with a solar and battery system that learns the customer's consumption, solar generation, battery behaviour and energy costs in real-time. It monitors the customer's usage patterns to optimise battery charging and discharging via its 'intelligent pre-charge'.

Samsung

Samsung has recently entered the home management space with a cloud-based platform that automates appliance in a home, controlled through the customer's choice of device. The smart home solution then analyses the consumer's data and lifestyle pattern to provide services to meet the individual's preferences. This includes an energy management component of being able to monitor and control household appliances via a smartphone.

Zigbee Smart Homes

The Zigbee Alliance is a group of global organisations who create, maintain and deliver standards for the Internet of Things. This includes developing solutions for wireless, standards-based solution that can control devices and appliances within a consumer's home to deliver energy management, and heating and cooling services.

Source: Samsung Home Management Solution (HMS): https://www.samsungsds.com/global/en/solutions/off/hms/SamsungSmartHome.html, Zigbee Alliace: https://zigbee.org/zigbee-for-developers/about-us/.

2.4 The opportunity presented by digitalisation

The wholesale market relies on participants and the market operator forming expectations about market outcomes in the future days, weeks, months, and years. The confidence around these expectations depends on the degree of firmness of the information participants provide to the market operator, as well as the information that participants observe from other sources (e.g the contract market). This information is revealed by participants to the market operator and indicates their availability and willingness to generate or use electricity, which changes as the time approaches and circumstances change.

Market participants submit their own information and rely on the collective results of these actions, as well as other types of information, to inform their operational and investment decisions. Participants also adjust expectations about market outcomes over time as new information emerges, and so, in turn, this adjusts the information that they provide to the market. Decisions are therefore iterative based on information provided. Without this information, investments become more challenging, and operational decisions become harder to get right. For the market operator, this information is critical for maintaining the safe, secure and reliable operation of the market.

When the NEM started twenty years ago, all generators provided information to the market operator in real time. All demand was forecast by the system operator, with some limited exceptions. This gave market participants a greater level of certainty with regard to expected market outcomes ahead of time.

The NEM now has a generation fleet that provides different degrees of information to the market about their operating intentions. Semi-scheduled generators (e.g utility scale wind and solar) provide less information to the market relative to fully scheduled generators. Most semi-scheduled generators are expected to generate based on central forecasts of output.[5] In addition, most behind the meter generation is not transparently monitored in real time meaning market participants and the market operator have limited information about its market impacts. Presently, there is:

- 8.1 GW of rooftop solar installed behind the meter[6]
- 2.8 GW of installed utility scale solar generation[7]
- 6.1 GW of installed wind generation[8]
- 4.8 GW of committed intermittent generation.[9]

Consumers are also becoming more price responsive. This combines to increase the variability in market outcomes and everyone might benefit from an increase in the amount of information provided by those driving that variability.

In a tighter demand-supply balance and changing characteristics of the source of electricity generation, the differences between forecasts and actual outcomes may have more significant consequences. As the uptake of DER continues, demand side participation grows, there are more variable renewable energy resources and more extreme weather days, forecasting is likely to become more difficult.

2.5 Benefits of achieving a two-sided market

There are significant benefits from digitalisation and a two-sided wholesale market where both sides (demand and supply) are actively engaged in scheduling and dispatch:

1. digitalisation lowers the scale where participation becomes economic, increasing participation and competition, putting more downward pressure on prices

5 Although, some utility scale solar farms have started self-forecasting. This means that instead of being expected to generate in-line with central forecasts, these generators can submit their own short-term forecasts.

6 AEMO, *Electricity statement of opportunities 2019*, August 2019, p. 36.

7 AEMO, Generator information webpage, accessed 9 October 2019, available: https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Planning-and-forecasting/Generation-information.

8 Ibid.

9 Ibid.

2. retailers and aggregators who work to best understand their customers demand and preferences, and act in the interests of their customers, would be lower cost, and therefore be rewarded with a greater market share
3. improved certainty associated with forecasts, which enhances the ability for market participants to make informed decisions and assist AEMO in maintaining the safe, secure and reliable operation of the power system
4. improved accuracy of forecasts by allocating forecasting challenges to the parties who can best manage them
5. capturing the efficiencies of increased demand side participation in the wholesale market to the benefit of all consumers
6. reducing the complexities of cost reflective pricing as consumer preferences for how they use their electricity are automated to reflect their own individualised value of electricity.

