VICTORIAN ELECTRICITY PLANNING APPROACH

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this document to provide information about the planning approach used in Victoria in relation to the electricity Declared Shared Network (DSN), as at the date of publication.

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Version control

Version	Release date	Changes
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CONTENTS

TABLES

FIGURES

1. INTRODUCTION

1.1 Electricity planning

This document describes the Australian Energy Market Operator's (AEMO's) approach to planning Victoria's high voltage electricity Declared Shared Network (DSN).

AEMO has multiple energy industry functions, including operating the National Electricity Market (NEM) and Western Australia's Wholesale Electricity Market (WEM), national electricity transmission planning, and publication of NEM-wide strategic development plans in the annual National Transmission Network Development Plan (NTNDP).

In Victoria, the planning and ownership of the DSN is split between AEMO and transmission network service providers. AEMO is responsible for planning and directing augmentations to the DSN, and plans and procures services from third parties to achieve this.

1.2 Victorian electricity planning criteria

In planning the DSN, AEMO's investment decisions are based on a cost-benefit analysis of the market impact of network limitations. Market impacts include changes to fuel costs, customer reliability, investment timing, operating and maintenance costs, network losses, ancillary service costs, market competition, and renewable energy target penalties.

Evaluating customer reliability includes considering the probability-weighted impacts from events such as:

- Single and multiple outages of transmission elements.
- Unexpectedly high levels of demand.
- Decline in minimum demand.

AEMO seeks to deliver a level of reliability that balances investment costs with the benefits of reliable supply to customers. The value of customer reliability (VCR)[1] measure is used to reflect the value that customers place on having a reliable electricity supply. The VCR is combined with data on the probability of an outage to estimate the energy at risk (or expected energy not supplied). The expected benefits of a potential network or non-network investment are then assessed, including reductions in energy at risk, in order to strike an economic balance between the costs of:

- Actions taken to ensure network capabilities are not exceeded (including load shedding and generation re-dispatch).
- Providing sufficient network and non-network capability to minimise the need to limit load.

1.3 Planning reports

To facilitate clear and transparent planning processes, AEMO publishes a series of planning reports on current network constraints and investment opportunities in Victoria and the NEM. The series comprises regional-level Victorian planning reports, Victorian investment consultation reports, and national planning reports, which are described in the following sections.

[1] For more information about the VCR, see http://www.aemo.com.au/Electricity/Planning/Value-of-Customer-Reliability-review.

1.3.1 Victorian annual planning reports

AEMO produces the Victorian Annual Planning Report (VAPR) for the DSN by 30 June each year[2] as well as independent connection point forecasts.[3] The five distribution businesses[4] responsible for planning and directing transmission connection point asset augmentations in Victoria (facilities to connect distribution systems to the DSN) jointly publish the annual Transmission Connection Planning Report (TCPR).

The VAPR and the TCPR both provide information about the transmission network's ongoing ability to supply customer load.

The VAPR looks at (among other things) the entire DSN and assesses the transmission network's ability to supply forecast demand at each transmission connection point over the next ten years. Transmission network limitations in the DSN can cause unserved energy at transmission connection points, and economically inefficient dispatch of generation to meet demand.[5] The VAPR assesses the magnitude, probability and cost of that expected unserved energy, and the expected costs from inefficient generation dispatch caused by each network limitation.

The VAPR also looks at longer-term adequacy of the DSN under different potential supply and demand scenarios, to determine triggers likely to cause and require transmission network investment.

The TCPR focuses on each transmission connection point's ability to meet forecast demand over the next ten years. It assesses the magnitude, probability and cost of expected unserved energy due to insufficient connection point capacity.

Together, the VAPR and the TCPR provide information about transmission limitations to efficient network development that will best meet consumer needs.

AEMO also carries out an annual Victorian short-circuit level review to identify maximum short-circuit levels (prospective three phase and single phase-to-ground maximum short-circuit currents) for all Victorian electricity transmission connection points for the next five years. It also provides information relating to the network's capability to withstand short-circuit currents. This review is shared with the Victorian Network Service Providers, and published with the VAPR.

