South Australian Energy Transformation

RIT-T: Market Modelling Approach and Assumptions Report

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Executive Summary

On 7 November 2016, ElectraNet commenced application of the South Australian Energy Transformation (SAET) Regulatory Investment Test for Transmission (RIT-T) process. The investment options being considered as part of the RIT-T include additional interconnection between South Australia and other jurisdictions in the National Electricity Market (the NEM), as well as non-network alternatives.

ElectraNet has identified three main drivers of the SAET RIT-T, namely:

1. Facilitating greater competition between generators in different regions, leading to lower dispatch costs and consequently lower wholesale prices, particularly in South Australia.
2. Providing appropriate security of electricity supply, including management of inertia, frequency of response and system strength.
3. Facilitating the transition to lower carbon emissions and the adoption of new technologies.

These three drivers form the basis for the benefits to be estimated in the assessment of options in the RIT-T process.

The SAET RIT-T occurs at a time of great uncertainty with regard to the future development of the NEM. The transition towards lower carbon emissions, rapidly evolving technologies and changing customer needs mean that policy decisions and technological innovation have an increased role in driving market outcomes in the long term. The result of the increased influence of these inherently less predictable factors is that a wide range of future market outcomes are possible over the lifetime of the proposed investments.

The purpose of this Market Modelling Approach and Assumptions Report is to set out how ElectraNet intends to address the inherent uncertainty in relation to future market development as part of the RIT-T quantitative modelling, and to provide stakeholders with an opportunity to comment on this and other elements of the proposed approach.

ElectraNet is seeking specific feedback on the proposed approach and key assumptions for quantification of the benefits of options in this RIT-T, including:

- In general, how well do you think this Market Modelling Approach and Assumptions Report explains the way that ElectraNet will begin assessing the options outlined in the South Australian Energy Transformation Project Specification Consultation Report and those put forward during consultation processes?
- What do you think of ElectraNet's proposed phased approach to assessing options? To what extent do you think this approach is appropriate for this situation?
- To what extent do you agree with ElectraNet's assessment of the key variables expected to drive net benefits? Are there other factors that you think should be taken into account?
- What do you think about ElectraNet's proposed tools and approaches for estimating market benefits? Are there any other considerations that you think should be included?
- To what extent do you agree with the key components identified in ElectraNet's wholesale market modelling approach? Are there other factors you think need to be addressed?
- Would you like to provide any other feedback about the Market Modelling Approach and Assumptions Report?

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1. Introduction

Australian energy markets are experiencing a time of significant change, driven by the transition to lower carbon emissions, rapidly evolving technologies and changing customer needs.

South Australia is at the forefront of this change with world leading levels of renewable energy penetration through large scale wind generation developments and rooftop solar photovoltaic (PV) installation. Around 45 per cent of South Australia's power generation now comes from renewable energy sources.

Successfully integrating this changing supply mix, while maintaining affordability, reliability and security of supply for customers is a key priority, and recent events in South Australia have heightened concerns about power system security.

Additional interconnection between National Electricity Market (NEM) regions can result in greater competition between generation sources, thereby delivering lower overall energy prices for customers, in addition to facilitating an increase in renewable generation and addressing security of supply concerns associated with energy market transition.

Non-network options can also provide benefits to the market to help with energy market transition. These options could include demand response, generation options, battery storage and other solutions.

On 7 November 2016, ElectraNet commenced application of the South Australian Energy Transformation (SAET) Regulatory Investment Test for Transmission (RIT-T) process.[1] The investment options being considered as part of the RIT-T include additional interconnection between South Australia and other jurisdictions in the National Electricity Market (the NEM), as well as non-network alternatives.

ElectraNet has identified three main drivers of the SAET RIT-T, namely:

1. Facilitating greater competition between generators in different regions, leading to lower dispatch costs and consequently lower wholesale prices, particularly in South Australia.
2. Providing appropriate security of electricity supply, including management of inertia, frequency of response and system strength.
3. Facilitating the transition to lower carbon emissions and the adoption of new technologies.

These three drivers form the basis for the benefits to be estimated in the assessment of options in the RIT-T process.

The Australian Energy Market Operator's (AEMO) National Transmission Network Development Plan (NTNDP) published on 12 December 2016 finds that a more integrated NEM is likely to deliver positive net benefits to customers.

AEMO recommends that potential developments like the ones being considered by ElectraNet be thoroughly assessed through a RIT-T process.

[1] South Australian Energy Transformation, RIT-T: Projection Specification Consultation Report, 7 November 2016.

1.1 Purpose of this additional consultation step

The SAET RIT-T occurs at a time of great uncertainty with regard to the future development of the NEM. The transition towards lower carbon emissions, rapidly evolving technologies and changing customer needs mean that policy decisions and technological innovation have an increased role in driving market outcomes in the long term. The result of the increased influence of these inherently less predictable factors is that a wide range of future market outcomes are possible over the lifetime of the proposed investments.

That is why ElectraNet is engaging in this further consultation step to set out how it intends to address the inherent uncertainty in relation to future market development as part of the RIT-T quantitative modelling, and to provide stakeholders with an opportunity to comment on this and other elements of the proposed approach.

The objective of this consultation paper is to set out, in broad terms, the overall modelling framework that ElectraNet proposes to adopt in undertaking the RIT-T assessment. In particular, this consultation paper has three principle functions:

- Describing and seeking feedback on the proposed overall modelling framework.
- Describing and seeking feedback on the key factors and assumptions that are likely to shape the range of possible future market scenarios and outcomes.
- Describing and seeking feedback on the proposed approaches for modelling specific benefit categories.

The AER's RIT-T Guidelines allow some discretion for proponents to choose the appropriate approaches to estimating the benefits associated with proposed investment options. ElectraNet's proposed approach is set out in this report, which is not prescribed as part of the RIT-T process.

ElectraNet has chosen to undertake this additional consultation to provide stakeholders with a further opportunity to comment on the approach to be undertaken in conducting the RIT-T assessment.

The responses to this consultation, together with the responses to the earlier Project Specification Consultation Report (PSCR), will inform the approach adopted by ElectraNet in assessing the net benefits associated with the different investment options under the RIT-T. The draft results of this assessment will be presented in the Project Assessment Draft Report (PADR), which ElectraNet expects to publish by June 2017.

1.2 Structure of this consultation paper

The remainder of this document is structured as follows:

- Section 2 provides an overview of the proposed modelling approach, and in particular how key uncertainties are intended to be taken into account.
- Section 3 discusses the key variables that are expected to influence market benefits and how they will be assessed.
- Section 4 sets out the proposed methods for assessing the market benefits associated with the RIT-T benefit categories, highlighting where these approaches may differ from previous RIT-T applications.

- Section 5 outlines ElectraNet's proposed approach to wholesale market modelling and highlights the most relevant assumptions for this RIT-T.

1.3 Feedback and next steps

ElectraNet welcomes written feedback on this Market Modelling Approach and Assumptions Report.