These benefits are outlined more below in Box 2 through a number of case studies.

BOX 2: CASE STUDIES — THE BENEFITS OF DIGITALISATION AND A TWO-SIDED MARKET

Case study 1

Tanya, Rhonda and Muriel have all installed a $100 device — the 'StayCool' — that allows them to adjust the settings their air-conditioner remotely in response to expected and actual wholesale prices. When installing the device, they add an app to their phone which allows them to set their comfort levels and the device acts autonomously.

Rhonda — aggregator program

Rhonda has a StayCool that was given to her by her retailer along with a $100 voucher and a small payment when it is activated. While it is more expensive for the retailer to install and operate the StayCool, it helps the retailer save on other hedging products such as cap contracts. The retailer and Rhonda are both able to benefit from the arrangement.

However, Rhonda's retailer is finding it harder over time to know when the StayCool should be operated. The greater levels of variability on the supply and demand side mean there is a greater chance that the retailer will use the StayCool at times when the spot price doesn't spike.

Muriel — aggregator and a two-sided market

Muriel also has a StayCool. Muriel is using her StayCool through a similar arrangement with her retailer *in a two-sided wholesale electricity market*. In this example, Muriel's retailer actively participates in the market. The retailer informs the market that it will consume 1,000 MW across all of its customers unless the wholesale price exceeds $1,000/MWh. If the price reaches or exceeds $1,000/MWh, the StayCools will activate and reduce the retailer's consumption to 800 MW for up to four hours (even lower for shorter periods).

On a hot afternoon, and unbeknownst to Muriel, hers and the rest of the retailer's StayCools start to pre-cool houses anticipating high spot prices. Because these prices are informed by *both* supply and demand side bids, the price forecasts are more accurate. In the late afternoon, wholesale prices start to climb and, at $1,000/MWh, the retailer's StayCools reduce consumption to 800 MW.

Not only does this benefit the retailer and Muriel — it benefits the rest of the market:

- the wholesale price is kept closer to an efficient level by being able to be set by either a supply or demand-side bid
- additional generation was not called on because the market knew 200 MW of demand response would occur when prices exceeded $1,000/MWh in the early evening
- the market operator had greater certainty it could maintain the supply/demand balance with sufficient resources in reserve for contingencies.

Case study 2

Mike and Sue have both purchased electric vehicles. The vehicles come with a smart charger that charges the car when electricity prices are lowest.

Mike — smart vehicle

Mike has a retail arrangement where the electricity he uses for his electric vehicle is paid for at the prevailing spot price. He logs when he expects to use the car and sets a minimum charge level that the car should not fall below.

On a mild week in Spring, the price forecasts show prices going negative in the middle of the day as solar output peaks. The smart charger waits until these prices eventuate. Mike essentially gets to recharge his electric vehicle for free and it all happened autonomously.

However, just like the StayCool, the smart charger has an increasingly difficult job trying to work out whether the forecast price troughs will actually happen. As more and more customers install solar and electric vehicles, the forecast prices start to become more and more uncertain.

Sue — smart vehicle and two-sided market

Sue has an electric vehicle and a smart charger. Sue is using her electric vehicle through an arrangement with her retailer *in a two-sided wholesale electricity market*. Sue also sets a minimum charge level that the car should not fall below not matter what the price is. This minimum level of charge will mean Sue has enough charge to use the car in unexpected circumstances.

In this example, Sue's retailer actively participates in the market. The retailer informs the market that it will consume 1,000 MW across all of its customers unless the wholesale price falls below $0/MWh. If the price goes negative, the electric vehicles will start charging and increase the retailer's consumption to 1500 MW for up to two hours.

On a mild day, and unbeknownst to Sue, hers and the rest of the retailer's electric vehicles wait to charge anticipating low spot prices. Because these prices are informed by *both* supply and demand side bids, the price forecasts are more accurate. At midday, wholesale prices go negative. The retailer's total electricity consumption climbs to 1500MW.

Not only does this benefit the retailer and Sue — it benefits the rest of the market:

- the wholesale price is kept closer to an efficient level by being able to be set by either a supply or demand-side bid
- it encourages additional solar generation during the middle of the day because demand side flexibility is able to shift consumption to mop it up
- the market operator had greater certainty it could maintain the supply/demand balance with sufficient resources in reserve for contingencies.