1.3.2 Victorian investment consultation reports

AEMO publishes various information and public consultation reports when considering DSN augmentations. These include consultation reports required under the Regulatory Investment Test for Transmission (RIT-T).[6]

1.3.3 National annual planning reports

AEMO produces the NTNDP, which considers how the NEM transmission network may develop over at least the next 20 years, and the NEM Electricity Statement of Opportunities (NEM ESOO), which investigates supply adequacy and provides supply and demand information about energy resources affecting the NEM over the next 10 years.

The NTNDP represents AEMO's view on efficient national transmission system development for a range of credible scenarios.[7]

Victorian Planning Reports consider and further explore the relevant findings from the NTNDP for Victoria.

[2] As required by Section 5.12.2(a) of the National Electricity Rules (NER), available at http://aemc.gov.au/Electricity/National-Electricity-Rules/Current-Rules.html. Viewed 9 Feb 2016.
[3] For more information about the connection point forecasts, refer to http://www.aemo.com.au/Electricity/Planning/Forecasting/AEMO-Transmission-Connection-Point-Forecasting/Transmission-Connection-Point-Forecasting-Report-for-Victoria. Viewed 2 June 2016.
[4] CitiPower, Powercor, AusNet Services, Jemena Electricity Networks (Vic) Ltd, and United Energy Distribution.
[5] In the long term, transmission network congestion may also impact generation investment decisions. These impacts are assessed in the National Transmission Network Development Plan (NTNDP) and detailed Regulatory Investment Test-Transmission (RIT-T) assessments.
[6] AEMO. Available at: http://www.aemo.com.au/Electricity/Planning/Regulatory-Investment-Tests-for-Transmission.
[7] Where appropriate, the Victorian planning process uses the same scenarios and input assumptions to ensure planned Victorian developments are consistent with the long-term developments the NTNDP highlights.

2. PLANNING PROCESS

This chapter describes AEMO's planning process in terms of its two core features:

- The phases of the planning process undertaken to identify potential network limitations and their solutions.
- The way the planning process is applied in an annual cycle to incorporate changes to the external environment and deliver information to the market.

2.1 Planning process

AEMO's planning process comprises four discrete phases, with each phase narrowing in scope and becoming increasingly detailed. Figure 1 shows the individual phases of this process.

Figure 1 The investigative process

Phase 1 – exploratory

The exploratory investigations, also referred to as screening studies, focus on transmission network performance projections under a range of future scenarios, to assess the significance and timing of identified network limitations.

The aim is to assess a wide range of future conditions to identify any potentially feasible limitation. At this stage, the network is stress tested by analysing scenarios with high demand growth and worst case generation dispatch.

These investigations also provide information about future conditions or triggers that could cause particular limitations, and identify when future work needs to be undertaken. This exploratory work is carried out annually in the VAPR.

Phase 2 – scoping

Scoping investigations help develop feasible network and non-network solutions to address the potential limitations identified in Phase 1. These investigations include high-level studies to assess each solution's technical effectiveness, high-level cost estimates, and environmental impact. This scoping work is carried out annually in the VAPR.

Phase 3 – pre-feasibility

Pre-feasibility investigations are the first stage of the cost-benefit assessment, and establish likely timings and economic justification, as well as the need for more detailed investigations.

Although Phase 3 is a more detailed study than Phase 1 or 2, several resource-saving approaches are used, involving (for example) only a small selection of investment options and a limited range of future scenarios. The requirement for pre-feasibility studies is identified as part of the VAPR.

Phase 4 – feasibility

Feasibility investigations are the most detailed, identifying all relevant benefits and costs, and all practical implementation considerations, to identify the optimal investment, including its timing and staging. For investments in the DSN, AEMO applies principles under the National Electricity Rules (NER) and the Australian Energy Regulator (AER)'s RIT-T. Under circumstances where the RIT-T does not apply[8], AEMO still undertakes a detailed cost-benefit assessment consistent with the RIT-T framework, but not the formal consultation process. The requirement for a feasibility study is identified after a pre-feasibility study.

Table 1 summarises the planning process phases, including the type of studies undertaken for each phase and where they are published.