Feedback is due on or before Monday, 6 February 2016. This is the same date as submissions to the Project Consultation Specification Report are due.

Feedback should be emailed to consultation@electranet.com.au.

2. Overall modelling approach proposed for this RIT-T assessment

Consultation question: What do you think of ElectraNet's proposed phased approach to assessing options? To what extent do you think this approach is appropriate for this situation?

The SAET RIT-T is being conducted in the context of a significant amount of uncertainty regarding the future development of the NEM. This uncertainty means that the potential range of costs and benefits of the options under consideration is expected to be large, and to differ depending on the future NEM development path assumed.

One consequence of this is that understanding the likelihood and key drivers of possible outcomes will help to 'future-proof' the choice of option and increase the likelihood that the option chosen delivers maximum benefits in the long term.

The approach ElectraNet intends to adopt focuses on the key assessment criteria under the RIT-T, being the net benefit to all those who consume, produce and transport electricity in the NEM, and considers how these net benefits are likely to change under different future states of the world.

When deciding on the preferred option, uncertainties only matter to the extent that they may affect:

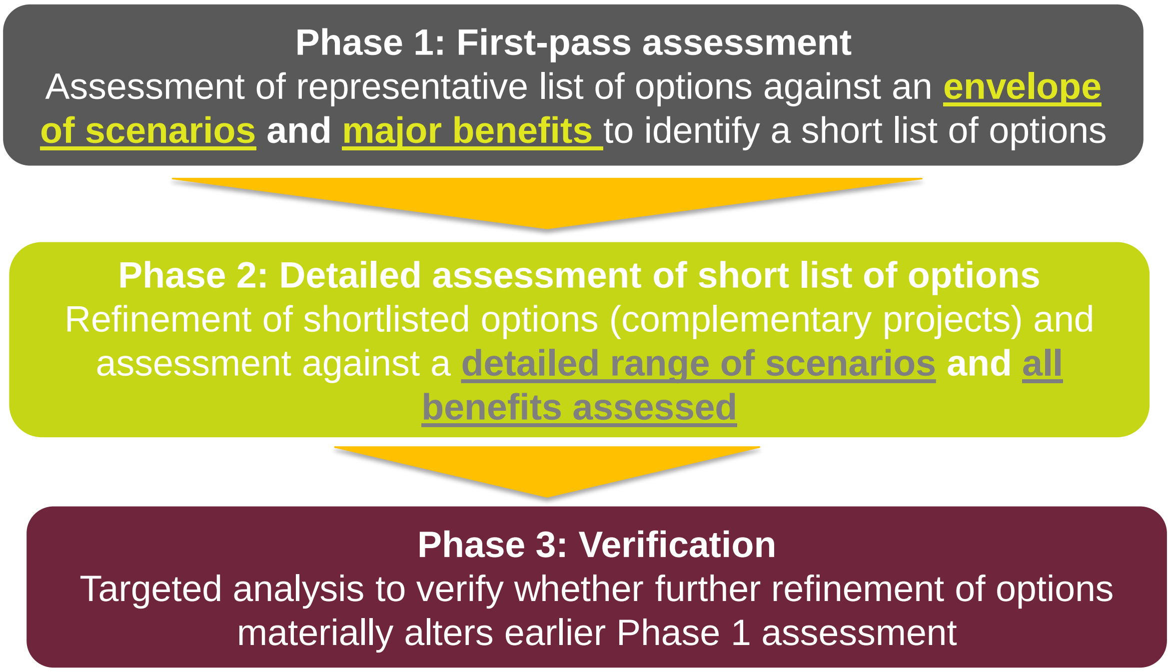
- The choice of the investment (i.e. which option is ranked first under the RIT-T).
- Whether the preferred investment is better than the 'do nothing' option (i.e. whether the overall net market benefit of the preferred option is positive).

ElectraNet intends to approach to the RIT-T assessment as three distinct phases to ensure the modelling approach is manageable and fit for purpose:

- Phase 1: First-pass screening of costs and benefits to prioritise credible options and, if appropriate, eliminate clearly lower ranked options.
- Phase 2: More detailed analysis of the benefits of prioritised shortlisted options, based on a more detailed engineering assessment of the options, and developing a more thorough understanding of the drivers and risks to the assessed market benefits.
- Phase 3: Verification of outcomes to ensure that the decision to screen out lower ranked options in Phase 1 remains robust.

These phases are outlined in in Figure 1 and discussed in turn below:

Figure 1: Proposed three-phase analysis



2.1 Phase 1: First-pass screening

The first phase of the proposed approach involves assessing options against a defined set of future scenarios, with the aim of identifying a prioritised short list of options on which to conduct more detailed assessment.

ElectraNet proposes to model high, central and low scenarios that cover a broad envelope of realistic potential market outcomes. Representative options will be included in this assessment, specified to a simplified approximate level of detail in the first pass. Through covering this broad envelope of future outcomes, the analysis will enable the estimation of a realistic range of net benefits associated with each option.

The level of technical detail of each option will be limited at this phase to the thermal capability of the interconnectors, which can be readily modelled. The large majority of the cost of each interconnector option is related to its thermal capability. Likewise, the majority of the benefits will be derived from the thermal capability of the option.

While further examination may reveal technical limits in addition to the thermal capability of the interconnector, solutions to these problems tend to be much less costly than the costs of creating additional thermal capability.

The 2016 NTNDP has identified major economic or reliability dispatch limitations across the NEM, which will also be represented in the first pass.

Such an approach allows for the early identification of:

- Options that clearly do not provide net market benefit, even under a generally optimistic range of assumptions.

- The relative ranking of options and whether these rankings are likely to change based on changes to key parameters.

ElectraNet proposes to use this first-pass screening to identify a prioritised short list of options. Options that are clearly inferior in all three scenarios or have a negative net benefit in all three scenarios will be screened out from further assessment (unless further analysis of other options in Phase 2 suggests that reconsidering these options might be prudent).

The purpose of this initial screening is to focus the Phase 2 assessment on a smaller set of short-listed options, to facilitate a more detailed technical specification of these options, as well as a more comprehensive assessment of the option benefits and risks. ElectraNet considers that this is a 'fit for purpose' approach, with detailed modelling to be undertaken in relation to those options that emerge as short-listed contenders, whilst ensuring that the overall amount of analysis to be undertaken is manageable.

2.1.1 First-pass screening scenarios

The scenarios used in the first-pass screening will need to reflect a sufficiently broad range of potential outcomes across the key uncertainties that may be expected to affect future market benefits.

The RIT-T Guidelines state that the scenarios must reflect variables or parameters that: "are likely to affect the ranking of the credible options, or the sign of the net economic benefits of any credible option".

ElectraNet anticipates that the scenarios in Phase 1 will consist of:

- A **high scenario** intended to represent the upper end of the potential range of realistic net benefits from an option.
- A **central scenario** which reflects the best estimate of the evolution of the market going forward aligned with AEMO's 2016 NTNDP neutral scenario.
- A **low scenario** intended to represent the lower end of the potential range of realistic net benefits from an option.