3 REFORMS TO INCREASE TWO-WAY PARTICIPATION

As noted in section 2.3, the technological barriers to greater consumer participation that have existed to-date are continually reducing. Therefore, it is timely to look at the current design of the NEM to determine whether it is best able to harness the benefits of technology in such a way that promotes the long-term interests of consumers. By discussing these design choices now, the market will be better positioned to respond as digitalisation of the energy market reaches critical mass.

This section sets out aspects of the market that digitalisation affects, and provides opportunities for greater two-way participation:

- participation in scheduling and dispatch
- dispatching more than one interval at a time
- locational pricing
- multi-settlement
- incentives for reliability
- sub-market optimisation
- incentives for security.

3.1 Assessment approach

The outcomes that the electricity market must deliver are prescribed in the laws that govern the NEM[10] :

> "...to promote efficient investment in, and efficient operation and use of, energy services for the long term interests of consumers of energy with respect to price, quality, safety, reliability and security of supply of energy"

The objectives under the NERO, NEO and NGO must underpin any views on digitalisation and the move to a two-sided market.

In order to assess whether the current market is able to harness the benefits of new technologies and facilitate a two-sided market, we have developed a two-stage framework to help facilitate discussion. In this framework we have:

1. identified a spectrum of choice for each design element with a view to looking at the impact of digitalisation and assessing whether the market should move towards one with stronger market signals, or stronger control process
2. developed criteria which would guide the choice along the spectrum that we believe would best deliver an efficient two-sided market.

Further information on each of these is provided below.

10 This National Energy Retail Objective (NERO) is outlined in the National Energy Retail Law (NERL), and other iterations of this objective can be found in the National Energy Law (NEL) as the National Energy Objective (NEO) and National Gas Law (NGL) and the National Gas Objective (NGO).

3.1.1 Description of market features and role of digitalisation

There are a number of identified market features that will be affected by digitalisation. Within these, are a spectrum of choice — obviously there are options that sit within the spectrum, but the framework is designed to identify the "ends". Table 3.1 below outlines the market features, the spectrum of choice for each of these, and the impact of digitalisation on those features.

Table 3.1: **Market features, spectrum of choice and the role of digitalisation**

CATEGORY	DESCRIPTION OF SPECTRUM	ROLE OF DIGITALISATION
Participation requirements	Participation by both sides of the market in central dispatch can be voluntary or compulsory (i.e. scheduled).	Digitalisation can make it less costly for demand and supply to reveal their price and quantity preferences in scheduling and dispatch.
Dispatch horizon	Inflexible generation can be committed via single or multi-interval dispatch.	Digitalisation can improve flexibility of some technologies and automate rebidding.
Degree of locational pricing	A single settlement price can be calculated for each node (nodal pricing) or for zones containing multiple nodes (regional pricing).	Digitalisation can make it less costly for smaller participants to respond to local prices and to assess the suitability of different risk management options, including financial hedging options.
Settlement periods	The spot market can be the outcome of a single dispatch settlement, or one or more ahead interval settlements with a balancing real time market.	Digitalisation could reduce the cost of implementing an operating multi-settlement trading systems.
Incentives for long-term reliability	Reliability can be managed centrally via market-wide reliability standards or as a matter of preference by participants themselves (decentralised).	Digitalisation (e.g. remote control over circuit breakers in premises and at the meter) will make it easier for retailers to manage reliability through bespoke arrangements with their customers.
Sub-market optimisation	Individual DER could be dispatched by a central market operator, or locally through an aggregator into the existing market model.	Digitalisation makes it less costly to operate either option.
Incentives for security	Security services can be separately procured or via operator procurement (co-optimised).	Digitalisation should reduce the cost of capturing what is going on in networks, which should make security needs more apparent. It also reduces the cost of

CATEGORY	DESCRIPTION OF SPECTRUM	ROLE OF DIGITALISATION
		participation.

3.1.2 Criteria for assessing design features

We have developed six criteria to guide choices that might best deliver on the energy objectives. These criteria are consistent with those used by the Commission for a number of market reviews (including the *Wholesale demand response mechanism* rule change) and with those used by KPMG in its recent paper on market design.[11] These criteria, which are presented in this paper to generate discussion and could be amended when considered in the broader ESB's 2025 work, are outlined in Table 3.2 below.