Table 1 Planning process summary

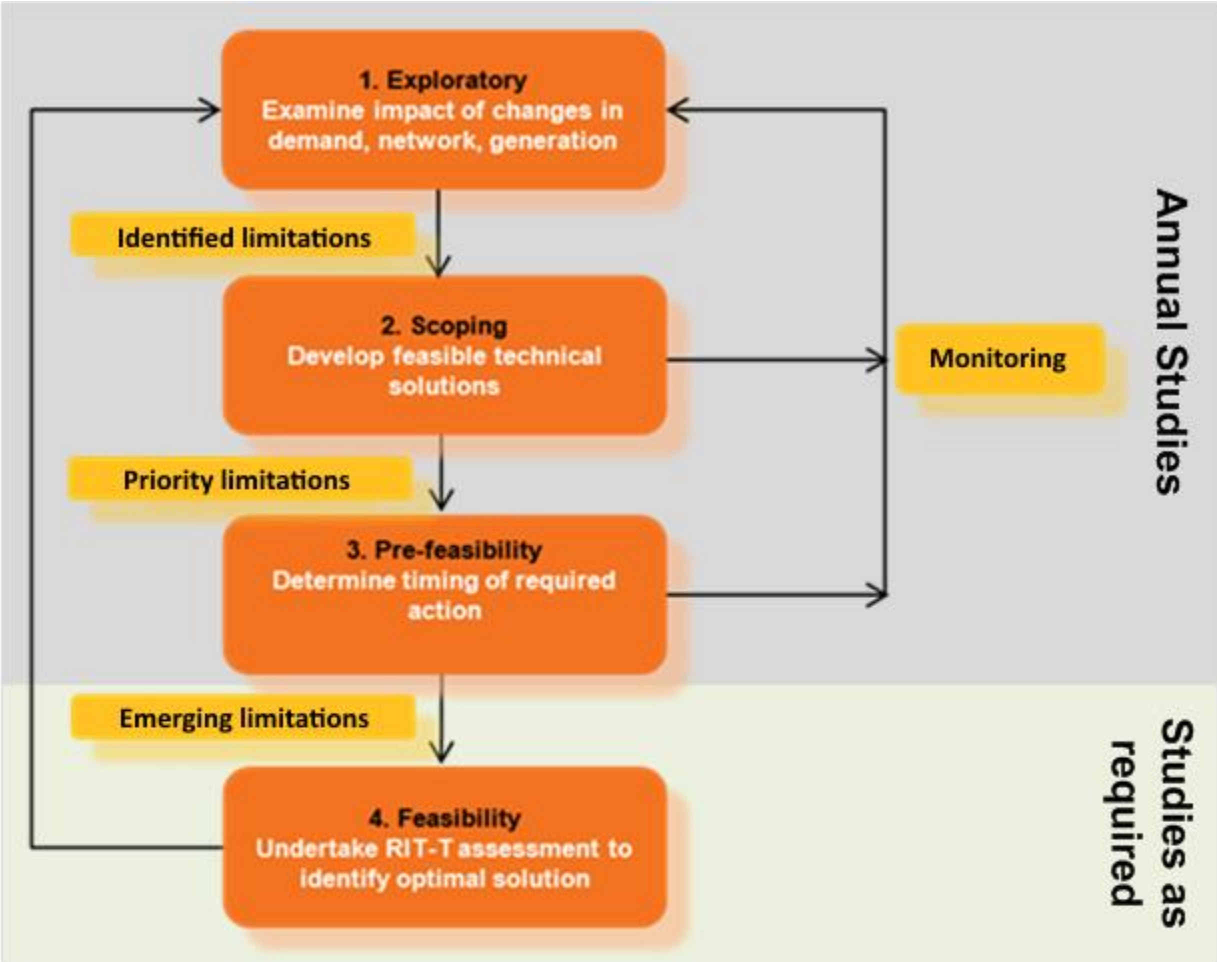
Planning process phase	Focus of studies	Type of studies	Planning publications
Exploratory	Identifying network limitations.	Deterministic: conservative worst-case assumptions.	VAPR
Scoping	Identifying potential solutions.	Deterministic: technical and environmental feasibility.	VAPR
Pre-feasibility	Confirming the need for detailed feasibility studies.	High-level probabilistic: limited scenarios.	VAPR, individual pre-feasibility reports
Feasibility	Identifying optimal investment and timing.	Comprehensive probabilistic: full range of scenarios.	Individual RIT-T reports

2.2 Annual planning review

AEMO's annual planning review considers the transmission impact of changed demand forecasts, new generation connections, and transmission augmentations; results are published in the VAPR. Figure 2 shows the annual planning cycle, and categories of limitations identified by the first three planning process phases. Detailed feasibility studies (RIT-Ts) are carried out as required, and each study may take at least 12 months to complete.