To specify these scenarios ElectraNet proposes to make preliminary judgements on the key uncertainties that are likely to affect net benefits, and to then verify the accuracy of these judgements through an iterative process.

The dominant variables that ElectraNet expects will influence the net market benefits are summarised in Table 1 below. These variables do not reflect all of the future uncertainties that may affect future market benefits of the options being considered, but are expected to provide a broad enough 'envelope' for the purposes of the first phase of the analysis. A broader range of uncertainties will be considered as part of the Phase 2 assessment.

Table 1 also provides a brief description of the proposed sources of the assumptions and/or the proposed values for each of the key variables under each scenario. ElectraNet intends to draw on the 2016 NTNDP scenarios developed by AEMO (i.e. the 'neutral scenario' and 'low scenario'), where possible. However, in order to provide a broad enough range of assumptions for the purposes of this screening phase, some divergence from these scenarios is expected to be required.

Table 1: Overview of scenarios

Key variable	High scenario	Central scenario	Low scenario
Gas prices	AEM0 2016 National Gas Forecasting Report (NGFR)[2] Strong	AEMO 2016 NGFR Neutral	AEMO 2016 NGFR Weak
Electricity demand (including impact from Distributed Energy Resources)	AEMO National Electricity Forecasting Report[3] Strong plus potential South Australian spot load development	AEMO NEFR Neutral	AEMO NEFR Weak
Carbon emissions policies	Renewable Energy Target 45 per cent reduction in emissions from 2005 levels by 2030 100 per cent reduction in NEM emissions by 2050.	Renewable Energy Target 28 per cent abatement from 2005 NEM emissions by 2030 and then constant	Renewable Energy Target
Cost of new entrant generators	AEMO 2016 NTNDP Medium adjusted to be 15% higher in 2030.	AEMO 2016 NTNDP Neutral	AEMO 2016 NTNDP Neutral adjusted to be 15% lower in 2030
Value of Customer Reliability (VCR)	High VCR estimate for major system disruption	Moderate VCR estimate for major system disruption	Low VCR estimate for major supply disruption
Length of supply disruption from a non-credible contingency	High ~ 18 hours	Medium ~ 9 hours	Low ~ 3 hours
SA security obligations	1Hz/s RoCoF	3Hz/s RoCoF	3Hz/s RoCoF

The scenarios developed as part of the first-pass screening are expected to reflect a realistic range of potential market outcomes. Emphasis will be placed on the range of potential market outcomes rather than seeking to define the policy, technical and economic conditions that would lead to each scenario. ElectraNet considers this approach appropriate, given the ‘screening’ nature of this assessment.

Each of the key uncertainties set out in Table 3, and their link with the expected market benefits from options considered under this RIT-T, are discussed in Section 3.

2 AEMO National Gas Forecasting Report, December 2016.

3 AEMO National Electricity Forecasting Report, June 2016

2.2 Phase 2: Detailed assessment of short listed options

In Phase 2, a more complex and time-intensive analysis will be conducted on the short listed options that would not be practical for the full list of potential options under consideration.

This additional analysis is expected to principally comprise three components, namely:

- **Technical specification and assessment of complementary projects** – further refinement of the technical aspects of each of the options, including exploration of the impact on the costs and benefits of the interconnector options when complementary network augmentation projects are included.
- **Risk and uncertainty assessment** – expansion of the set of scenarios investigated through the exploration of different values of variables with the purpose of understanding the drivers which would give rise to substantively different positive or negative net benefits.
- **Estimation of any option value** – assessment of option value through considering the staging of option development, if required.

These are discussed in turn below.

2.2.1 Technical specification and assessment of complementary projects

The exact technical specification of each of the options is a significant task involving detailed engineering work to inform the specific network constraints that should then be reflected in the wholesale market modelling, to ensure that the first-pass estimate of market benefits is correct.

Having narrowed the set of options down to a short list through Phase 1, this additional technical specification work can be focused on the options that are more likely to maximise market benefits under the RIT-T analysis.

In addition, for the interconnector options in particular, the benefits derived from the options may be further enhanced by complementary network augmentation projects (that would also add to the overall project cost). Such projects are typically aimed at better integrating the new interconnector into the existing system, and ensuring that benefits associated with the expanded capacity flow through to other parts of the network. Examples of such projects could include:

- Additional network augmentation to relieve upstream or downstream congestion that will prevent the additional investments being fully utilised (or downsizing the investment if these constraints are too expensive to relieve).
- Making additional investments in plant such as Static Var Compensators (SVCs), or series compensation to ensure better utilisation of the investment.
- Co-ordination of load shedding or storage schemes to improve utilisation and ensure grid stability for non-credible contingencies.

For those options that are shortlisted in Phase 1, further work will be conducted to specify and cost these potential complementary projects. Additional simulations of market outcomes will then be run to estimate the additional net benefits associated with these projects.

2.2.2 Risk and uncertainty assessment

Owing to increased uncertainty in relation to future market outcomes, ElectraNet considers that additional effort is warranted to better understand the potential differences in benefits that may occur under a large range of potential scenarios, including scenarios which may have a low probability of occurring, but which could materially change the RIT-T assessment.

The purpose of this assessment is to understand whether there are any outlying cases or dynamics that cannot be observed through the more simplified scenario analysis conducted in Phase 1, and to ascertain whether these additional insights have the potential to materially influence the rankings of options.

In particular, this type of analysis assesses the likelihood of regretting the choice of option; i.e. choosing an option that turns out with hindsight not to be the optimal choice given how the market actually develops.

Provisionally, ElectraNet proposes to analyse the following additional scenarios as part of Phase 2:

- State-based emissions policies, such as the Victorian Renewable Energy Target and 50% renewables targets in Queensland and South Australia.
- The development of renewable generation hubs in other jurisdictions (e.g. in Victoria).
- Distributed generation uptake scenarios that are substantially higher than those incorporated in the NTNDP.
- Additional spot-load development in South Australia.
- Generation developments in critical locations.
- Additional network augmentation in other NEM regions.
- Major and rapid generator retirements.
- Major load retirements.
- Possible gas supply shortages and resulting prices.
- Internet of Things (IoT) and tariff reform that may alter the load shape reducing the differences between maximum, average and minimum demand.
- Increasing incidence of extreme weather events

In addition, ElectraNet may assess the competition benefits associated with the short-listed options, depending on whether this is expected to have a material effect on the rank or sign of the net benefits of the options. Competition benefits are discussed further in section 3.3.

2.2.3 Option value

Option value is the additional benefit associated with the ability to defer decisions on part of an investment until a future time at which current uncertainties may be resolved.

There are a number of prerequisites for option value to exist:

- A project or projects must have ‘stages’, whereby multiple investment decisions can be made over time.
- New information with respect to drivers of costs and benefits must become available between the stages of the project.
- The new information must materially influence the ranking of different project options.

Therefore, option value analysis is not useful in a circumstance where there is little scope to change the nature of a project over time or where no new information that is relevant to the choice of project will become available over time. Importantly, new information that becomes available will not necessarily lead to a substantially more informed decision.