Table 3.2: **Criteria for assessing market design choices**

Criterion	Description
1. Competition and market signals	Competition and market signals, where feasible, generally lead to more efficient operational and investment decisions as well as being more flexible to changing market conditions and provide consumers with the services they value in the most efficient manner possible.
2. Appropriate risk allocation	Risk allocation and the accountability for investment and operational decisions should rest with those parties best placed to manage them.
3. Competitive / technology neutrality	Markets that are technology neutral and do not favour one technology or business model over another encourage consumer needs to be met at the lowest cost and promote innovation. Externalities are also recognised and ideally should be valued so there are clear price signals for the attributes.
4. Information asymmetries	Information asymmetries should be minimised to market participants have confidence they are competing on a level playing field.
5. Cross-market integration	Costs to consumers will be minimised when markets complementary to energy, such as ancillary services and emissions, are designed in a way that is consistent with the price discovery mechanism in the electricity market.
6. Regulatory and administrative costs	Practical, operational and compliance impacts result in minimal unintended consequences. Changes to regulatory frameworks come with associated costs. These costs include both those imposed to implement change and the ongoing costs associated with making the change.

11 KPMG, *Coordinating electricity market reform — A framework to assess the congruency of wholesale market reforms in the National Electricity Market — A report for the Australian Energy Council*, September 2019.

Source: AEMC, and *KPMG, Coordinating electricity market reform — A framework to assess the congruency of wholesale market reforms in the National Electricity Market — A report for the Australian Energy Council,* September 2019.

Note: As an explanatory note to competitive neutrality — technology externalities should be recognised. For example, zero emissions technologies that contribute to government emissions reduction policies should be recognised.

3.2 Initial view on design choices

By using this framework, an indicative assessment emerges of where on the spectrum you are likely to land when designing an efficient two-sided market. This is shown in the matrix in Figure 3.1 below. The spectrum moves from stronger market signals at one end (the top figure) to stronger control processes at the other (the bottom figure).

The figures are designed to show, at a high level, where either end of the spectrum is more likely to deliver on (via a 'tick') or less likely to deliver on (via a 'cross') the six criteria. A 'dash' indicates that either option is viable.

Where the design choice at one of the spectrum meets more of the criteria (i.e has more 'ticks') it is, more likely to deliver on a wider range of criteria, and is therefore more likely to facilitate digitalisation and provide the most benefit to consumers.

Importantly, we note that this assessment appears binary. That you can either land on one end of the spectrum or the other. However, the answer is not as certain, nor binary. There are many potential iterations along the spectrum of choice and multiple middle ground solutions to be explored. The spectrum and the criteria are designed to highlight the types of outcomes you may see at either end of the spectrum, and to facilitate discussion. This is new territory to be explored both within the NEM, and internationally. The framework and approach seek to enable a more in-depth and detailed discussion on harnessing the potential of digitalisation.

The thinking behind each of the choices in the matrix, and the assessment against the criteria is provided in the following sections and in appendix a.

Figure 3.1: Initial assessment of design features

Stronger market signals

		Criteria					
Design feature	**End of Spectrum**	Competition and market signals	Appropriate risk allocation	Competitive / technology neutrality	Information asymmetry	Cross-market integration	Regulatory and admin costs
Participation	Compulsory	✓	-	✓	✓	✓	×
Dispatch horizon	Single	✓	✓	✓	×	×	✓
Locational pricing	Nodal	✓	✓	✓	✓	-	×
Incentives for reliability	Decentralised	✓	✓	✓	✓	-	✓
Settlement periods	Single settlement	×	×	✓	×	×	✓
Sub-market optimisation	Hierarchical	-	-	-	-	-	-
Incentives for security	Co-optimised	-	-	-	-	-	-

Stronger control systems

		Criteria					
Design feature	**End of Spectrum**	Competition and market signals	Appropriate risk allocation	Competitive / technology neutrality	Information asymmetry	Cross-market integration	Regulatory and admin costs
Participation	Voluntary	×	-	×	×	×	✓
Dispatch horizon	Multiple	×	×	×	✓	✓	×
Locational pricing	Regional	×	×	×	×	-	✓
Incentives for reliability	Centralised	×	×	×	×	-	×
Settlement periods	Ahead settlement	✓	✓	×	✓	✓	×
Sub-market optimisation	Simultaneous	-	-	-	-	-	-
Incentives for security	Separate market	-	-	-	-	-	-

3.2.1 Participation in scheduling and dispatch

As discussed earlier, currently, in the central dispatch process AEMO balances electricity supply and demand within five-minute intervals. In order to achieve this balance AEMO receives information from scheduled participants on their generation and consumption intentions, and forecasts generation and consumption for the remainder of the market (including demand).[12] In looking at a two-sided market, a key market design involves determining whether both supply and demand *must* provide information on generation and consumption (in the same way as a scheduled participant), or whether this could be a voluntary requirement.

