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16 May 2017

Mr John Pierce
Chairman
Australian Energy Market Commission
PO Box A2449
Sydney NSW 1235

Lodged online via: www.aemc.gov.au

Dear Mr Pierce,

Reporting on drivers of change that impact transmission frameworks

TransGrid welcomes the opportunity to respond to the Australian Energy Market Commission's (AEMC's) Draft Stage 1 Report in relation to the drivers of change that impact transmission frameworks.

TransGrid is the operator and manager of the high voltage transmission network connecting electricity generators, distributors and major end users in New South Wales and the Australian Capital Territory. TransGrid's network is also interconnected to Queensland and Victoria and is central to a secure electricity system that allows for interstate energy trading.

TransGrid understands that this review is the first application of a biennial reporting regime requested by the COAG Energy Council in response to the AEMC's final report on Optional Firm Access, Design and Testing. Its intent is to assess whether the drivers of investment in transmission and generation have changed such that major investment is likely but is uncertain in technology or location. The AEMC's assessment may trigger a second stage which will consider how to encourage more optimal generation and transmission investment, consistent with the National Electricity Objective (NEO).

TransGrid's response

TransGrid supports efforts to better coordinate transmission and generation investment given that this is an important aspect of a successful transition to a lower emissions future. Responses to the Report's consultation questions are shown below.

Question 1 Do you agree with the Commission's analysis of the drivers of change in transmission and generation investment?

TransGrid broadly agrees with the AEMC's discussion of the drivers of change in investment presented in the Report. Issues raised include the ongoing uncertainty about environmental policy and the rapid pace of technology change and uncertainty about how this will impact on supply and demand.

TransGrid also agrees that a range of other factors such as wholesale and contract market trends, market and power system reviews, ongoing Rule changes and Government interventions have greatly increased uncertainty.

Question 2 How do these drivers impact on transmission and/or generation investment?

The resulting uncertainty has impacted investment confidence generally. More specifically, TransGrid is concerned that sub optimal generation investment decisions are being made under the current framework as a result of the barriers to investing in new network.

Abundant renewable resources are often remote and not well served by transmission networks. To use these resources, new generators are liable for the cost of connecting to the shared network. Due to distance, this cost can be significant and can render an individual project unviable. As a result, generators often locate closer to existing networks, even if the resource is less abundant. This may not be the most efficient solution for the economy and consumers.

While the location of abundant renewable resources is well known, the current regulatory framework also impedes the development of new transmission network to facilitate optimal renewable generation investment.

There are therefore barriers to both efficient generator location and the transmission investment which would enable it. TransGrid is less confident than the AEMC that proposed reforms to replacement expenditure planning arrangements will significantly improve generator and transmission investment coordination[1].

It is TransGrid's view that a successful transition to a lower emissions future will require reforms to the investment framework and better coordination of transmission and generation investment.

Question 3 Are there any additional areas that should be considered in this Review?

TransGrid understands that this review is related to the AEMC's previous work on Optional Firm Access (OFA). TransGrid does not consider that OFA resolves the issues above. TransGrid supports a regulatory framework based on net economic efficiency analysis which enables planning, investment and cost recovery of transmission corridors to resource rich areas, in consultation with generation investors. This would support an efficient and secure transition to a lower emissions future. However, any change needs to be mindful of the wide range of reforms and review processes currently underway.

TransGrid encloses its submission to the Independent Review into Future Security of the National Electricity Market. This sets out TransGrid's vision for the future of the Australian energy market and section 2 describes possible reforms relevant to this response.

If you would like to discuss these issues further with TransGrid, please contact me on 02 9284 3120. We look forward to engaging further with the AEMC and other stakeholders on this important review.

Yours faithfully

Nicola Tully
Acting Executive Manager, Strategy and Regulation

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[1] As set out on p51 of the Draft Stage 1 Report

TransGrid

Independent Review into the

Future Security of the National Electricity Market

Submission

Contents

Executive Summary

Australia is in the midst of an energy transformation. This is primarily driven by community expectations, retirement of existing generation and advances in renewable energy technologies. Consumers have expressed to TransGrid their strong support for the objectives of energy security and reliability, affordability and reduced emissions.

TransGrid believes that a trajectory towards 100% renewable generation is feasible, and that the technical challenges associated with this transition can be met in a way that is affordable for consumers.

The energy system of the future will feature customer choice and control, enabled by an increasingly interconnected network. Generation will comprise a mix of large-scale generation and distributed energy resources (DER) and participants will able to share resources and services, with the network providing the platform for energy transport and power system stability.

A blueprint to transition to this energy system will need to address four key elements:

1. A pathway towards **generation with a low levelised cost of energy** (LCOE) that meets emissions targets.
2. Development of **transmission networks** to integrate large-scale renewable energy whilst ensuring power system stability.
3. Mechanisms that provide **ancillary services** at the lowest possible cost.
4. **Market design** appropriate to the future energy mix, that promotes genuine competition and protects consumers when there is ineffective competition.

This submission focuses on the role of transmission networks. Transmission networks are pivotal to the energy system of the future and in a unique position to underpin the achievement of energy security, affordability and reduced emissions.

> Transmission networks maintain **energy security** through core expertise in power system security and stability, and a thorough understanding of the planning and operation of the power system.

> Transmission networks deliver **affordability** for consumers as the platform on which the competitive wholesale electricity market operates.

> Transmission networks are integral to **reducing emissions** in the electricity sector by transporting energy between areas with abundant renewable resources and areas where electricity is used.

TransGrid proposes several reforms that will be essential to a successful transition:

1. **Connection of large-scale renewable generation** in areas with abundant renewable resources will be enabled by extension of the transmission network to those areas.
2. An increasing proportion of intermittent generation will be made possible by greater interregional transmission capacity and large-scale energy storage. This will allow **sharing of geographically diverse resources and smoothing of the intermittent generation profile** to fit the demand profile.
3. As existing synchronous generation is retired, there will be a need for **new ancillary services to manage system stability** in place of inherent synchronous inertia. Until 2030, the synchronous generation projected to remain in the NEM will provide sufficient inertia for the power system as a whole, if shared between regions though stronger interregional connections. New technologies, such as large-scale battery storage that provides fast frequency response, should be incorporated into networks early so their application in practice can be understood and validated in system stability models.
4. The **regulatory framework will need to evolve** to support the energy system of the future.

TransGrid looks forward to the opportunity to further discuss these reforms with the Expert Panel and work with the industry as a whole to achieve a successful energy transformation.

1 Vision for the energy system of the future

The energy system of the future will be substantially based on renewable energy, with customer choice and control enabled by an increasingly interconnected network that allows sharing of resources and services. The transition is largely driven by a combination of community expectations, technology development, public policy and increasingly the low cost of renewable energy.

The energy system of the future will consist of large-scale renewable generation contributing approximately 65% of the generation mix by 2050, with customer-sited distributed energy resources (DER) contributing around 30%.[1]

The energy system of the future is shown in **Figure 1**.

A transition towards an energy system with this diversity of generation will recognise that:

- **Customers will remain connected to networks** to access a diversity of generation sources and share resources.
- **The greatest large-scale renewable energy resources** are in areas remote from most customers and existing networks.
- **Network extensions will be required** to connect renewable generation in these areas.
- **This will cost only around 5%** of the total cost of the energy transformation.
- **More granular energy trading will be possible** for existing generation, new large-scale generation and individual customers with DER.
- The system will become significantly **more complex** to plan and operate to maintain stability. Logical electrical nodes will be more important than state borders and network boundaries.
- A **different market and regulatory model** is required.

Figure 1: The energy system of the future

1. Energy Networks Australia, Electricity Network Transformation Roadmap: Key Concepts Report, December 2016.

The significant difference between the existing electricity system and a future energy system that features widespread adoption of DER is shown in **Figure 2**.

A blueprint to transition to the energy system of the future will need to address four key elements:

1. A pathway towards generation with a low levelised cost of energy (LCOE) that meets emissions targets.

   This may include both the deployment of existing generation technologies that meet these criteria and initiatives to reduce the LCOE of emerging generation technologies with low emissions. Initiatives to support the development of emerging technologies include support for innovation, proof of concept and implementation.

2. Development of transmission networks to integrate large-scale renewable energy and ensure power system stability.

   New transmission services will be required to transport energy between areas with abundant renewable resources and areas where electricity is used. They will also be able to share energy between regions to diversify the intermittent patterns of some types of generation. The transmission network will also increasingly provide ancillary services to stabilise the power system.

   The implementation of these services will comprise a small part of the overall cost of the transition to low emissions generation, contributing to delivery of the most cost-effective overall outcome for consumers.

3. Mechanisms that provide ancillary services at the lowest possible cost.

   Ancillary services are used to manage the stability of the network. They are currently provided by existing generation and transmission assets, and have the potential to be provided in future by new technologies such as large-scale battery storage.

   Planning of these services should remain with transmission networks because their quantity and location is important. New technologies, such as large-scale battery storage that provides fast frequency response, should be incorporated into networks early so their application in practice can be understood and validated in system stability models.