An assessment of option value is a computationally intensive task and therefore an analysis of option value will only be undertaken in circumstances where the result of the option value analysis is likely to have a material impact on the relative ranking of options or the sign of the net benefits.

2.3 Phase 3: Verification

In conducting the additional analysis in Phase 2, it is likely that modification will be required to elements of the modelling and/or key assumptions.

To ensure that these modifications would not alter the conclusions of the assessment in Phase 1, ElectraNet intends to conduct a verification process as the third and final step of the overall approach.

The verification process will involve the following:

- Assessment of any material additional benefits identified in Phase 2.
- Assessment of the extent to which these additional benefits could also apply in the options that were discarded as a result of the Phase 1 assessment.
- Verify that the additional benefits would not have changed the relative assessment of the options in Phase 1.

3. Key drivers of net benefits

This section describes each of the key variables that are expected to drive net benefits and how they will be incorporated into the modelling conducted under Phase 1 and 2 as outlined in section 2.

Consultation question: To what extent do you agree with ElectraNet’s assessment of the key variables expected to drive net benefits? Are there other factors that you think should be taken into account?

3.1 Gas prices

Given the recent retirement of coal fired power plants, South Australia is reliant on gas-fired generators for its firm electricity supply. Consequently, dispatch costs and wholesale prices in South Australia are heavily influenced by the price of gas. In relation to the market benefits for this RIT-T, gas prices will primarily affect fuel costs, changes in costs to other parties (through changes in generator capital investment) and, potentially, voluntary load shedding.

Interconnection or non-network options will tend to be more valuable when gas prices are relatively high and less valuable when gas prices are relatively low. In the case of interconnectors, this is because an interconnector will facilitate the import of cheaper generation from another state, which will displace higher cost gas-fired generation within South Australia.

In the case of non-network options, new technologies, such as batteries or demand side participation, may be able to reduce demand for gas-fired generation through smoothing or reducing demand for electricity during peak times.

In order to develop a reasonable future range of gas prices, a number of potential future uncertainties need to be taken into account, including:

- Future exports from LNG terminals in Queensland and international competitiveness.
- Future retirements of conventional generators and the increased (retirement of coal) or decreased (retirement of gas) usage of gas for generation associated with these retirements.
- Relaxing of restrictions on CSG gas development in New South Wales or Victoria.
- The availability of gas and the costs of development and transportation to support South Australia’s reliance on gas generation.

Against this background, ElectraNet proposes to model the following three gas price scenarios as part of the first phase:

- A **high gas price case**, as defined in AEMO’s 2016 NGFR Strong forecast.
- A **central gas price** case, as defined in AEMO’s 2016 NGFR Neutral forecast.
- A **low gas price case**, as defined by in AEMO’s 2016 NGFR Weak forecast.

ElectraNet proposes to use AEMO’s NGFR gas prices forecasts that were also used in AEMO’s 2016 NTNDP modelling, but recognises that assessment of a wider range of gas prices may be required in order to cover a broad range of future potential market outcomes. Where this is required, ElectraNet will draw on public sources as far as possible to underpin the gas price scenarios used.

3.2 SA security obligations

One of the expected benefits of either a new interconnector option or a non-network option is meeting system security obligations in SA at a lower cost.

The SA government recently implemented legislation that requires ElectraNet to ensure a maximum Rate of Change of Frequency (RoCoF) in the South Australian region of 3 Hz/s for coincident loss of both circuits of the Heywood Interconnector. ElectraNet has consequently provided limit advice to AEMO to assist in limiting flows on the Heywood Interconnector when necessary to achieve this standard. The effect of this constraint is to increase generation from conventional generators in South Australia during times when the constraint is binding, in order to increase system security in South Australia.

More recently, AEMO has introduced an operating condition requiring two sufficiently large synchronous generators to be online in South Australia at all times[4].

Currently, there are a number of processes underway that could ultimately lead to changes to the way that system security is managed. These processes include:

- AEMC System Security Market Frameworks review, which will include consideration of rule change proposals in relation to a potential ancillary services market for inertia and mechanisms for managing the rate of change of frequency and fault levels in South Australia.
- AEMO Future Power System Security Program.

These processes are also considering what the appropriate level of security is for the NEM. Historically, South Australia was rarely exposed to potential RoCoF outcomes – for the loss of Heywood leading to separation – of greater than 1 Hz/s. [5]

ElectraNet proposes to test uncertainty around future system security obligation in South Australia with an assumption of a 1 Hz/s RoCoF constraint in the high scenario and the current 3 Hz/s constraint in the medium and low scenario.

3.3 Value of Customer Reliability (VCR)

One of the key expected benefits associated with the options being considered under this RIT-T is a decrease in supply disruptions, as a result of improved system security.

The extent of supply disruption will depend on the assumed length of outage. ElectraNet intends to consider three alternative major disruption outage durations: short, moderate and long. In each case, the assumption will be that the entire SA load is disrupted, and will be progressively restored over the duration of the outage.

The magnitude of system security benefits will partly be a function of the value assumed for the Value of Customer Reliability (VCR). As flagged in the PSCR, there is general acceptance that the standard VCR estimates published by AEMO do not capture the full value to customers of avoiding widespread and prolonged disruptions to electricity supply.

ElectraNet proposes to adopt a range of VCR estimates appropriate for each scenario. At the low end, AEMO's current VCR estimates from the 2016 NTNDP will be used. ElectraNet will explore appropriate values to use in the moderate and high scenarios respectively. This is consistent with the approach suggested by AEMO.[6]

4 AEMO, *Secure Operation of South Australia*, 2016

5 AEMO, *NTNDP,* 2016

6 AEMO, National Transmission Development Plan, 2016

3.4 Emissions reduction policy

South Australia has abundant, high-quality renewable energy resources. Higher penetrations of renewables in South Australia, all other things being equal, will tend to increase the market benefits associated with an interconnector option, as it will allow for higher utilisation of these resources and the ability to defer (or avoid) investment in lower-quality renewable resources to meet given environmental policy targets. This benefit would be further increased where additional network augmentation (separate to that being considered in this RIT-T process) improved access to otherwise weakly connected or unconnected regions of Australia that also have abundant renewable generation potential.

The future of renewable energy and emissions policies in Australia remains uncertain. Australia currently has a renewable energy target of 33,000 GWh of renewable generation by 2020. This is expected to deliver around 23 per cent of Australia's grid connected energy from renewable sources.[7]

In addition, federal government policy is to reduce economy wide emissions by 26-28 per cent from 2005 levels by 2030.[8] It is expected that the stationary energy industry, and in particular the NEM, will be required to achieve a reduction that is equivalent to the national reduction target, therefore implying a 26-28% reduction in emissions from the NEM by 2030.

The Australian government has issued non-binding emissions reduction targets and ratified international agreements which suggest a requirement for further increased renewable generation. Australia has signed up to the "Paris Agreement" which requires a limit on global temperature rises to 2 degrees and the pursuit of a limit on global warming of 1.5 degrees.