The current arrangements reflect past decisions about the relative costs and benefits of submitting information on intentions to generate and consume electricity. Historically, it has been difficult and onerous for smaller or intermittent generators on the supply side, and the demand side to provide AEMO with information on their generation and demand intentions. However, as digitalisation allows the market to get access to greater and more timely information, and loads become more responsive, it would likely be less costly for demand and supply to reveal their price and quantity preferences.

Further, allowing entities other than the system operator to provide their own forecasts could be beneficial since, by disaggregating the provision of forecasts, risks associated with the forecasts can be shared between multiple parties that may be better placed to manage them.

As such, digitalisation could lower the costs of bidding in the same way as scheduled generation currently does, with incentives that reward those that are more accurate than others. Equally, there may be some opportunities to relax some of the strict requirements on scheduled generators and existing scheduled loads in order to create a level playing field. This is akin to what happened when Uber was legalised in Australia, and some rules and costs on taxis were relaxed to ensure that traditional taxis were better able to compete on a level playing field with the disrupting Uber service.

3.2.2 Dispatching horizon

At the inception of the NEM, five-minute dispatch was considered the shortest operational timeframe practicable. However, the NEM adopted different periods for dispatch and settlement because of limitations in metering and data processing in the 1990s. Digitalisation has reduced these limitations and increased consumer participation, enabled by advanced metering, solar, battery and other automation technologies.

12 AEMO forecasts semi-scheduled generation via specific wind and solar forecasting models. The semi-scheduled generators then specify prices for their generation. AEMO can require these generators to limit their output to a specific level if required. Non-scheduled generators may be intermittent or non-intermittent and generally have a nameplate capacity between 5 MW and 30 MW. These generators are not required to provide information on their generation intentions. AEMO forecasts the output from this category, and generally does not constrain their generation output. Although some utility scale solar farms have started self-forecasting. This means that instead of being expected to generate in-line with central forecasts, these generators can submit their own short-term forecasts.

The market is currently in the process of moving to five-minute settlement that will align the physical electricity system — which matches demand and supply of electricity every five minutes — with the price signal provided by the market for that five-minute period. Improved price signals can lead to more efficient bidding and operational decisions by generators, and more efficient investment in flexible technologies, such as aggregating DER and rapid demand response. Over time, this would feed through to lower wholesale costs, which make up around one third of a typical electricity bill.

It is possible to increase the dispatch horizon from a single five-minute interval to multiple intervals. For instance, the PJM market in the United States dispatches three five-minute intervals every five minutes and optimises dispatch of generation in the day ahead market over the whole day.

Optimising the dispatch of resources over multiple intervals has some benefits and costs. There is a short-term benefit because it enables slower resources to compete with faster ones in central dispatch, increasing competition and lowering costs.

However, this optimisation is subject to greater regret (i.e. dispatching slower resources which turned out not to be needed, which generally attract uplift payments) and dampens prices and incentives for resources available in the five-minute period they are needed. For example, the five-minute prices that result from a fifteen-minute dispatch horizon are not as sharp as they are under a five-minute dispatch horizon, and would undo some benefits achieved from moving to five minute settlement.

3.2.3 Locational pricing

Nodal pricing, where both the demand-side and generation-side face local prices, provides a more accurate indication of the value of electricity in a participant’s location, which encourages more efficient operation, hedging, and investment decisions.

Moving to full nodal pricing is attractive from the perspective of economic efficiency, since it has the advantage of more accurately reflecting the costs of network congestion to all parties, including non-scheduled generation and load.

As the NEM moves toward a two-sided market and demand side resources become more responsive to wholesale market prices, the advantages of allowing non-scheduled market participants to face a locational marginal price will increase. The proposed approach in COGATI to establishing a common regional price provides flexibility to move to locational marginal pricing for non-scheduled participants over time, if this was found to be in the long-term interest of consumers.

3.2.4 Incentives for long-term reliability

Long-term reliability can be managed either in a centralised or decentralised way. The unreliability of the overall electricity supply is primarily a product of network failures. However, there is a small portion of loss of supply (less than one per cent) that occurs because there is not enough generation to meet every unit of demand. When we talk about incentives for long-term reliability, we are talking about this risk, not the loss of supply experienced as a consequence of network failure.