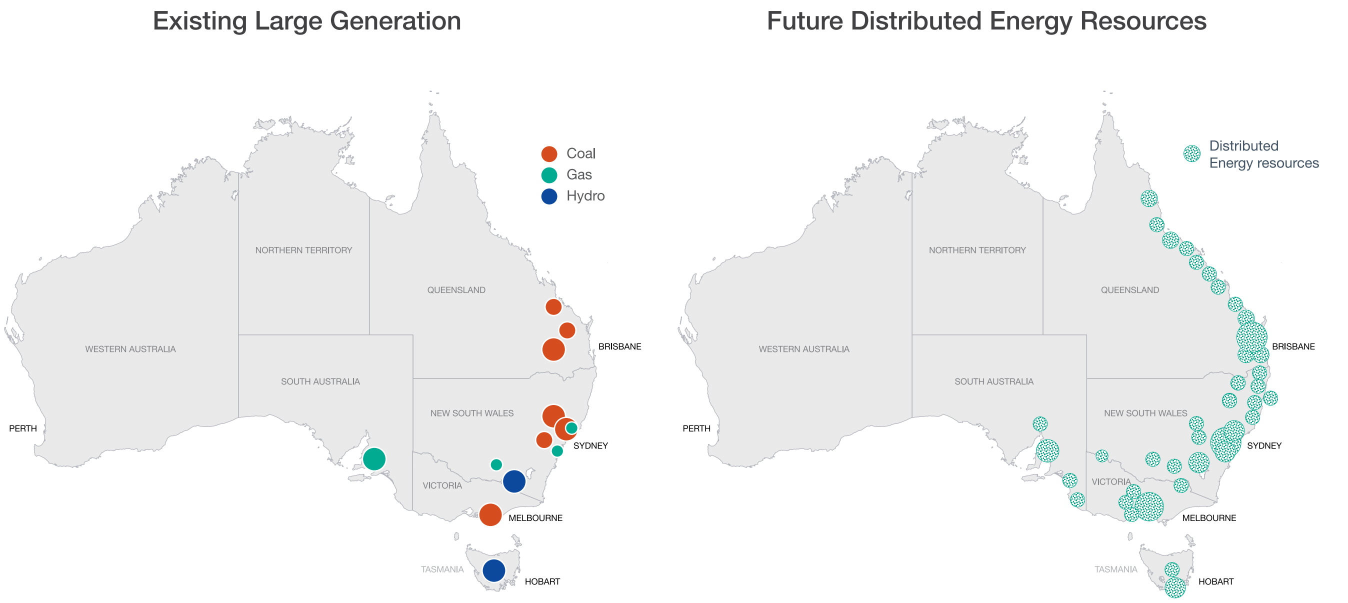
   Ongoing provision of these services should be at the lowest cost. A range of options, including a competitive contract-based arrangement that delivers the most efficient outcome between non-regulated and regulated options, may be appropriate. The current arrangement for procurement of Network Support and Control Ancillary Services (NSCAS) reflects this approach.

4. Market design appropriate to the future energy mix, that promotes genuine competition and protects consumers when there is ineffective competition.

   With the growth of distributed energy resources (DER) and other emerging technologies, centralised dispatch of generation may not be possible. The energy system of the future may comprise multiple dispatch mechanisms, which in aggregate will need to be operated to within the technical limits of the network.

   Market design will also need to consider situations of lack of liquidity and limited competition for provision of some services. Experience in certain areas of the National Electricity Market has resulted in outcomes that have been to the detriment of consumers.

Figure 2: The transition from centralised generation to distributed energy resources in the NEM



2 Reforms that will be essential to a successful transition

2.1 Connection of large-scale renewable generation

Connection of large-scale renewable generation in areas with abundant renewable resources will be enabled by extension of the transmission network to those areas.

The energy system of the future will include an increasing amount of large-scale renewable, low emissions generation. The use of large-scale generation has the advantage of economies of scale, and establishment of this generation in areas with abundant renewable resources will maximise its energy conversion efficiency.

Wind and solar resources are generally most abundant in areas remote from the majority of customers, as shown in **Figure 3**.

Deployment of renewable generation to date has been in areas with access to the existing transmission network, rather than where the greatest energy conversion efficiency could be realised, as there is limited transmission capacity to remote areas.

Transmission networks typically have energy losses of approximately 2%.[2] Improvements to the energy conversion efficiency of renewable generation by locating it in areas with abundant renewable energy resources are likely to far outweigh the additional losses from extension of the network to these areas.

The cost of extending the transmission network to integrate increasing renewable energy generation in Europe has been estimated approximately 5% of the total cost of investment in the power system.[3] TransGrid estimates a similarly low proportion for Australia.

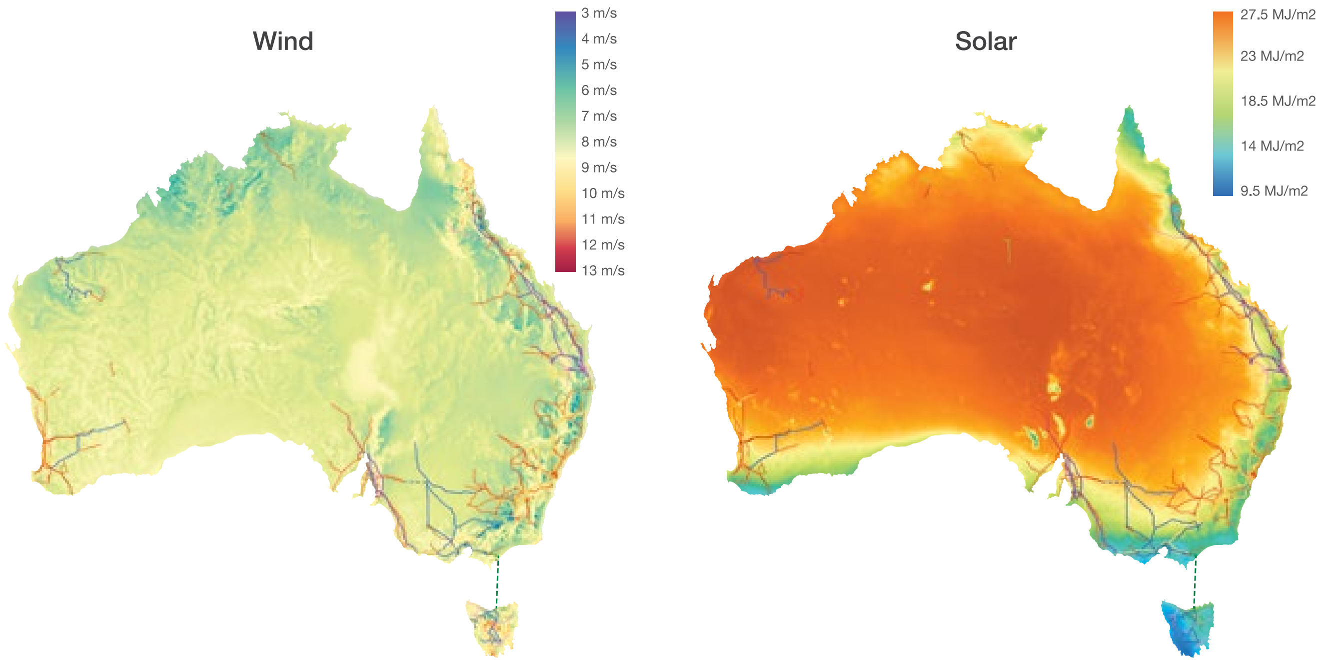
2.2 Increasing proportion of intermittent generation

Intermittent generation will be effectively and efficiently managed by connection of geographically diverse resources and large-scale energy storage.

The benefits of greater interregional transmission capacity include management of intermittent generation profiles using geographic diversity, lower energy prices for consumers, greater energy security and emissions reduction benefits from better utilisation of renewable energy resources.

The benefits of large-scale energy storage include supply smoothing, frequency regulation, spinning reserve voltage support, black start, resource adequacy and transmission congestion relief.

Figure 3: Wind and solar resources and transmission networks in Australia
Source: Australian Renewable Energy Mapping Infrastructure.



2. TransGrid, Electricity Network Performance Report, October 2015, p6.
3. McKinsey & Company, Transformation of Europe's Power System Until 2050, October 2010, p39.

2.2.1 Greater interregional transmission capacity

2.2.1.1 Connection of geographically diverse resources

The intermittency of generation sources such as wind and solar can be offset by locating this generation to leverage geographical diversity. The potential benefits of this are evident from profiles of actual generation.

Figure 4 shows the average wind farm output as a proportion of installed capacity, by state and time of day. Wind generation in Queensland and South Australia follows a similar profile of greater generation overnight than in the daytime, whereas wind generation in New South Wales and Tasmania follows the reverse profile.

Solar generation will generate in the daytime and have greater generation when the solar radiation from the sun is the greatest, in the middle of the day. This complements wind generation patterns in Queensland and South Australia. Situating large-scale solar generation west of major load centres would provide greater efficiency, as the time of evening peak demand at load centres would correspond to an earlier time of day with greater solar radiation in more westerly time zones. Geographic diversity of solar generation also mitigates the effect of reductions in output in periods of localised cloud cover.

The geographical diversity of renewable energy sources can only be leveraged by sufficient transmission capacity between different areas with abundant renewable resources.