Energy Networks Australia and CSIRO consider that it is plausible to achieve zero net emissions by 2050.[9] However, while the Paris Agreement requires countries to submit pledges to achieve emissions reduction targets, the ramifications for not meeting targets are minimal. Therefore, some doubt remains around the impact that the agreement will have on actual emissions outcomes.

To capture the uncertainty inherent in renewable energy and emissions policies over the lifetime of the investments being considered, ElectraNet proposes to assess three separate renewables policy cases as part of the first pass assessment, namely:

- RET only target – This is the lower bound for future renewables policy and represents no further action on renewables after the existing RET is met.
- A 28 per cent reduction by 2030 target – This case represents the current pledge by the Australian government for emission reduction, but with no further emissions reductions after this target is achieved. This assumption is in line with that adopted by AEMO for the 2016 NTNDP Neutral scenario.
- A 45 per cent reduction by 2030 target – This case represents substantial action towards emissions reduction with the electricity sector reaching 100 per cent reduction by 2050. This is similar to the reduction legislated by the UK in the Climate Change Act 2008 as well as in European jurisdictions, which have 80 per cent economy wide emissions reductions targets by 2050 from 1990 levels.

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7 Clean Energy Regulator, *Large-scale Renewable Energy Target*, accessed December 2016

8 Department of the Environment and Energy, *Australia's 2030 climate change target*, 2015

9 Energy Networks Australia, *Electricity Network Transformation Roadmap*, December 2016

The proposed approach focusses on emissions targets and does not pre-suppose the particular mechanism(s) that may be adopted to meet these targets (such as a carbon price or a continuation of the current Direct Action scheme), consistent with the approach taken by AEMO in the 2016 NTNDP.

ElectraNet proposes to analyse the potential effect of any state based Renewable Energy Targets, in particular the Victorian RET target, as part of the Phase 2 assessment of options.

3.5 Costs of new entrant generators

The costs of new entrant large scale generators will be a significant factor in the determining the value of future generation investments.

The prevailing trend in the costs of new entrant generation is the falling costs of renewable generation, in particular solar PV and battery storage. In the next 10 years, battery storage costs are expected to fall by 50 per cent and solar panel costs by around 30 per cent.[10] These cost reductions are expected to increase uptake of solar and storage technologies both on the grid in large scale forms and behind the meter at residential and commercial premises.

First pass screening in Phase 1 will use the new entrant generator costs assumed in AEMO's 2016 NTNDP Neutral modelling as the starting point. ElectraNet recognises that a broader range of new entrant costs may be required to create scenarios that capture the broad envelope of potential future market outcomes. However, at Phase 1 it is proposed to make the simplified assumption that the high scenario costs will be 15 per cent higher than the moderate scenario in 2030. Likewise the low scenario costs will be 15 per cent lower than the moderate scenario.

Additional scenarios where new entrant generator costs are significantly lower than expected and where uptake of distributed generation rapidly reaches a level of saturation will be assessed as part of Phase 2.

3.6 Electricity demand

Future electricity demand growth will tend to increase the benefits from an interconnector option, due to increased demand for transfer capacity across the interconnector. Levels of demand will ultimately affect the entire range of potential benefits from interconnection or non-network solutions, but in particular the benefits associated with reducing fuel costs and deferring capital investment.

Future grid demand for electricity in South Australia is somewhat decoupled from actual demand growth due to the growth in Distributed Energy Resources (DER). As such, grid demand is subject to a number of uncertainties which will be captured in the range of demand cases investigated in the modelling. These include:

- Uptake of rooftop solar PV behind the meter.
- Uptake of storage behind the meter, particularly at a residential level to complement the large amount of rooftop solar PV installed.
- The presence of new, large industrial loads in South Australia, such as new mining load.

10 AEMO, NTNDP Database, 2016

- Uptake of electric vehicles, which would bring both additional load as well as storage capacity.
- Reductions in demand due to high electricity prices, should high wholesale prices continue to occur in South Australia.

AEMO produces forecasts of future electricity demand annually in the NEFR. ElectraNet proposes to use the strong, neutral and weak scenarios for demand and energy forecasts from the 2016 NEFR. These forecasts implicitly include forecasts of the level of uptake of DER.

ElectraNet will also give consideration to whether there are specific spot loads in regions of South Australia that warrant assessment in the scenarios. Spot loads in specific areas of South Australia can potentially have disproportionately significant impacts on the benefits of interconnector options due to interactions with the existing network and potential localised congestion issues.

Potential spot loads include:

- A number of mining projects are under investigation on the Eyre Peninsula, this includes the 20 mtpa Central Eyre Iron Project and supporting infrastructure.[11]
- Mining development in the Far North of South Australia.

ElectraNet intends to incorporate one or more of these spot loads to augment the demand profiles from the AEMO NEFR for specific sub-regions within South Australia, for the ‘high’ demand scenario.

3.7 Discount rate

The choice of discount rate effects the relative weighting of short term versus longer term costs and benefits derived from the modelling. As is required under the RIT-T, ElectraNet proposes to apply a commercial discount rate in assessing the net benefits for each of the scenarios analysed in the first-pass screening. ElectraNet will also conduct sensitivity testing on the discount rate. ElectraNet proposes to use the discount rate values in Table 2 which are reflective of a real pre-tax Weighted Average Cost of Capital (WACC). The Low has been determined from ElectraNet’s proposed WACC in its Preliminary Revenue Proposal (PRP) of 5.75%. [12] [13]

Table 2: Proposed commercial discount rates

	Low	Medium	High
Discount rate (%)	3.8	6	8.5

[11] Iron Road, Central Eyre Iron Project, Fact Sheet, 2016

[12] ElectraNet, Preliminary Revenue Proposal, 2016

[13] ElectraNet may amend the low subject to outcomes from the AER’s ElectraNet Revenue Determination. Powerlink’s Revised Proposal dated 1 December 2016 has proposed a WACC of 5.48%