Currently, the NEM allows for wholesale electricity spot prices to vary widely enough to induce enough generation to achieve a pre-determined level of reliability (i.e. the reliability standard). In order to deliver on this standard, the Reliability Panel determines the price settings for the wholesale electricity market price to be high enough to induce generation and demand to match nearly all the time. Wholesale spot and contract market prices drive the operational, contracting, and investment decisions of market participants (retailers, consumers and generators). At times when demand is higher or generation is lower than expected, generators earn higher revenues (or experience a financial cost if they fail to deliver fixed quantities agreed in contracts) while retailers are exposed to the potential for higher prices for every unhedged unit of electricity. At other times, the reverse is true.

However, there are also safety nets in place if the market fails to deliver generation sufficient to meet the reliability standard. For example, the Retailer Reliability Obligation (RRO) and the central procurement of the Reliability and Emergency Reserve Trader (RERT). As a last resort, AEMO can instruct Distribution Network Service Providers (DNSPs) to operate rotational consumer load shedding to maintain a secure system.

Making decisions centrally about reliability and cost trade-offs is fraught by incentive and accountability problems. At present, reliability is delivered by market participants bearing both the risks and the rewards of their investments in response to settings determined by a central body (the Reliability Panel). Market participants bear the risk of oversupply (through lower returns) and consumers, market participants, AEMO, and politicians bear the consequences of under supply causing loss of supply. It is hard to pin accountability for the meeting or otherwise of the reliability standard on the Reliability Panel for not being able to guess societal preferences.

There are additional centralised controls, such as capacity markets, which would provide more control to a central body (Reliability Panel or another body) over the quantity of generation contracted to meet demand. This would change the incentives and accountabilities; shifting the risk of over supply from market participants to the central body, and the cost of oversupply from generator investors to consumers. Consequently, the central body would become accountable for suboptimal outcomes (significant periods of over or under supply) that suggest it "got it wrong".

Alternatively, digitalisation brings with it the opportunity to change the way we treat power system reliability. In a fully digitalised world, instead of having a system wide level of reliability, individual consumers would be enabled to nominate their own preferred level of reliability. Individual consumers, aggregators or retailers could adjust consumer demand in response to price signals in the wholesale market. With additional digitalisation and technology change, enabling a more dynamic provision of reliability services would likely result in a lower costs to the market, and consumers. However, we are conscious that consumers may need time to adapt to this degree of reform, given existing levels of consumer participation and technology.

3.2.5 Increasing the number of settlement periods

At present, the NEM operates a single settlement spot market. A single settlement system relies on the incentives provided by the wholesale market to coordinate generation and contracts to manage cash flows and operate resources to meet dispatch.

However, as the nature of generation is changing, AEMO is, at times, directing specific generation stations in some places to be operated to maintain the safe, secure and reliable operation of the market. In addition, there is a perception that pre-dispatch schedules are becoming inaccurate, leading to less efficient commitment decisions. 'Inaccurate' pre-dispatch schedules are a product of changes to the inputs (generation, demand, network limits), which are carried out by participants and have cost implications, but do not attract an explicit cost.

Advances in communications and control technology will soon enable digital electrical devices to be controlled and optimised in response to wholesale prices and to participate in ancillary service markets, but result in schedules becoming more variable.

Adding an additional settlement interval ahead of dispatch would make the spot price a balancing price that signals the cost and reward of varying output or consumption from the quantities settled in the ahead interval. The most common form of multi-settlement is the day ahead market that operates in most American and European electricity markets. This market is devoted to financially settling quantities and prices for each trading interval of the following day. Adding a financial settlement interval (or intervals) would make the pre-dispatch schedule between the ahead interval and dispatch firmer and could potentially improve the coordination of resources, resulting in net cost savings that outweigh the cost of this intervention.

Any decisions about the level of 'aheadness' required would create winners and losers. It is not possible to choose an optimal settlement interval for an ahead market without making an assumption about the resource mix needed to meet the required energy services (including system services such as inertia and system strength). Therefore, careful consideration will be needed to choose the optimal amount of 'aheadness'.