Transmission interconnectors provide a cost-effective solution to share renewable energy between geographically diverse areas. Analysis undertaken for the most recent National Transmission Network Development Plan (NTNDP) found that the cost of forecast interconnection over the next 20 years would equate to approximately 4% of the investment in generation over the same period.[4]

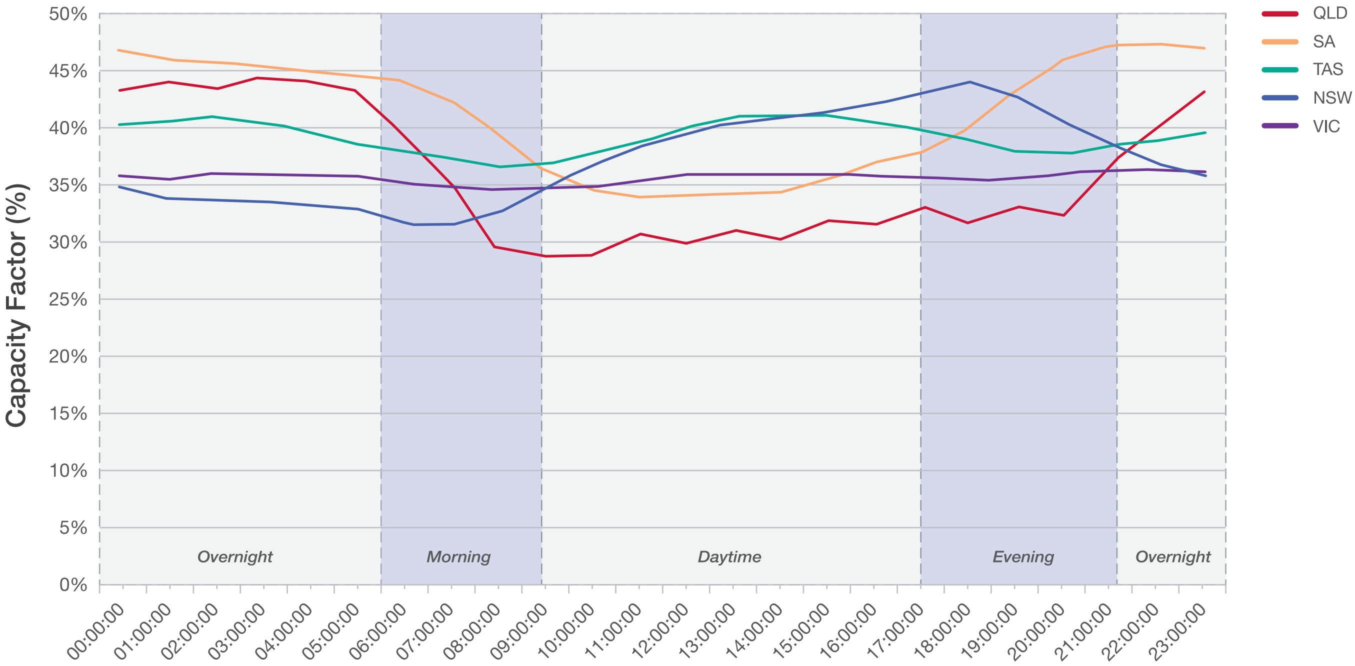
The International Energy Agency (IEA) has identified interconnectors as the most cost-effective approach for integrating and aggregating a large share of variable renewable energy and maintaining energy security.[5] The European Union has set an overall target to have 10% of all European generation capacity interconnected by 2020 (it is currently around 8%) and 15% by 2030 to facilitate greater market integration and additional renewable energy capacity.[6]

International jurisdictions with ambitious renewable energy targets, including Germany, the UK and Denmark, see greater interconnection as a key tool to enable the transition towards a decarbonised electricity network. This is summarised in **Figure 5**.

A particularly pertinent example to the Australian context is Denmark, which generated 40% of its electricity from wind in 2016, similarly to South Australia. Denmark currently has a total of five interconnectors connecting the Danish electricity market to Norway, Sweden and continental Europe through Germany. Denmark's existing interconnector capacity is equal to its peak demand capacity, in contrast to just 23% of South Australia's peak demand capacity available through its connection to Victoria.

There is a parallel between the situation in Europe and Australia. In Europe, countries with ambitious renewable energy targets pursue greater interconnection to facilitate a diverse generation mix and maintain energy security. In Australia, a similar approach would enable the integration of intermittent generation while maintaining energy security.

Figure 4: Average wind farm operation by time of day[7]
Source: Australian Energy Market Operator.



4. AEMO, National Transmission Network Development Plan, December 2016, p32.
5. International Energy Agency, Re-powering Markets - Market design and regulation during the transition to low-carbon power systems, 2016.
6. European Commission, Communication from the Commission to the European Parliament and the Council – European Energy Security Strategy – SWD (2014) 330 Final, May 2014.
7. AEMO, National Transmission Network Development Plan, December 2016, p33.

Figure 5: Grid interconnections in Germany, UK and Denmark

Germany	United Kingdom	Denmark
Germany is planning grid expansions, as shown, due to the increase in large-scale wind developments. The German grid regulator has indicated that an additional 2,650km of transmission lines will be required by 2023.	The UK has four existing interconnectors, with seven new projects approved by Ofgem in the pipeline, as shown. estimated to require between £7-8bn of investment up to 2020.	Denmark has a total of five interconnectors, as shown. In addition to the existing interconnectors, the Ministry for Energy, Utilities and Climate of Denmark recently approved an additional 400 MW connection to Germany and has launched public consultation on the proposed 1,400 MW Viking Link to the UK.

Existing interconnectors · Cap and floor granted in principle · Approved · Other future project

2.2.1.2 Lower energy prices for consumers

Transmission interconnectors deliver lower energy prices for consumers through improved competition in the wholesale electricity market.

Generators with a low short-run marginal cost (SRMC), such as wind and solar, dispatch first under existing market arrangements. However, the clearing price is set by the last generator ('marginal generator') required to meet demand in the merit order. In a market such as South Australia, where there is often a significant cost difference between generators with low SRMC and the marginal generator, the benefits of the low SRMC generation are often lost in the prices paid by consumers.

Analysis by PWC[8] found that wholesale prices in South Australia between January 2013 and August 2016 were 29% higher than in New South Wales. South Australia experienced the greatest volatility and largest number of price spikes in the NEM over the period. In its analysis, PWC estimates the cost of these price spikes at approximately $489 million. This is shown in **Figure 6**.

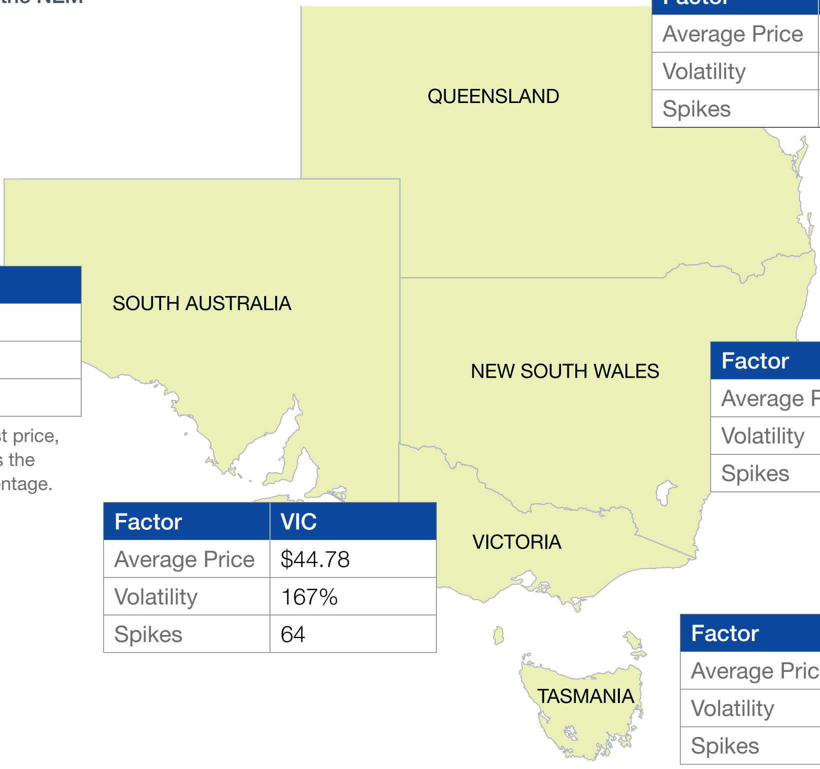
The benefits of low cost renewable energy will be more evident with greater interconnection, as market access will improve while diversity in the generation mix across the states will facilitate and promote opportunities for trade. New renewable generation, if properly integrated, would reduce opportunities for rent seeking behaviour by incumbent generators during times of tight supply and demand balance, and reduce the number of periods when more expensive generation is dispatched.[9, 10]

An interconnector with South Australia would allow available generation in other regions to be exported to South Australia when required, while allowing the abundant wind capacity in South Australia to benefit the other regions. Using historical data, it was estimated that an additional interconnector would reduce wholesale prices in South Australia by approximately $16.75/MWh, whilst only resulting in a minor increase in other regions of $1.06/MWh.[11] International studies have generated similar findings. A 2014 study undertaken by National Grid found that each gigawatt (GW) of additional interconnector capacity would reduce wholesale prices in the United Kingdom by 1-2%.[12]

Importantly, greater interconnection may also be used to allow the network to 'share' crucial ancillary services such as frequency control and spinning reserve between jurisdictions. This would reduce the need to source ancillary services locally and increase competition and liquidity in the market, delivering lower prices to electricity users.