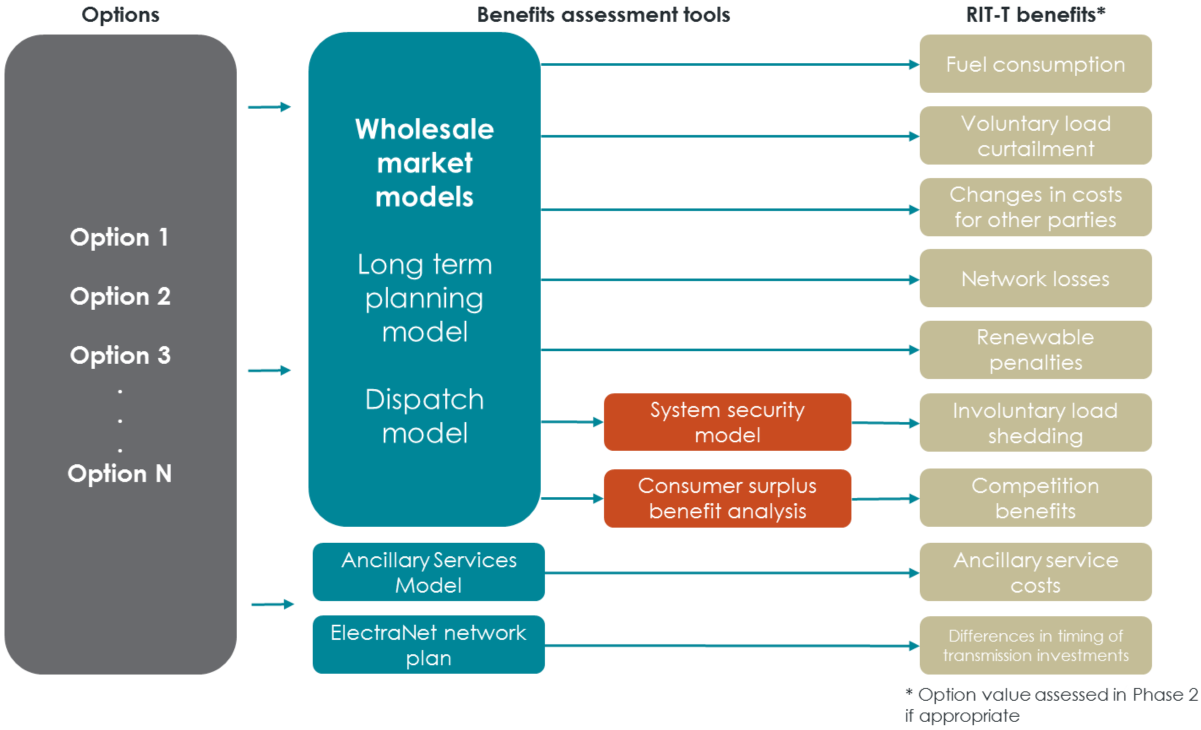
4. Methods for assessing market benefits

This section outlines the proposed suite of tools and approaches that will be utilised in estimating the market benefits associated with each of the RIT-T benefit categories.

Consultation question: What do you think about ElectraNet's proposed tools and approaches for estimating market benefits? Are there any other considerations that you think should be included?

Figure 2 provides an overview of the mapping between the tools that will be utilised in assessing the benefits and the RIT-T benefit categories[14].

Figure 2: ElectraNet will adopt a range of modelling tools to estimate the RIT-T benefits



In the remainder of this section we discuss each of the key tools and approaches illustrated above. Section 5 then contains a fuller description of the wholesale market models, as representing a key tool in the analysis.

4.1 Benefits estimation using wholesale market modelling

Many of the RIT-T benefits associated with the options under consideration arise due to changes in outcomes in the wholesale electricity market. These benefits are estimated using wholesale market modelling to understand how market outcomes can be expected to differ as a result of each of the proposed options.

A wholesale market model involves simulating outcomes of the wholesale market and the technical, economic and policy factors that influence market outcomes. We discuss the wholesale market modelling framework and the proposed assumptions in more detail in Section 5.

[14] These are the market benefit categories prescribed by the AER in the RIT-T

4.2 System security benefits estimation

System security benefits arise through a reduction in the likelihood and severity of major disruptions to customer electricity supply. ElectraNet proposes to model the benefits associated with improved system security through weighting the impact of such events by the probability of these events occurring, given the prevailing system conditions.

The benefits associated with increased system security are a function of the following four factors:

1. Probability of non-credible separation of South Australia from the rest of the NEM.
2. Probability of non-credible separation leading to unserved energy.
3. Estimates of the unserved energy during a separation event.
4. Estimates of the value that end consumers place on unserved energy.

We discuss each of these elements in turn below.

4.2.1 Probability of non-credible separation of South Australia from the rest of the NEM

Recent history suggests that despite the best efforts of network operators and planners, separations of South Australia from the rest of the NEM continue to occur. Despite the implementation of learnings from these separation events, the rapidly changing nature of the market means that the risk of future separation events remains.

Recent examples of separation events include:

- An extreme weather event on 28 September 2016 leading to damage to transmission assets and loss of wind generation, and tripping of the Heywood Interconnector resulting in a wide-spread system black in South Australia.
- Credible outages of a Heywood Interconnector circuit under prior outage of the remaining circuit leading to a separation event.
- Non-credible loss of generation leading to loss of synchronism protection separating South Australia from the rest of the NEM.

For the purposes of estimating system security benefits ElectraNet proposes to adopt a probability estimate that reflects the past frequency of non-credible separation events. This is estimated to be approximately once every four years.

4.2.2 Probability of non-credible separation leading to unserved energy

The likelihood of a non-credible separation of South Australia from the rest of the NEM leading to unserved energy is a function of the prevailing system conditions at the time of the event occurring.

Factors that will influence this likelihood will include:

- The magnitude of flows on the interconnectors between South Australia and Victoria at the time of the event.
- The level of inertia in the system in South Australia, which is a function of the number of conventional synchronous generators on-line at the time of the event.
- The presence of fast frequency response technologies.

Estimates of interconnector flows and level of inertia (derived from the generation mix) are a direct output of the market modelling that will be conducted as part of the assessment.

The recent introduction of the RoCoF standard in South Australia has helped to mitigate the likelihood of major system disruption in the future. The incorporation of this constraint will have a material lessening of the probability of a severe system disruption. However, the standard has not removed the risk entirely, and ElectraNet will seek to quantify the magnitude of remaining risk.

More recently, AEMO has introduced a minimum operating condition in South Australia of requiring two thermal generating units operating at all times. This is intended to strengthen the operation of the South Australian grid and assist to reduce the probability of a system wide black event.

While the measures implemented will reduce the probability of major disruption and associated unserved energy, the options being considered in this RIT-T will deliver additional benefits by relieving the constraints imposed by the system security measures. These benefits will be captured in the wholesale market modelling.

4.2.3 Estimates of the amount of unserved energy during a period of islanding of South Australia

The volume of unserved energy that is likely to be lost during a non-credible separation is a function of the geographic scope of any outages and the length of time over which the outages occur.

In the case of the recent non-credible separation event in South Australia and the resulting blackout, the full demand of South Australia was lost for approximately 3 hours, with full demand only being restored after approximately 9 hours. Future events may or may not follow a similar pattern as this recent example.

International experience, in advanced economies such as Australia, indicate the potential for event durations of as much as 18 hours.[15] ElectraNet will consider a maximum event duration of 18 hours in the high scenario, 9 hours for the central scenario – reflecting recent experience in South Australia[16] - and 3 hours in the low scenario.

ElectraNet proposes to assess the range of outage scenarios assuming native demand.[17] The high scenario will assume higher than average demand, the central scenario average demand, and the low scenario lower than average demand.

Some adjustments will be made subject to the level of DER that has been assumed in each scenario.

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[15] AEMO Reliability Panel, *International comparison of major black outs and restoration*, 2016

[16] The long term outages that occurred as a result of damage to the network during the events of 28 September will be considered separately to this benefit

[17] Native demand includes behind the meter generation. Such generation is typically incapable of operating without a frequency signal to follow.