[8] Clause 5.16.3(a) of the National Electricity Rules (NER) provides exceptions where the RIT-T will not be adopted, such as, when the most expensive option to address the identified need which is technically and economically feasible is less than $5 million (as varied in accordance with a cost threshold determination).

Figure 2 Planning cycle



The annual planning review identifies limitations in the exploratory studies, which are forecast to occur within the VAPR outlook period (up to ten years). The identified limitations normally occur due to changes in generation, demand or network configuration and are broken into three categories through scoping and pre-feasibility studies. They are:

- **Monitoring limitations** which may result in supply interruptions or constrain generation periodically, but for which there is currently no known credible solution likely to deliver positive net market benefits in the next ten years. AEMO will reassess these limitations annually, when the triggering conditions change, or when any new credible solution becomes available.
- **Priority limitations** for which credible solutions may deliver positive net market benefits in the next ten years. AEMO will undertake further pre-feasibility assessment of these limitations within 12 months.
- **Emerging limitations** for which credible solutions are likely to deliver positive net market benefits in the next ten years. AEMO will begin RIT-T applications within 12 months to identify the optimal solution and investment timing.

3. PLANNING METHODOLOGY

This chapter describes how AEMO identifies network limitations, develops feasible solutions, determines the required time for action, and identifies the optimal solution in the planning process.

3.1 Exploratory investigations – identifying network limitations

Exploratory investigations (screening studies) are carried out in the VAPR to identify DSN limitations over the next ten years.

Two different types of studies are used:

- Screening studies to identify limitations.
- Trigger studies to identify the conditions that may cause a limitation to emerge.

The VAPR always incorporates screening studies, and may include trigger studies if necessary. Trigger studies are generally recommended if expected changes in generation, demand, or other planning inputs can have a significant impact on the results.

3.1.1 Screening studies

Screening studies identify limitations by assessing network performance in terms of security and performance obligations under a range of different power system configurations.

Security and performance obligations define the transmission system's technical limitations, for example voltage ranges, stability limits, maximum fault currents, and fault clearance requirements. These obligations ensure that connected assets (and the power system itself) are designed to operate within known technical limits.

Typically, screening studies are undertaken for a base case and a worst case scenario, in order to capture a wide-range of limitations. A limitation is a network element that is loaded to 90% of its continuous rating during system normal, or 90% of its short term rating after a contingency, over the ten year planning horizon.

Base case scenario for high demand periods

The base case scenario is a medium energy growth scenario incorporating all committed transmission and generation projects, with selected advanced generation projects also incorporated when forecast Victorian supply becomes insufficient.

The base case uses the transmission connection point demand forecasts developed by AEMO assuming a coincident, 10% probability of exceedance (POE) summer maximum demand forecast for the Victorian region.[9]

Base case scenario for light demand periods

The light load base case incorporates the same committed transmission and generation projects as above. Demand is based on historical minimum demand from the current financial year (normally 26 December), or the minimum demand forecast produced by AEMO.

Worst case scenario

The worst case scenario differs, depending on the transmission network element under consideration, and is a variation on the base case scenario designed to test that network element.

[9] For more information about the Connection Point Forecasts, see http://www.aemo.com.au/Electricity/Planning/Forecasting/AEMO-Transmission-Connection-Point-Forecasting/Transmission-Connection-Point-Forecasting-Report-for-Victoria.

Worst case scenarios are defined for each Victorian electrical area as follows:

- Eastern Corridor: maximum Latrobe Valley generation and Basslink import (flow into Victoria), and minimum local area customer demand.
- South-Western Corridor:
  - Peak demand variant 1: maximum South Australian export (flow into Victoria) and gas generation in the South-Western Corridor.
  - Peak demand variant 2: maximum Victorian export (flow into South Australia).
  - Low demand (light load): maximum South Australian export (flow into Victoria) and wind generation in the South-Western Corridor.
- Regional Victoria Corridor: maximum Murraylink export (flow into South Australia) and regional demand (non-coincident peak).
- Northern Corridor:
  - Peak demand: maximum New South Wales export (flow into Victoria) and Victorian hydroelectric generation.
  - Low demand (light load): maximum Victorian export (flow into New South Wales).
- Greater Melbourne and Geelong: minimum Greater Melbourne and Geelong generation, and maximum Greater Melbourne and Geelong demand (non-coincident peak).