8. Price Waterhouse Coopers, Electricity Market Issues in South Australia, August 2016.
9. Clean Energy Council, RET Policy Analysis, May 2014.
10. SKM, Estimating the Impact of Renewable Energy Generation on Retail Prices, June 2013.
11. Price Waterhouse Coopers, Electricity Market Issues in South Australia, August 2016.
12. National Grid, Getting More Connected - The opportunity from greater electricity interconnection, March 2014.
13. Poyry, Costs and Benefits of GB Interconnection, February 2016.

Figure 6: Price volatility in the NEM
Source: PWC.



Factor	QLD
Average Price	$59.90
Volatility	365%
Spikes	405

Factor	SA
Average Price	**$61.78**
Volatility	**260%**
Spikes	**610**

South Australia has the highest price, number of spikes and also has the second highest volatility percentage.

Factor	NSW
Average Price	$47.80
Volatility	162%
Spikes	22

Factor	VIC
Average Price	$44.78
Volatility	167%
Spikes	64

Factor	TAS
Average Price	$59.03
Volatility	128%
Spikes	311

2.2.1.3 Improved energy security

Interconnection improves energy security by enhancing the resilience of the power system. Diversity in transmission paths will reduce the risk of an area of the power system being 'islanded' in the event of a fault, as happened in South Australia on 28 September 2016.

The economic cost of low energy security is significant, with the financial impact of the recent system black in South Australia estimated at $315 – $629 million.[14]

An extended blackout would be likely to have even greater cost implications than those estimated, due to the impacts on sensitive loads. For example, the Tomago Aluminium Smelter constitutes more than 10% of the average demand in NSW and contributes $1.5 billion to the Australian economy each year.[15] Large energy users, including Tomago, make up approximately 20% of the total demand for electricity in the NEM. For many large energy users, the costs associated with an outage reflect lost production, as outlined in reports such as AEMO's Value of Customer Reliability.16 However, for some large customers such as Tomago, extended outages could be catastrophic and result in irreversible equipment damage. A loss of supply for a period longer than 3 hours would result in significant, and most likely uneconomic, costs to repair and restart the plant. This highlights the importance of system restart ancillary services (SRAS) to be provided to a standard that ensures that large-scale industrial consumers would not be adversely affected, even in a high impact, low probability event.

A study by Deloitte Access Economics[17] for the Australian Energy Market Commission (AEMC) identified intangible costs that could result from a major system outage, particularly if it is prolonged. These include significant impacts on health and wellbeing, employment, education and community.

2.2.1.4 Emissions reduction benefits

There are emissions reduction benefits from interconnection because renewable generation can export energy to other jurisdictions during times of high output without being curtailed.

In its most recent NTNDP, AEMO found that insufficient interconnection would result in 'spill' of wind generation. This may lead to either LRET penalties for retailers or an overinvestment in renewable generation to meet LRET targets. Greater interconnection to access more diverse renewable resources can hence deliver both dispatch and capital investment efficiency benefits.[18]

2.2.2 Large-scale energy storage

Large-scale energy storage can enable smoothing of intermittent generation and provide the ability to shape the generation profile. It will become more important in the energy system as the proportion of intermittent generation increases.

Large-scale energy storage can be provided through a range of means, such as:

14. AEMO, National Transmission Network Development Plan 2016, December 2016
15. http://www.pacificaluminium.com.au/61/Tomago-Aluminium
16. AEMO, Value of Customer Reliability – Final Report, 28 November 2014.
17. Deloitte Access Economics, Economic assessment of System Restart Ancillary Services in the NEM, 19 August 2016.
18. AEMO, National Transmission Network Development Plan, December 2016

- Chemical energy in large-scale battery systems, which can be controlled to charge and discharge at high speeds to match an output profile.
- Gravitational potential energy in pumped hydroelectric systems, which can also provide synchronous ancillary services to assist power system stability.
- Gravitational potential energy in existing hydroelectric generation systems in the NEM, which could be repurposed to provide load following services and synchronous ancillary services.
- Other emerging technologies such as solar thermal systems.

These technologies can also be leveraged by the transmission network to provide a number of increasingly important services for the performance and stability of the power system.

Large-scale battery storage is unique in its ability to provide a number of services to the electricity system, providing the technical capability to integrate increasing amounts of variable renewable energy into the electricity network. This makes it an important future tool for the transmission network to achieve a reliable, secure, low emissions, and cost-effective future power system.

Services provided by large-scale battery storage which will grow in importance as the amount of intermittent renewable energy on the network increases are listed in **Table 1**.

The importance of storage to facilitate the integration of renewable energy has convinced a number of international jurisdictions with ambitious renewable energy agendas to mandate network-led deployment of storage. These are shown in **Figure 7**.

There are clear advantages from having an entity with the requisite expertise, such as transmission networks, deploying storage, as shown in **Table 2**.

Transmission networks are well placed to manage the co-ordinated introduction of large-scale battery storage across all of its capabilities to maximise the benefit to consumers.

Table 1: Capabilities provided by large-scale battery storage

Capability	Description
Supply Smoothing	Large-scale battery storage can be used to charge and discharge to follow a demand profile.
Frequency Regulation	Baseload generators generally take minutes to respond to imbalances on the network. Large-scale battery storage can respond within seconds (fast frequency response) and has the potential to replace spinning reserve on the network. This also makes it an ideal technology to partially address the likely lack of inertia in the future power system.
Spinning Reserve	Refers to fast response generation capacity able to ramp up or down in the event of supply and demand imbalances. As such, it can be seen as a subset of frequency regulation.
Voltage Support	Voltage on the power system must be maintained within limits. This service is currently provided by generators, tap changers in power transformers and network reactive as demand changes on the network. A similar service can be provided by drawing reactive power from a large-scale battery storage system.
Black Start	Black start services are currently provided by synchronous generation assets. Large-scale battery storage has the potential to provide a similar service, and may be used in conjunction with fast starting generation.
Resource Adequacy	Peaking generation plant is currently installed to meet peak period generation requirements. Large-scale battery storage systems made available during peak periods could act as an alternative to these assets.
Transmission Congestion Relief	Battery storage could be installed downstream of congested sections of the transmission network to minimise congestion in the transmission system during certain periods.

Table 2: Transmission networks' advantage in managing large-scale battery storage

Capability	Description
Expertise	Transmission networks have the knowledge of power systems to optimise location, size, and timing of storage deployment for maximum benefit.
Cost certainty	If provided as a network service, the cost would be known in advance and there would be no risk of price spikes or other unexpected pricing events.
Transparency	Information on the locations in which storage would be installed and rationale for those locations would be publicly available, as would information on the services and benefits the system would provide.
Accountability	Transmission networks have clear accountability for the performance of network assets to meet the service obligations required to support the network.
Planning efficiency	Networks would be able to consider all options and their synergies to optimise the investments, providing least cost solutions to consumers.
Power system optimisation	Enables integration and coordination with other resources provided by networks and generators for an optimised solution.

Figure 7: Examples of network-led storage mandates

California	Italy	Germany	China
In 2013, The California Public Utilities Commission (CPUC) passed legislation mandating the state's utilities Pacific Gas and Electric (PG&E), Southern California Edison (SCE), and San Diego Gas and Electric (SDG&E) to deploy 1.3GW of storage by 2024. The proposed procurement target includes 700 MW to be installed on the transmission network.	Italy has been experiencing severe balancing problems related to renewable production (mainly located in the south) and electricity consumption (mainly in the north) with limited interconnection between regions. To address this, in 2011 Italy stipulated that Terna, the national transmission system operator, is able to build and operate batteries under certain conditions. Terna has since deployed 278MWh of storage (NaS technology) at its SANC storage site in Campania.	Program KfW 291 provides loans from 25 to 50 million Euros with a fixed interest rate for 10 years to provide energy supply, efficiency, storage and transmission solutions for the purpose of providing storage for energy efficiency or load management. Additionally, utility-scale battery projects are being built to support network operation including 50 Hertz receiving a grant to install 10 MWh of storage for grid stability, load balancing of wind resources and ancillary services.	The Chinese government released, in its 5-year plan for 2011-2015, a new policy directive that requires intermittent renewable generators to pair their generator with energy storage as a grid connection requirement. State Grid, a transmission and distribution company, has recommended that storage is sized at 14% of the generation capacity.

2.3 Management of system stability

As existing synchronous generation is retired, there will be a need for new ancillary services to manage system stability in place of inherent synchronous inertia. TransGrid's studies show that until 2030, the synchronous generation projected to remain in the NEM will provide sufficient inertia for the power system as a whole, if shared between regions though stronger interregional connections. New technologies, such as large-scale battery storage that provides fast frequency response, should be incorporated into networks early so their application in practice can be understood and validated in system stability models.

The existing power system was designed based on flows of electricity from large, synchronous, dispatchable generation to major load centres. The significant increase in intermittent renewable generators and simultaneous retirement of some synchronous generators pose a number of challenges to the stability of the power system.

Currently, coal and gas fired baseload power plants exclusively use synchronous generators to convert the energy embedded in the primary fuels to electricity. Because of the inherent characteristics of synchronous generators, they also provide the ability to:

> control network voltages;

> smooth the impact of system disturbances, by providing inherent inertia that manages the rate of change of system frequency; and

> meet short-term power imbalances.