4.2.4 Estimates of the value that end consumers place on unserved energy

When supply of electricity is interrupted, there is a cost to consumers. This cost is typically captured by the VCR which is defined by AEMO as the value that different types of customers place on having reliable electricity supplies under different conditions.[18]

As discussed in Section 3.3, ElectraNet proposes to consider a range of values for VCR as part of the scenarios modelled in Phase 1.

4.3 Competition benefits estimation

Competition benefits arise where the impact of an option on the wholesale market is to reduce the extent to which generators adopt non-Short Run Marginal Cost (SRMC)[19] bidding approaches, leading to changes in both the investment and dispatch outcomes in the market, as well as increased welfare for consumers due to the change in the price they pay for electricity (i.e. demand-response component).

Estimating competition benefits requires time and computationally intensive simulation of spot market prices using strategic bidding algorithms. Therefore, ElectraNet proposes to only estimate competition benefits if necessary. For example, competition benefits could help to separate two or more options that are assessed as having similar benefits from the other categories of market benefit, but only in instances where the competing options can be expected to have different competition benefits – this might arise if two network options substantially differed in maximum operating capability.

Further work undertaken by ElectraNet since publication of the PSCR indicates that competition benefits are unlikely to be a critical factor in determining the option with the highest net benefits in this RIT-T. That should not be interpreted as the options do not create competition benefits. Rather the magnitude of the benefits are not by themselves sufficient to exceed the likely cost gap between options.

Further, any modelling of competition benefits would only be conducted as part of Phase 2 assessment of shortlisted options.

If competition benefits analysis is required, the approach that ElectraNet proposes to adopt is in line with the approaches adopted in previous RIT-T assessments.[20]

In brief, the demand-response element of competition benefit is derived from consumers in the constraint-affected region being able to consume more electricity at lower prices and therefore deriving additional welfare from their consumption of that electricity. For example, where residential consumers would not operate their air conditioners at the higher prices, but at the lower prices they do, this benefit would include value to customers in the form of the additional in-home comfort they are afforded. In addition, low cost producers outside of the constraint-affected region are able to dispatch more electricity and derive additional profit from it.

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[18] AEMO (2015), Fact Sheet – Value of Customer Reliability, Australian Energy Market Operator, Available at: https://www.aemo.com.au/-/media/Files/PDF/AEMO_FactSheet_ValueOfCustomerReliability_2015.pdf

[19] Non-SRMC bidding occurs when generator offers diverge from the true financial cost of supplying energy. This will tend to occur under conditions of relative supply scarcity where other generators have limited opportunities to respond.

[20] Powerlink and TransGrid, *Development of the Queensland-New South Wales Interconnector, Methodology for Assessing Competition Benefits*, Consultation Paper, April 2013.

The benefit nets off the lower welfare associated with the reduction in electricity consumed in the rest of the NEM due to higher prices and some of the value that high-cost generators operating within the constraint-affected region were deriving.

This demand-response benefit will only exist when there are significant price differences between the constraint-affected region and the rest of the NEM. In particular, demand-response benefits will only arise when there is a restriction on supply (which will only be material when a constraint is binding), and there are likely to be many trading periods when this is not in fact the case.

4.4 Ancillary services benefits estimation

Currently, the future form and development of ancillary service markets and the costs of procuring the level of required services from those markets are subject to a high degree of uncertainty.

Historically, the magnitude of the Frequency Control Ancillary Services (FCAS) markets has tended to be a small proportion – around 1 per cent over the long term – of the energy market. The FCAS markets are unlikely to be material to the benefits of the options unless the future costs diverge from historical levels. This could happen either in a specific region or across the NEM. The likelihood of either local increases or NEM wide increases are considered below.

AEMO's 2016 Electricity Statement of Opportunities (ESOO) states that there are existing FCAS facilities to meet demand for the entire NEM and within each region for system normal operation. This also applies where separation is a credible risk and facilities are already generating in the region at risk of separation or islanding. All regions currently have sufficient System Restart Ancillary Services (SRAS) to meet the system restart standard.

In 2015, AEMO introduced a 35 MW regulating requirement in South Australia when there is a credible risk of South Australia separating from the rest of the NEM, to ensure sufficient provision of services post-contingency. This requirement ensures that sufficient facilities are already generating prior to a separation event. This is an example of a local requirement. The cost of this requirement since its introduction has been high as a result of an unusually high number of outages on the Heywood Interconnector. Once normal operation returns, these costs are also likely to reduce. The lower costs are not expected to differentiate between the options considered in this RIT-T.

Across the NEM, the 2016 ESOO states that supply could become scarce as synchronous generation withdraws. In particular any further withdrawals in South Australia and New South Wales will reduce the ability of those regions to be restarted if islanded.

The possible future retirements and the role of increased interconnection in alleviating emerging supply shortfalls will be examined for FCAS and SRAS in phase 2.

In addition to the existing FCAS markets, there is the potential that additional markets could be introduced to replace services currently provided by conventional generators (for example to provide inertia).

There are a number of reviews currently underway that can be expected to shape the future provision of ancillary services, particularly for fast frequency response and inertia. These include:

- The AEMC's System Security Market Frameworks review, which will include consideration of rule change proposals in relation to a potential ancillary services market for inertia and mechanisms for managing the rate of change of frequency and fault levels in South Australia.
- AEMO's Future Power System Security (FPSS) Program.

These reviews may introduce new markets or alternative mechanisms for the provision of these services, which are expected to be introduced NEM wide.

Importantly, these mechanisms will only be introduced if the cost of the provision of services is lower than the counter-factual "do nothing" scenario. While "do nothing" may lead to an increase in risk, that risk must be sufficiently great to warrant introducing new solutions. In the context of South Australia, the cost of "do nothing" can be measured by the increasing risk of major supply disruption. As has already been discussed, this has resulted in the introduction of the Rate of Change of Frequency standard.

The cost of this standard to the market will be captured via a constraint on the Heywood Interconnector in the wholesale market modelling (and not by modelling ancillary services costs). This new standard has reduced the likelihood of major supply disruption, but has not eliminated the risk. The remaining risk of major supply disruption will then be captured via the system security benefit (i.e. the reduction in unserved energy rather than by the ancillary services).

While these costs are captured in South Australia, the potential costs of the shortages of inertia across the NEM has not yet been considered. These costs, and the requirements for the NEM, will be determined by the reviews discussed above.

Given the uncertainty around future ancillary services markets, particularly for operational time frames shorter than are currently included in ancillary services arrangements, it is not possible currently to develop an accurate NEM-wide model of these future arrangements. This presents a difficulty in understanding how the future NEM requirement would be influenced by a network or non-network investment in South Australia. However, given that there is currently a shortage of these services in South Australia, the outcomes of this RIT-T is not expected to be of consequence to the rest of the NEM.

To the extent that greater clarity on future NEM requirements is resolved over the course of this RIT-T, ElectraNet will review the benefits of ancillary services during phase 2 of the PADR.