Power system configurations

The screening studies have three main aims:

- Identification of transmission network limitations that will lead to a failure to comply with power system operation requirements.
- A focus on identifying transmission network limitations that, without re-dispatch or a pre-contingent loss of load, will lead to an unsatisfactory operating state or an insecure operating state under N and N-1 conditions. Limited studies are also carried out on transmission network limitations that will only occur under N-1-1 conditions, but that will significantly impact the market when they do.
- Estimating the scale of market benefits that can be realised by addressing the identified transmission network limitations.

The screening studies consider three power system configurations:

- N conditions (system normal), when all system components are in service.
- N-1 conditions, which follow a single credible contingency event.[10]
- N-1-1 conditions, which follow a single credible contingency event with a prior outage (either forced or planned).

The power system should be able to be operated in a secure operating state.

- A satisfactory operating state requires that frequency, voltage, current, protection and other plant forming part of or impacting on the power system be operated within their relevant operating ratings and limits.
- When in a satisfactory operating state, the power system is further considered to be secure if the power system will return to a satisfactory operating state following the occurrence of any credible contingency event. If the power system becomes insecure, it should be able to be returned to a secure operating state within 30 minutes.

[10] A contingency event is an event affecting the power system that AEMO expects is likely to involve the failure or removal from operational service of one or more generating units and/or transmission elements (NER clause 4.2.3(a)). A credible contingency event is a contingency event AEMO considers reasonably possible (NER clause 4.2.3(b)).

The general principles for maintaining power system security are further outlined in Chapter 4 of the NER.

3.1.2 Trigger studies

Trigger studies examine the triggers likely to cause transmission network limitations in the longer term. Their main aim is a high-level quantification of the increase in load, generation, import, or export likely to lead to loading limitations within different Victorian electrical regions.

The trigger studies that consider the latest NTNDP generation and transmission outlook, start with some future year (for example, the outlook period's tenth year), and apply the base case demand and generation profile used in the screening studies. The network is then tested by increasing demand, generation or interconnector power transfers until the network is overloaded under N-1 conditions.

3.2 Scoping studies – developing feasible solutions

The scoping studies identify feasible solutions to identified limitations. A list of potential network and non-network options are developed, and power system studies undertaken if necessary, to determine each option's effectiveness in addressing the limitation at a high level.

Factors taken into account when developing the list of options to address Victorian network limitations include:

- Long-term plans of the distribution companies.
- AusNet Services' asset replacement and refurbishment plans.
- The NTNDP long-term plans.
- Potential availability of sites and easements.
- Whether an automatic load shedding control scheme can be used to enable five minute short term ratings[11] to effectively address the limitation, and defer the need for additional network or non-network investment.

For each technically feasible solution, a high-level cost estimate and the likely lead time to implement the option are estimated.

3.3 Pre-feasibility studies – determining the need for further investigation

The need for further investigation depends on the costs incurred due to the limitation, and the cost and implementation lead times for available solutions.

The pre-feasibility studies aim to determine if the market benefits of any available solution will be greater than the costs taken to plan, procure and implement within a given timeframe. This enables AEMO to decide whether starting a feasibility study in the current planning review cycle is needed.

Due to the uncertainties surrounding demand growth and generation investment, the detailed analysis required for transmission investment decisions is undertaken shortly before the need arises.

3.3.1 Evaluating the market impact of a limitation

For each network limitation identified, market simulation studies are performed to assess the limitation's market impact under a range of scenarios. Market impacts are caused when a transmission network

[11] In Victoria, transmission lines are typically operated to 15 minute ratings, but the ratings can be increased to five minute ratings with control schemes that can automatically reduce line loading following a contingency by shedding preselected loads. For more information on the rationale for including the operational capability of control schemes in long-term planning in Victoria, please refer to the Victorian Planning Criteria Change Factsheet, available at http://www.aemo.com.au/Electricity/Policies-and-Procedures/Planning/Victorian-Electricity-Planning-Approach.

element is at risk of exceeding its defined limits for N and N-1 conditions, and power flow is curtailed to ensure the network can operate within its performance requirements.

There are two key operational actions, in terms of value or cost to the market:

- Energy not supplied to customers through load reduction (unserved energy).
- Constrained generation dispatch.