These characteristics are fundamental to the stable operation of the existing power system. They are not inherently provided by non-synchronous generation, including renewable technologies such as solar and wind generation. Therefore, the effective replacement of existing baseload generation with renewable generation will require the development of innovative alternatives to provide these functionalities.

2.3.1 Network voltage control

Synchronous generators are able to provide voltage support, which is critical during and immediately following network faults. As these generators are withdrawn, it reduces voltage stability in the surrounding area, which can lead to larger voltage fluctuations during network faults.

Network providers deploy technologies to ensure voltage is maintained within prescribed standards and manage power flow to within the physical limitations of the network. These mature technologies include solutions such as Static VAr Compensators (SVCs), Static Compensators (STATCOMs) and rotating

Synchronous Condensers. Emerging technologies, such as battery storage, could also be leveraged by network providers to provide voltage control.

The degree to which additional voltage control capacity will be required as more renewable energy is introduced will vary depending on the type and location of the installation. Currently, many of the enquiries to connect renewable generation are for connection at weak points in the network. TransGrid's planning studies show that this will lead to new voltage control infrastructure being required.[19]

2.3.2 Rate of change of frequency

Synchronous generators have inherent inertia, which provides stability to the power system by easing the impact of changes in power system frequency due to rapid changes in generation or load. Following a disturbance to the system, such as the trip of a load or generator, a lack of inertia results in faster changes in system frequency. This in turn may result in further disturbances across the system.[20]

Wind and solar generators do not inherently provide inertia, although some wind turbines can produce "synthetic inertia" from kinetic energy stored in the blades and generator of wind turbines. As a result, in systems with a high proportion of renewable energy, the inertia inherent in the system is reduced, which results in a less stable power system.[21, 22]

Until 2030, the synchronous generation projected to remain in the NEM will provide sufficient inertia for the power system as a whole, if shared between regions through stronger interregional connections. Beyond 2030, the management of a power system with decreasing inertia will require innovative solutions.

For example, hydroelectric generation systems and pumped hydroelectric storage can provide inertia. Existing hydroelectric generation in the NEM could be repurposed to provide these services and new hydroelectric storage systems installed.

New technologies, such as high-speed demand control and large-scale battery storage that provides fast frequency response, will be increasingly important for the management of system frequency in the future. These should be incorporated into networks early so their application in practice can be understood and validated in system stability models.

The installation of new synchronous generation, such as gas fired generation, would also assist in replacing inertia that is removed from the system when existing baseload generation is retired.

2.3.3 Meeting short-term power imbalances

Large synchronous generators currently have spinning reserves to ramp up or down in response to imbalances in supply and demand caused by substantial changes in generation or load.

Wind and solar farms are generally operated at capacity to generate the maximum amount of electricity at any given time. This means that, unlike most synchronous generators, wind and solar generators operated in this way are unable to provide a boost of energy output for a short time when there is a generation deficiency in the power system. Therefore, as synchronous generators are retired and replaced with renewable generators, there will be a need for an alternative solution to supply this service.

Operation of wind and solar generators with some reserve and the use of energy storage systems to provide energy injection for a short time are viable alternatives to relying on large-scale synchronous generation.

2.4 The regulatory framework will need to evolve

The regulatory framework will need to evolve to support the energy system of the future.

As the energy system evolves, the frameworks that govern energy markets and regulation will also need to evolve to support the objectives of energy security and reliability, affordability and reduced emissions in the context of evolving technologies.

While the existing energy market has worked well in the past, it is predicated on effective competition that is unconstrained by physical network topology. In practice, some areas of the NEM have operated to the detriment of consumers, particularly where there has been ineffective competition in a region or for an ancillary service. The experience of South Australian electricity users of ongoing high prices and poor supply reliability is one such example. In short, the NEM has failed the people of South Australia.

The regulatory framework also does not completely support the objectives valued by energy users. For example, economic tests for network investment do not consider benefits associated with reductions in emissions.

TransGrid proposes several changes to the frameworks that govern energy markets and regulation to better support a transition to the energy system of the future:

- Transmission networks should be allowed to participate in provision of a broader range of services, including ancillary services that are essential to the stability of the power system, and receive appropriate returns.
- The Regulatory Investment Test for Transmission (RIT-T) should be amended to consider the benefits aligned with all objectives of the energy transformation, including contributions to reductions in emissions.
- The advent of DER is likely to require a move away from a single centralised market with few generation participants to multiple regional markets with many participants. This form of market across the NEM will be too complex to be managed by a single, centralised approach to generation dispatch. The emerging complexity will require greater regional operational control to ensure that all markets in aggregate are operated to within the technical limits of the network.

2.4.1 Energy market reform

To function in the long-term interests of consumers, the NEM relies on effective competition in the wholesale and retail energy markets. Evidence in recent years suggests that competition is becoming increasingly ineffective in some areas of the NEM.

19. ROAM Consulting, Impact of the LRET on the costs of FCAS, NCAS and Transmission Augmentation, 2011.
20. AEMO, National Transmission Network Development Plan, November 2015.
21. Pieter Tielens, Dirk Van Hertem, Grid Inertia and Frequency Control in Power Systems with High Penetration of Renewables, 2012.
22. Deloitte Access Economics, Energy markets and the implications of renewables - South Australian case study, November 2015.

2.4.1.1 Lack of liquidity leading to high pricing

The lack of liquidity in some areas of the NEM is evident in the occurrence of high prices. For example, the limitations of the frequency control ancillary services (FCAS) market in South Australia were highlighted in late 2015 and mid 2016 when the interconnector between Victoria and South Australia failed or was being upgraded. In addition to rolling blackouts across South Australia, these events caused spikes in FCAS payments as shown in **Figure 8**.

The total cost for FCAS in the NEM between 11 October and 10 November 2015 was around $27 million above the historical average.[23] The total cost between 5 August and 2 December 2016 was around $35 million above the historical average.

Part of the reason for the significant spikes was the relatively limited number of providers of FCAS in South Australia.[24] When the interconnector to Victoria is operating, there is sufficient competition across the NEM to suppress prices, as highlighted by historically low prices across the NEM prior to October 2015. However, when the interconnector is unavailable, the lack of competition may result in inefficient market power being exercised by FCAS providers.[25]

This experience is likely to be exacerbated in a future in which the demand for FCAS is likely to increase while the number of suppliers will diminish.

Greater interconnection across the NEM would improve liquidity and competition in the FCAS market by removing regional constraints. Similarly, expanding the role of transmission networks to be able to provide frequency support, including fast frequency response, would improve liquidity and competition in the provision of these services, delivering lower costs for consumers.

2.4.1.2 Competitive markets leading to higher margins

In 2013, the Essential Services Commission (ESC) of Victoria initiated an investigation into retail pricing and margins following deregulation of the state's retail market in 2009.

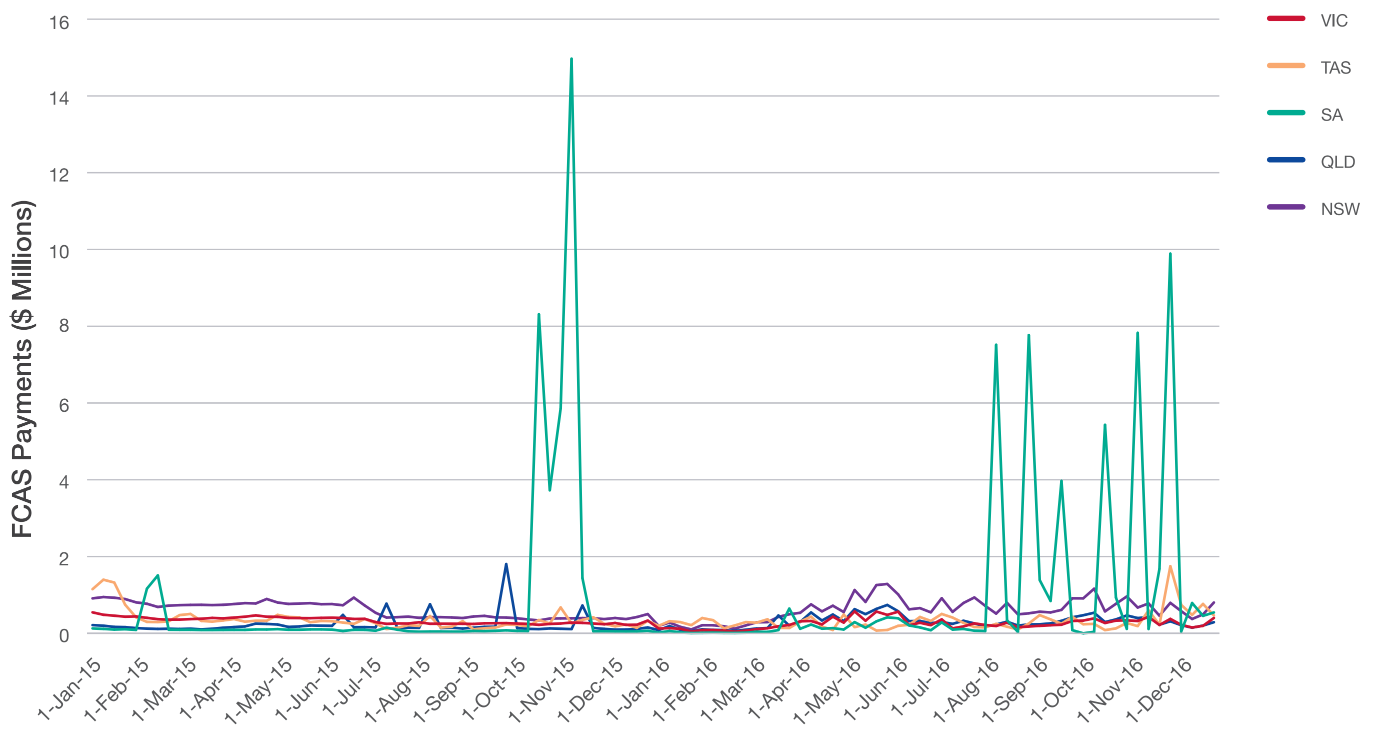
Modelling undertaken by SKM-MMA[26] for the report found that retail margins had remained higher in Victoria following deregulation, compared with New South Wales and South Australia, as shown in **Figure 9**.