5. Wholesale market modelling approach

Wholesale market modelling is a means of simulating the outcomes from the electricity market. Developing a model of the wholesale market requires a number of simplifications and assumptions regarding the market operation and the decision making processes undertaken by market participants – this is standard practice in market modelling.

This section outlines ElectraNet's proposed approach to wholesale market modelling and highlights the most relevant simplifications and assumptions, for the purposes of this RIT-T assessment.

ElectraNet's wholesale market modelling approach involves both a long-term expansion model and a time sequential dispatch model. The purpose of these models is explained as follows.

Consultation question: To what extent do you agree with the key components identified in ElectraNet's wholesale market modelling approach? Are there other factors you think need to be addressed?

5.1 Long term expansion model

The long term expansion component of the market model allows ElectraNet to test how the alternative options may influence long term market outcomes. These long term outcomes may include:

- Large scale generation investment across each of the NEM regions.
- Locations of new investments.
- Uptake of distributed generation resources.
- Retirement of generators.
- Emissions reductions outcomes.
- SRMC price outcomes.
- Network augmentations (besides those related to the options under consideration).

The long term expansion model is similar to the modelling framework used by AEMO in its NTNDP modelling. The model solves for the least cost way of meeting demand subject to a range of operational and economic constraints that reflect the operation of the physical electricity market. This modelling framework assumes perfect foresight over the modelling horizon and therefore is a simplification of the actual decision making processes that underpin investment decisions in the NEM.

The model is solved over a long time horizon (30 years or longer), to allow for investments to be recouped within the modelling horizon (20 years). Owing to the computational complexity of solving the long term planning model, the model utilises a simplified model of the transmission network.

The forecast of generation capacities and implied carbon prices from the long term planning model are used as an input to the time-sequential dispatch model.

ElectraNet's proposed approach involves a number of simplifications and methodological assumptions that may impact on the estimation of benefits in the RIT-T assessment. In particular:

- The method for incorporation of future emissions policy.
- The method for incorporating generator retirements.
- Representation of the network within the model.

These are discussed in turn below.

5.1.1 Method for incorporation of emissions policy

The long-term expansion model results in renewable generators being forecast to ensure the electricity industry achieves renewable energy and emissions targets.

Future renewable policies will be incorporated into the long term planning model using additional constraints that must be met in identifying an optimal solution. These constraints can come in two forms, namely:

- Constraints on renewable generation.
- Constraints on emissions.

Constraints on renewable generation ensure that electricity generated through renewable resources must be greater than the demand set by a renewable energy target otherwise a penalty is incurred. A penalty price will be applied to allow the constraint to be violated if it results in lower cost to not meet the target and incur a penalty. ElectraNet proposes to model the RET and any state based certificate trading schemes that may be investigated in this manner. For the current national RET this penalty value is set at $93.[21]

Constraints on emissions ensure that the total level of emissions that are produced must not exceed the target level unless a penalty be incurred. The emissions limit is set by government targets (see Section 3.4 for a discussion of the emissions targets which ElectraNet proposes to model). A penalty price will also be applied to allow the constraint to be violated. ElectraNet proposes to adopt a penalty factor of $100/tCO$_2$e.[22]

Emissions Intensity of Generation estimates will be sourced from AEMO[23] and will be consistent with the values used in AEMO's Carbon Dioxide Equivalent Intensity Index.

ElectraNet's proposed approach is distinct from adopting an assumption that there will be a carbon price into the future. However, adopting an emissions constraint does result in an implied carbon price.[24] This implied carbon price is an output reported by AEMO as part of the NTNDP modelling.

An emissions constraint will not necessarily result in additional intermittent renewable generation. The long term expansion model will often bias decision making towards firm capacity, with supply shortfalls avoided by planting relatively low capital cost Open Cycle Gas Turbines (OCGT). The firm capacity of intermittent generation will be based on the long term average output of intermittent generators and any correlation they have to demand. The variability of renewables will be further tested in the time sequential modelling and this might result in fine tuning the expansion results.

5.1.2 Retirement of conventional generators

The assumed retirement of conventional generators can be equally as important to the RIT-T assessment as the assumptions made about new generation investment.

Retirement of existing conventional generators is expected to be a regular occurrence in the electricity market, where renewable generation capacity continues to expand. The impact of generator retirement on the potential market benefits associated with

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21 AEMO, NTNDP, 2016

22 The alternative is to adopt a hard constraint, that cannot be violated at any price

23 AEMO, NTNDP, 2016

24 This is derived from the shadow price associated with the emissions constraint.

interconnection is significant owing to the impact of retirements on fuel costs and future investment decisions.

ElectraNet's proposed approach is to model generator retirement within the long term planning model. The model will assess whether it is in the interest of any generator to cease operating based on a range of factors:

- Proposed retirements and expected technical life.
- Fixed and variable operating costs associated with generating.
- Expected future spot price revenues.
- Opportunity cost of generating, such as revenue from on-selling gas into the spot market or emission reduction policies.

5.2 Time sequential dispatch model

The purpose of conducting time sequential dispatch modelling is to capture a number of market dynamics that are not able to be represented in the long term planning model. ElectraNet will use time sequential dispatch modelling to derive dispatch outcomes across the NEM, in order to calculate several of the market benefit categories; namely

- Fuel costs.
- Changes in voluntary load curtailment.
- Changes in involuntary load shedding (with the exception of the use associated with non-credible contingency events).
- Changes in network losses

In contrast to the long term planning model, the time-sequential dispatch model involves solving for dispatch outcomes in each period in a sequential manner. The grid expansion that is found in the long term phase is taking as an input to the time sequential dispatch. This allows the model to focus on a detailed network representation including losses. This stage gives far more insight into the power flows that can be expected over time and hence the effects of the options on the network.

Modelling at this resolution also allows for improved modelling of variable output from renewables.

5.3 Network representation

The long term planning model includes a representation of the network at a regional level. Therefore, the only network constraints are related to the interconnectors between regions of the NEM. This means that intra-regional constraints that may influence the benefits associated with the options may not be fully captured in the long term planning model.

The representation of the network will be more detailed in the time sequential dispatch model and therefore an understanding of the impact of these constraints will be gained through that model. Such an approach reduces the computational complexity associated with the long term planning and therefore makes the long term planning modelling more tractable.

For the time sequential dispatch modelling, the network is drawn from a refined national electricity market model suitable for detailed power flow and steady state analysis of the network. This network model covers the mainland NEM regions in fine detail. The level of detail represented can be customised to each region. That is, to reduce the size of the computational problem, the 132 kV network, for example, can be removed from the power flow simulations on a region-by-region basis or even at the individual transmission line level.

Consultation question: In general, how well do you think this Market Modelling Assumptions Report explains the way that ElectraNet will begin assessing the options outlined in the South Australian Energy Transformation Project Specification Consultation Report and those put forward during consultation processes?

Consultation question: Would you like to provide any other feedback about the Market Modelling Approach and Assumptions Report?