Monte Carlo time-sequential market simulations

Monte Carlo time-sequential market simulations capture the market cost of these operational actions:

- Time-sequential market simulations attempt to represent the complex interaction between consumer and producer behaviours, technical infrastructure, and the variability of environmental factors (weather, wind, and solar radiation).
- Monte Carlo approaches are used to model random generation outages under high and medium regional demand conditions and different network configurations (including prior outage conditions) based on their forced outage rates.

The market simulations for the pre-feasibility studies typically use the same simulation tools and a similar database to that used for the NTNDP studies.[12] VAPR studies look into localised unserved energy and constraints that may affect generation dispatch. Studies are typically undertaken over ten years, with and without constraint equations in place to represent the limitation. The limitation's impact, in terms of energy not supplied to customers (unserved energy) as well as the difference in total generation dispatch costs, can then be determined.

Unserved energy is valued using the VCR[13], which is an estimate of the value electricity consumers place on having a reliable electricity supply. This value is equivalent to the cost to consumers of having their electricity supply interrupted for a short time.

The constrained generation dispatch cost is valued using the short-run marginal cost (SRMC) of generation, including any price on carbon.

A probabilistic approach to assessing the market impact of network limitations

The pre-feasibility studies use a probabilistic approach to assess the annual gross market benefit of removing each transmission network limitation, where the cost of unserved energy and the cost caused by constrained generation dispatch is weighted by the probability of the limitation occurring.

The probability is determined based on probabilistic market simulations considering the following uncertainties:

- Demand forecasts, 50% POE and 10% POE (with a 70% and 30% weighting respectively).
- Wind generation, based on historical wind generation availability.
- Dynamic ratings based on historical weather conditions.
- New generation scenarios, based on the NTNDP generation development scenarios.
- Outage rates based on historical generation and transmission forced outage rates.
- Control scheme failure rates, based on survey and research results, including the failure of multiple control schemes.

3.3.2 Evaluating the need for feasibility studies

In the pre-feasibility study stage, the Net Present Value (NPV) of market benefits associated with removing a limitation is compared with the estimated cost of the feasible solutions, to determine if any

[12] For more information about planning assumptions derived from the NTNDP, see http://www.aemo.com.au/Electricity/Planning/Related-Information/Planning-Assumptions. Viewed 2 June 2016.
[13] For more information about the VCR, see http://www.aemo.com.au/Electricity/Planning/Value-of-Customer-Reliability-review. Viewed 2 June 2016.

feasible solution is likely to be economically justifiable. The studied solutions are assessed at a high level, so the analysis may not capture all benefits associated with removing the limitation, or may not consider other binding limitations which can reduce the benefits or increase the costs.

Further market modelling studies may be required to determine the benefits associated with particular solutions more accurately.

A decision on whether to commence a feasibility study in the current planning cycle will be made based on:

- Whether or not the limitation's NPV can justify the cost of the feasible options.
- The economic timing of any new investment.
- The lead times of the feasible options (that is, the time required to plan, procure and implement).
- Any operational measures, such as network switching, that can be implemented temporarily if the lead time is not sufficient.

3.4 Feasibility studies – identifying the optimal solution

The feasibility studies are designed to identify the preferred solution for removing or alleviating a limitation, and optimal timing for implementing the solution. Undertaken using the Australian Energy Regulator's (AER) Regulatory Test for Investment (RIT-T)[14] framework, the feasibility studies have a series of key objectives:

- Economic efficiency, where investments must maximise the present value of net economic benefit to all those who produce, consume and transport electricity in the market.
- Competitive neutrality, where all credible network and non-network investment options must be considered without bias.
- Predictability, consistency and transparency, where the test must be capable of being applied in a predictable, consistent and transparent manner.
- Proportionality, where the level of analysis required should reflect the scale of the investment.

Refer to the AER's RIT-T application guideline for more information on the classes of transmission investment benefits considered, and the RIT-T process.[15]

[14] AER. Available from: https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/regulatory-investment-test-for-transmission-rit-t-and-application-guidelines-2010. Viewed 9 Feb 2016.
[15] AER. Available from: https://www.aer.gov.au/system/files/Final%20RIT-T%20application%20guidelines%20-%2029%20June%202010.pdf. Viewed 9 Feb 2016.