Subsequent analysis undertaken in 2015 found that the non-network component of a customer's electricity bill was significantly higher in Victoria than the rest of the NEM and that the Victorian retail component had increased relative to the implied wholesale price, as shown in **Figure 10**.

The AEMC's 2015[27] report on residential electricity price trends also indicates that the drivers of retail bill increases are moving away from network-related costs towards costs related to the competitive elements of the market in generation and retail.

As part of the transition to the energy system of the future, the design of energy markets must be appropriate to the future energy mix, promote genuine competition and protect consumers when there is ineffective competition.

Figure 8: FCAS payments in the NEM
Source: Australian Energy Market Operator.



23. AEMO, NEM – Market Event Report – High FCAS Prices in South Australia – October and November 2015, December 2015
24. The recent closure of the Northern Power Station has since this event further reduced the number of FCAS providers in SA to just two.
25. http://www.businessspectator.com.au/article/2015/11/2/energy-markets/are-intermittent-unreliable-wind-farms-causing-havoc-sa-again
26. SKM-MMA, Analysis of Electricity Retail Prices and Retail Margins 2006 – 2012, May 2013
27. AEMC, Residential Electricity Price Trends 2015, 2015.

Figure 9: Single rate, average gross retail margin from host retailer
Source: SKM-MMA.

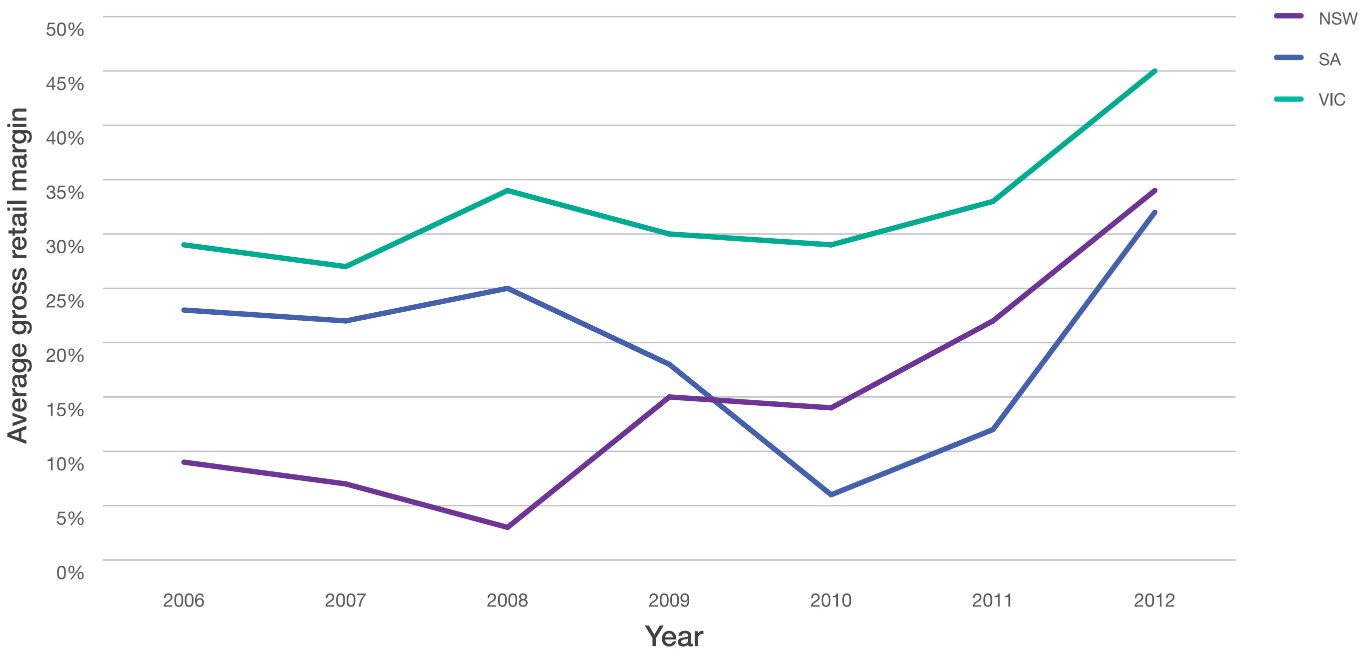


Figure 10: 2015 electricity price breakdown (left) and indexed wholesale and retail price (right)
Source: CME.

2.4.2 Services provided by transmission networks

The role of market participants in the NEM will need to evolve to meet the requirements of the power system in the future. Ancillary services which were inherently available from the performance of large synchronous generators will be gradually withdrawn and need to be carefully planned and obtained by alternative means.

Given this new paradigm, there is an advantage in expanding the services provided by transmission networks. Transmission networks can use existing and emerging technologies to provide voltage control, frequency regulation and stabilising services throughout the network, taking advantage of efficiencies in scope and scale.

2.4.2.1 Transmission networks can deliver ancillary services at a lower cost than generators

Transmission networks have already demonstrated the ability to provide ancillary services at a lower cost than generators in some circumstances.

In 2012, the NTNDP identified a gap for voltage control in southern NSW, which required up to 800 MVAr of absorbing reactive power of Network Support and Control Ancillary Services (NSCAS) over a five year period.[28] TransGrid successfully tendered for the provision of reactive support as a non-regulated transmission service. The service under this agreement commenced from 31 March 2014 and will end on 30 June 2019.

28. AEMO, 2012 National Transmission Network Development Plan, December 2012

Table 3 summarises the quantity and cost of NSCAS services over the past three years.

It is clear that significant reductions in the cost to consumers were delivered by TransGrid providing the service.

2.4.2.2 International regulatory frameworks provide appropriate incentives

In certain international jurisdictions, greater emphasis on the services provided to the consumer has already been explored, understood, and implemented. A report by Cambridge Economics Policy Associates (CEPA) studying California, New York and the United Kingdom found that while core network services were still regulated through a building block approach, all three had incentives on top of base revenue to drive the desired outcomes of their regulators.[29]

For example, in the UK, the functional division of network companies is comparable to Australia (with separation of transmission and distribution providers) but the interpretation of the valuable services these entities provide have been expanded under the recently implemented RIIO framework (Revenues = Incentives + Innovation + Outputs). Incentives exist for environmental impact, social impact, connections and reliability metrics. Innovation incentives are rewarded if actions by the network help deliver a sustainable energy network, with output metrics related to safety, environmental, impact, reliability, customer satisfaction and DER connections, amongst others. Although a building blocks approach to returns is used, a total expenditure (totex) benchmarking approach has been incorporated, allowing the network provider to gain a regulated return for 'slow OPEX' related to long-term service contracts and pre-determined capitalisation rates.[30, 31]

An incentives and penalties based approach similar to the RIIO framework could provide an appropriate framework for network providers to facilitate the future services required to integrate increasing amounts of large-scale renewable energy into the grid.

2.4.2.3 Refining the role of transmission

In Europe, transmission networks have a broader remit than those in Australia, allowing them to act as:

> the operator of capacity trading allocation platforms (such as auction platforms for interconnection capacity between regions); and

> a market participant (such as providing storage capacity).

This creates an alternative investment approach to interconnectors, which can be deployed either as a regulated or merchant solution. In Europe, interconnectors derive their revenues from congestion charges, which depend on the existence of arbitrage opportunities between markets at either end of the interconnector. The interconnection capacity is made available to market participants through an auctions-based system, which can be operated by the transmission service provider.[32]

A broader definition of the role of the transmission network has the benefit of creating competition for key system services that will grow in importance as the amount of renewable energy and DER on the network increases.

2.4.3 The Regulatory Investment Test for Transmission

The RIT-T should be amended to consider the benefits aligned with all objectives of the energy transformation.

The benefits of greater network interconnection include lower energy prices for consumers, greater energy security, access to high quality renewable energy resources, emissions reduction benefits, and broader economic benefits. These benefits are currently not well captured in the RIT-T.

As the electricity system is currently undergoing significant change, it is increasingly important for the regulatory framework for network investments to recognise all available benefits from interconnection and promote and facilitate an orderly transition.