3.2.6 Centralised or decentralised sub-market optimisation

At present, individual DER are dispatched directly though an aggregator into the existing wholesale market. In looking at a two-sided market, there is potential that individual DER could either be dispatched by a central market operator (centralised), or optimised first locally through an aggregator into the existing market model (decentralised). Digitalisation makes it less costly to operate either option and therefore either end of the spectrum of choice for this feature is feasible. The final option should be one that provides consumers greater choice while preserving necessary consumer protection in relation to their energy supply and DER.

3.2.7 Incentives for security

The transformation of the energy sector is presenting both opportunities and challenges for system security, including for the management of frequency, voltage and system strength.

In theory, digitalisation should reduce the cost of accurately identifying the state of the power system, which should make the security needs and requirements at a particular point in time more apparent. It also reduces the cost of participation, increasing potential for greater competition in providing those services. However, until the required security services are adequately specified, including their characteristics such as whether you could have a meaningful price, it is unclear whether they should be supplied by markets (co-optimised) or via central procurement (separate procurement). This is a key decision that needs to be made in light of new and emerging information.

It is desirable to consider whether improvements can be made to the minimum system strength and inertia frameworks in the NER to more effectively and efficiently identify and address shortfalls in system strength and inertia as they arise in the NEM.[13]

13 This includes the Commission's work on *Investigation into intervention mechanisms and system strength in the NEM* — https://www.aemc.gov.au/market-reviews-advice/investigation-intervention-mechanisms-and-system-strength-nem.

ABBREVIATIONS

AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
ARENA	Australian Renewable Energy Agency
COGATI	*Coordination of generation and transmission investment*
Commission	See AEMC
DER	Distributed energy resources
DNSP	Distribution Network Service Provider
ENERF	*Electricity networks economic regulatory frameworks*
ESB	Energy Security Board
FCAS	Frequency Control Ancillary Services
MCE	Ministerial Council on Energy
MWh	Megawatt hour
NEL	National Electricity Law
NEM	National electricity market
NEO	National electricity objective
NERL	National Energy Retail Law
NERO	National energy retail objective
NGL	National Gas Law
NGO	National gas objective
PASA	Projected Assessment of System Adequacy
PPA	Power purchase agreement
RERT	Reliability and Emergency Reserve Trader
RRO	Retailer Reliability Obligation

A ASSESSMENT OF FEATURES AGAINST SIX CRITERIA

This appendix provides further detail on the design features assessed against the six criteria. It does not include incentives for security or market structure as digitalisation means either end of the spectrum is feasible.

A.1 Participation

Table A.1: **Participation — compulsory or voluntary**

PRINCIPLE	COMMENT
1. Competition and market signals	Increasing proliferation of DER and demand response has blurred the boundaries between consumers and generators. Greater participation for generators and load would increase the information available to sets the price of electricity and increase the incentive for participants to respond to these market signals.
2. Appropriate risk allocation	Not applicable.
3. Competitive / technology neutrality	Increasing the number of participants responding to price signals would allow for greater competition in the market. Additionally, it would further incentivise the most flexible technology to enter the market, whether it is generation or consumption.
4. Information asymmetries	Increasing participation would reduce information asymmetries (more information revealed about participant intentions) and lead to more efficient market signals.
5. Cross-market integration	Having information about the intentions of more market participants might help with procurement and optimisation of ancillary services such as voltage/FCAS.
6. Regulatory and administrative costs	Allowing for voluntary or differentiated participation would enable participants that are more capable of complying with the requirement to do so and avoid unnecessary costs for smaller participants where it is unreasonably costly to do so.

A.2 Dispatch horizon

Table A.2: Dispatch horizon

PRINCIPLE	COMMENT
1. Competition and market signals	The current spot market allows participants to self-commit in response to dispatch and pre-dispatch price signals. This allocates risk to participants, who base their decisions on the latest information and react to what the market needs most.
2. Appropriate risk allocation	Single interval dispatch makes market participants responsible and accountable for the financial outcomes (good or bad) of commitment decisions made via bids.
3. Competitive / technology neutrality	There is a short-term benefit from multi-interval dispatch because it enables slower resources to compete with faster ones in central dispatch, increasing competition and lowering costs. However, this optimisation centralises the cost of regret (i.e. dispatching slower resources which turned out not to be needed), which generally attracts uplift payments borne by consumers and dampens prices and incentives for resources available in the five-minute period they are needed.
4. Information asymmetries	A multi-interval dispatch horizon would improve information asymmetries as AEMO and other market participants would be privy to the commitment logic of parties that used this facility.
5. Cross-market integration	Multi-interval dispatch may lead to greater cross-market integration as both the operator and participants have more information about commitment decision, which could be factored into decisions in other markets.
6. Regulatory and administrative costs	Moving to a multiple interval dispatch horizon model would increase regulatory and administrative costs for participants that may outweigh the limited benefits of this option.