Table 3: Quantities and cost of NSCAS over the past three years[33]

Facility	Benefitting Region	NSCAS Service	Quantity	Cost 2013-14 ($)[34]	Cost 2014-15 ($)	Cost 2015-16 ($)
Combined Murray and Yass substations	NSW	VCAS	800 Mvar	3,195,621	9,896,698	10,055,572
Combined Murray and Tumut power stations	NSW	VCAS	700 Mvar	41,301,706	134,494	171,797
Total				**44,497,327**	**10,031,191**	**10,227,368**

Note: The VCAS at Murray and Yass substations is based on a fixed quantity and cost per month. The VCAS from Murray and Tumut Power Stations is based on an enabling charge per generating unit that is payable when the service is enabled.

29.Cambridge Economic Policy Associates, Future Regulatory Options for Electricity Networks.
30. Cambridge Economic Policy Associates, Future Regulatory Options for Electricity Networks.
31. ENA & Accenture, Network Business Model Evolution, January 2015.
32. https://www.ofgem.gov.uk/electricity/transmission-networks/electricity-interconnectors
33. AEMO, Non-market Ancillary Services Cost and Quantity Report 2015-16, September 2016.
34. TransGrid's services were only active for part of 2013-14.

2.4.4 An increase in regional markets and control

The advent of DER is likely to require a move away from a single centralised market with few generation participants to multiple regional markets with many participants. This form of market across the NEM will be too complex to be managed by a single, centralised approach to generation dispatch. The emerging complexity will require greater regional operational control to ensure that all markets in aggregate are operated to within the technical limits of the network.

The Electric Power Research Institute (EPRI) recently outlined the basics for an integrated grid which is characterised by a complementary mix of centralised and distributed resources including generation, energy storage, power flow and stability control devices, and control systems including sensing devices and load management capabilities.[35]

This integrated grid consists of resources owned and controlled by a number of parties including utilities, merchant distributed generators, merchant energy storage, demand aggregators, energy services firms and customers. To provide safe and reliable operation, such a system requires an integrated and coordinated operational paradigm that clearly delineates roles and responsibilities between participants.

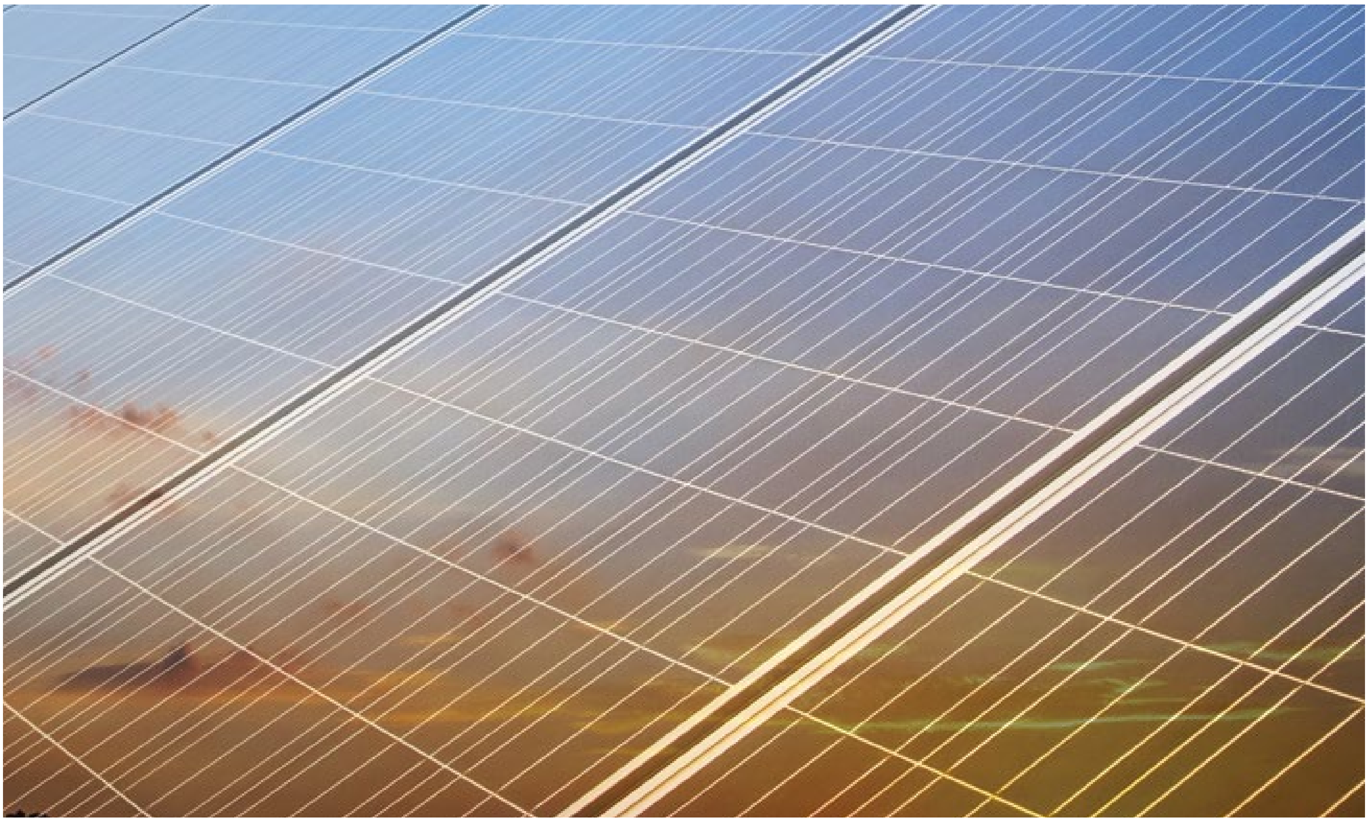
The role and responsibility of the transmission network will remain to provide access to the network and deliver reliable transmission services. The new challenge for the transmission network will arise from the need to securely integrate both large-scale renewable energy and increasing dynamic net load as the penetration of flexible DER increases and alters the transmission and distribution interface.

The need for energy transaction coordination across the transmission and distribution interface will increase with the growth of DER and related excess energy to transact. At a minimum, the physical aspects (not the financial aspects) of these transactions will need to be coordinated between transmission and distribution networks to meet their joint reliability objectives.

This will necessitate an expanded role for the transmission network in providing regional operational control. This can be considered as a 'tiered' approach, in which transmission and distribution networks take operational responsibility in their respective regions and closely coordinate operational decision making across the transmission and distribution interface.

In planning connectivity of supply and demand, interconnection assets would be between nodes, not states, and the appropriate investments for interregional power transmission would be driven by market forces as well as the need for system security.

The inherent complexity of the future power system, largely reliant on renewable generation and with increasing amounts of customer-sited DER, will simply make it too big a system for a single entity to manage. Ultimately, TransGrid sees a future with multi-layered resource orchestration and optimisation across the network, where logical electrical nodes are recognised rather than state borders and network boundaries, and transmission networks ensure system security.



35. The Electric Power Research Institute, The Integrated Grid: Realizing the Full Value of Central and Distributed Energy Resources, 2014

3 Responses to questions

3.1 Technology is transforming the electricity sector

Question	Response
1.1. How do we anticipate the impacts, influences and limitations of new technologies on system operations, and address these ahead of time?	The choices that customers make will drive the transformation in the energy system, which makes it more challenging to determine a single approach. This puts a strong emphasis on implementing a clear framework that is flexible enough to facilitate this transition. In the short term it will be important to adopt a flexible approach, including: > Trials of emerging technologies to ensure that they can perform in line with the requirements of the power system. For TransGrid, this involves technologies to enhance the stability of the network in the context of reducing system inertia. > An innovation mechanism, with the aim to provide a financial catalyst for innovation by networks as the system transitions towards one substantially based on renewable energy. **Please refer to Sections 2.2 and 2.3 for further details.**
1.2. How can innovation in electricity generation, distribution and consumption improve services and reduce costs?	If provided with appropriate governance and incentive mechanisms, the power system can be enhanced to meet the challenges raised by the gradual withdrawal of synchronous generators and facilitate increasing amounts of renewable energy, while maintaining a reliable, secure, and cost-effective electricity supply. TransGrid sees the following solutions as particularly important in meeting these challenges: 1. Deployment of technologies to enhance of network utilisation, system stability and performance while integrating increasing amounts of renewable energy. 2. Additional interconnection to access the abundantly available renewable resources across Australia and to use their diversity as an advantage to smooth out the impacts of intermittency of renewable generation. **Please refer to Sections 2.2 and 2.3 for further details.**

3.2 Consumers are driving change

Question	Response
2.1. How do we ensure that consumers retain choice and control through the transition?	TransGrid's vision for the Australian power system revolves around ensuring consumer choice and control, where an increasingly interconnected network allows market participants to share resources and services. A blueprint to transition to this energy system will need to address four key elements: 1. A pathway towards generation with a low levelised cost of energy (LCOE) that meets emissions targets. 2. Investment in transmission networks to integrate large-scale renewable energy and ensure power system stability. 3. A mechanism to provide ancillary services at the lowest possible cost. 4. Market design appropriate to the future energy mix, that promotes genuine competition and protects consumers where there is imperfect competition.

Question	Response
2.3. How do we ensure the needs of large-scale industrial consumers are met?	Energy security and affordability are imperative for large-scale industrial consumers. Normally, the only electricity supply to industrial consumers is provided by the network and a loss of supply may require significant effort and cost to remediate plant and resume production after an uncontrolled shutdown. In some cases, remediation may not be economic, leading to potential closure. The provision of on-site backup generation is often infeasible due to scale. For these businesses, certainty of energy security is critical to their viability and it is imperative that a transition to different forms of generation is done in a way that does not compromise energy security. In particular, it is important that ancillary services that are critical to the stability of the power system are managed in a planned way. Other ancillary services such as system restart ancillary services (SRAS) should be implemented to a standard that ensures that large-scale industrial consumers would not be adversely affected, even in a high impact, low probability event. Similarly, affordability of energy supply is essential to the competitiveness of Australian industry in an increasingly global economy. The reforms TransGrid has proposed for a successful transition will ensure that the needs of large-scale industrial consumers are met.

3.3 The transition to a low emissions economy is underway

Question	Response
3.1. What role should the electricity sector play in meeting Australia's greenhouse gas reduction targets?	The electricity sector has the potential to contribute proportionally more than other sectors to meeting Australia's greenhouse gas reduction targets. With networks as the platform of the electricity system, generation based on low emissions fuel sources can be readily integrated. The integration of increasing amounts of low emissions generation to facilitate emissions reductions will depend on two underpinning enablers: 1. Additional interconnection to access the abundantly available renewable resources across Australia and to use their diversity as an advantage to smooth out the impacts of intermittency of renewable generation. 2. Deployment of technologies to enhance network utilisation, system stability and performance as required to integrate increasing amounts of renewable energy. **Please refer to Sections 2.1, 2.2 and 2.3 for further details.**
3.2. What is the role for natural gas in reducing greenhouse gas emissions in the electricity sector?	Gas turbines can assist with the integration of renewable, low-emissions generation by smoothing intermittency and providing synchronous inertia to manage the stability of the power system. This and other alternative solutions for providing these services should be considered against the objectives of energy security, affordability and reduced emissions.
3.4. What are the key elements of an emissions reduction policy to support investor confidence and a transition to a low emissions system?	An emissions reduction policy must provide stability and clear direction to provide investors with the confidence to make long-term investment decisions. A stable regulatory framework that supports the emissions reduction policy will also be essential to provide investors with confidence.

3.4 Integration of variable renewable electricity

Question	Response
4.1. What immediate actions could be taken to reduce the emerging risks around grid security and reliability with respect to frequency control, reduced system strength, or distributed energy resources?	Immediate operational measures could be adopted to reduce emerging risks relating grid security. For example, the operation of the power system in South Australia has already changed to incorporate additional constraints relating to grid security following the system black in 2016. TransGrid's studies show that until 2030, the synchronous generation projected to remain will provide sufficient inertia for the power system as a whole, if shared between regions though stronger interregional connections. New technologies, such as large-scale battery storage that provides fast frequency response, should be incorporated into networks early so their application in practice can be understood and validated in system stability models. Actions to develop stronger interregional connections and integrate new stability technologies could be commenced without delay. **Please refer to Section 2.3 for further details.**
4.2. Should the level of variable renewable electricity generation be curtailed in each region until new measures to ensure grid security are implemented?	TransGrid does not consider there is a need to curtail the level of intermittent renewable generation as technologies, solutions and operational measures are currently available to manage the integration of renewables. **Please refer to Section 2.3 for further details.**
4.3. Is there a need to introduce new planning and technical frameworks to complement current market operations?	As the energy system evolves, the frameworks that govern energy markets and regulation will also need to evolve to support the objectives of energy security and reliability, affordability and reduced emissions in the context of evolving technologies. TransGrid proposes several changes to the frameworks that govern energy markets and regulation to better support a transition to the energy system of the future: > Planning of ancillary services that are essential for the stability of the power system should remain with transmission networks. > Transmission networks should be allowed to participate in provision of a broader range of services, including ancillary services that are essential to the stability of the power system, and receive appropriate returns. > The Regulatory Investment Test for Transmission (RIT-T) should be amended to consider the benefits aligned with all objectives of the energy transformation, including contributions to reductions in emissions. > The advent of DER is likely to require a move away from a single centralised market with few generation participants to multiple regional markets with many participants. This form of market across the NEM will be too complex to be managed by a single, centralised approach to generation dispatch. The emerging complexity will require greater regional operational control to ensure that all markets in aggregate are operated to within the technical limits of the network. **Please refer to Section 2.4 for further details.**
4.3.2. Should all generators be required to provide system security services or should such services continue to be procured separately by the power system operator?	TransGrid believes that the most effective and efficient mechanism for provision of system security services is their provision or procurement by transmission networks. The planning of these services should remain with transmission networks because their quantity and location is important. Ongoing provision of these services should be at the lowest cost and a range of options, including a competitive contract-based arrangement that delivers the most efficient outcome between non-regulated and regulated options, may be appropriate. The current arrangement for procurement of Network Support and Control Ancillary Services (NSCAS) reflects this approach. **Please refer to Section 2.4 for further details.**

Question	Response
4.4. What role can new technologies located on consumers' premises have in improving energy security and reliability outcomes?	There is potential for customer-sited distributed energy resources (DER), such as small battery storage technologies, to participate in energy markets and provide ancillary services. In order to make this possible: > The DER would need to be made available for the transmission network to use for ancillary services. > A method of payment to DER owners may need to be established. > Telecommunications infrastructure, common communication standards and aggregation platforms would need to be developed. With these enablers, DER could complement large-scale storage technologies and other mechanisms for provision of ancillary services.
4.4.1. How can the regulatory framework best enable and incentivise the efficient orchestration of distributed energy resources?	The advent of DER is likely to require a move away from a single centralised market with few generation participants to multiple regional markets with many participants. This form of market across the NEM will be too complex to be managed by a single, centralised approach to generation dispatch. The emerging complexity will require greater regional operational control to ensure that all markets in aggregate are operated to within the technical limits of the network. **Please refer to Section 2.4.4 for further details.**
4.5. How could high speed communications and sensor technology be deployed to better detect and mitigate grid problems?	TransGrid recognises the need to have a dispersed, wide bandwidth communication network connecting all participants of the NEM to facilitate the energy transition. Extensive transmission networks, which enable the electricity supply chain, efficiently provide this functionality as one of their services. TransGrid is in the process of enhancing its operational communication system, with the vision that the 'Smart Network' of the future will be one of real-time monitoring with integrated sets of interoperable sensors, monitoring devices and management systems supported by a high capacity fast and reliable telecommunications network. This vision will enable use of demand monitoring and control for supporting the operating functions such as managing the intermittency of the connected renewable generating sources and enhancing supply reliability and resilience of the power system under contingencies, including potential high impact low probability events.
4.6. Should the rules for AEMO to elevate a situation from non-credible to credible be revised?	TransGrid supports revision of the rules associated with operation of the power system under non-credible events, considering: > Impact of the introduction of new technologies on system security during non-credible events. > Availability of new technologies for managing the events. > The cost of implementing the potential solutions and economic benefits of avoiding system wide disruptions due to non-credible events.

3.5 Market design to support security and reliability

Question	Response
5.1. Are the reliability settings in the NEM adequate?	TransGrid does not consider the existing reliability settings in the NEM to be adequate. The settings should be revised to include standards for all services required to manage the stability of the power system, and be sufficiently flexible to take into account new services that may be provided by emerging technologies, such as fast frequency response.
5.6. What additional system security services such as inertia, as is currently being considered by the AEMC, should be procured through a market mechanism?	TransGrid supports the considered identification of services that are used to ensure system security and efficient provision of the services where there is a need. Market-based approaches to sourcing ancillary services have experienced limitations in the past, highlighting that a market-based mechanism does not always deliver the desired outcome, in particular where these is inadequate competition and liquidity. An alternative approach would be to allow TNSPs to deploy technologies such as large-scale storage and provide or compete for the provision of ancillary services that are critical to the stability of the power system. **Please refer to Section 2.4 for further details.**
5.6.1. How can system security services be used as 'bankable' revenue over a sufficient period of time to allow project finance to be forthcoming?	The inherent risks to the electricity system in the transition towards a system substantially based on renewables are too great to rely on the market alone to provide a response to ensure system security is maintained. A stable regulatory framework that ensures system security is maintained is also essential. Against this backdrop, regulation of some services should be considered where it provides the greatest benefit to consumers, and the ability of regulated entities to provide cost-effective solutions for other services in competition with market participants should be considered. **Please refer to Section 2.4 for further details.**

3.6 Prices have risen substantially

Question	Response
6.2. What are the alternatives to building network infrastructure to service peak demand?	A number of options exist to building network infrastructure, including: > Demand response – load control used to curtail demand on sections of the network during times of high demand or during network contingencies causing a significant generation-load unbalance. > Large-scale storage – storage installed at key locations on the network to reduce demand during peak times. > Residential storage – storage installed at residential premises, which could be aggregated and operated to reduce network demand during peak times.

3.7 Energy market governance is critical

Question	Response
7.5.2. Should the NEO be amended?	The National Electricity Objective (NEO) should be amended to include emissions reduction outcomes to align with national targets. This can then flow through to rule making and coordinate efforts to reduce emissions in the electricity sector. In particular, this change would allow the RIT-T to be amended to consider the benefits aligned with all objectives of the energy transformation, including emissions reduction objectives. **Please refer to Section 2.4.3 for further details.**