A.3 Locational pricing

Table A.3: Locational pricing — nodal or regional

PRINCIPLE	COMMENT
1. Competition and market signals	Nodal pricing gives more accurate indication of the value of electricity in a participant’s location, which

PRINCIPLE	COMMENT
	encourages more efficient operation, hedging, and investment decisions. An accompanying financial transmission right system allows people to manage basis risk and so continue to trade. In contrast, regional contract markets are more liquid but they ignore the potential to signal to participants the value of managing congestion.
2. Appropriate risk allocation	Nodal pricing assigns congestion risks and costs to those that are affected and can manage it. Regional pricing spreads congestion risks and costs around the parties in a region.
3. Competitive / technology neutrality	Regional pricing suits oligopolistic competition between a few large retailers focussed on regional and NEM-wide scale competition. Nodal pricing suits start up retailers focussed on finding niches of customers that suit their business model.
4. Information asymmetries	Nodal pricing provides more transparency about what is going on in the network — transmission flows, value, costs.
5. Cross-market integration	There is little difference between regional or nodal pricing with respect to cross-market integration.
6. Regulatory and administrative costs	Nodal pricing requires major changes to market systems — something COGATI is exploring.

A.4 Incentives for long-term reliability

Table A.4: **Incentive for reliability — centralised or decentralised**

PRINCIPLE	COMMENT
1. Competition and market signals	In a fully digitalised world, supply and demand reliability (not network reliability) could be set by consumers themselves as a term of their retail contract (subject to relevant consumer protections) so that retailers could ration demand of their customers in response to reliability issues in the market. The current price-driven approach is designed to provide market incentives that drive the private sector to invest in generation capacity and demand response capability that is available when and where customers and

PRINCIPLE	COMMENT
	the power system need it.
2. Appropriate risk allocation	Making reliability a contractual matter between a customer and their retailer would better align risks between parties as long as the retailer had agency over the remote operation of customer appliances and/or connection of supply at the gate meter.
3. Competitive / technology neutrality	Some centralised reliability mechanisms can discriminate between different technology types. A decentralised approach would allow consumers to choose their own level of reliability without prescribing how this should be achieved.
4. Information asymmetries	Centralised mechanisms rely on central bodies making assumptions regarding the value of lost load of consumers when managing unserved energy, representing a significant information asymmetry.
5. Cross-market integration	Not applicable
6. Regulatory and administrative costs	The consumer protection concerns on allowing customers to choose to be switched off for short periods mean we are a long way from seeing a decentralised approach be a reality.

A.5 Increasing the number of settlement periods

Table A.5: Settlement periods — Multi settlement ((ahead) or single settlement (dispatch))

PRINCIPLE	COMMENT
1. Competition and market signals	A single settlement system relies on the incentives provided by the reliability settings to coordinate generation and contracts to manage cash flows and operate resources to meet dispatch. Adding an additional settlement interval ahead of dispatch would make the spot price a balancing price that signals the cost and reward of varying output or consumption from the quantities settled in the ahead interval. An additional settlement interval would make the pre-dispatch schedule between the ahead interval and dispatch firmer and might result in improved coordination of resources, with net cost savings that outweigh the cost of the intervention.

PRINCIPLE	COMMENT
2. Appropriate risk allocation	The costs and rewards of varying from the quantities settled in the ahead interval would flow to the parties that made the choices to do so, and would therefore allocate risks appropriately.
3. Competitive / technology neutrality	The choice of the ahead settlement interval creates winners and losers as you cannot choose an optimal interval without making an assumption about the resource mix. Therefore, it is not technology neutral. However, neither is the choice of the length of a dispatch/settlement interval.
4. Information asymmetries	The pre-dispatch schedule in a single settlement system contains greater information asymmetries than one with multiple settlement intervals.
5. Cross-market integration	A multi-settlement system creates more potential to line up fuel supplies as it makes pre-dispatch schedules more certain. It could assist in the procurement of system services and reduce the need for interventions in the market.
6. Regulatory and administrative costs	Adding additional settlement intervals adds costs for both AEMO and market participants.