NATIONAL TRANSMISSION NETWORK DEVELOPMENT PLAN

EXECUTIVE BRIEFING 2010

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

FOREWORD

AEMO's National Transmission Network Development Plan (NTNDP) is an independent strategic plan for the National Electricity Market transmission network.

It provides information for the energy industry, policy makers and investors to better understand, analyse and discuss Australia's electricity transmission network needs over the next 20 years.

The National Transmission Network Development Plan:

- Gives potential investors information on the National Electricity Market (NEM) and its ongoing development, including where and when electricity transmission will be required.
- Highlights investment opportunities for the energy industry.
- Plays a key role in preparing the energy industry for future development by modelling the impacts of climate change policies on the NEM.
- Identifies how the national transmission network will need to evolve to cater for these changes.
- Enables electricity generators to see how the national transmission network may develop under various market development scenarios, to carry their power to the market and ultimately to consumers.

The NTNDP incorporates the Transmission Network Service Providers' (TNSPs) current network and development plans for the National Electricity Market (NEM). AEMO has worked closely with the TNSPs to include their views and commitments, which dominate the first five years of this plan in all modelled scenarios.

These projects represent about $2 billion of the TNSPs broader 5 year transmission capital investment of approximately $7.5 billion which includes capital for asset replacement projects. AEMO has not questioned these projects and has taken this as the starting point for the NTNDP analysis.

In this plan, AEMO explores a wide range of scenarios to determine potential electricity transmission outcome impacts. The scenarios are based on several drivers, the two most prominent being demand growth and carbon price. Our aim is to provide the energy industry with a comprehensive information source to enable dialogue and support the development of a responsive transmission network.

The future for both supply and demand over the next 20 years is linked to a number of uncertain outcomes. The forecast is for continued growth in electricity demand driven by a growing economy. Electricity generation will need to grow to meet this demand. It will also need to adapt to a future requiring reduced carbon intensity and increased energy efficiency.

Growth in the economy and increasing population are driving electricity demand in the NEM. By 2030 this expansion will see our energy consumption increase by 30% to 70% above today's levels.

Based on AEMO's scenario modelling, substantial investment is required for augmentation of the shared transmission network and development of new generation assets across the NEM. The majority of this investment is required in new generation assets.

In preparing the NTNDP, AEMO has used a new optimisation model that assesses market benefits and assists in guiding efficient investment. The model provides capacity to examine outcomes for multiple plausible scenarios.

AEMO will update the NTNDP scenarios each year as the Australian energy market develops.

We will also work with the energy industry, governments and stakeholders to continuously improve our modelling and analysis.

The NTNDP provides a NEM-wide view of where future generation could be clustered to make the best use of both renewable and non-renewable resources. The location of these generation clusters is an important outcome of the national planning process, allowing planners to develop efficient connecting transmission and minimise overall costs to both customers and generators.

AEMO has also developed and modelled the concept of a large-scale interconnection running from Queensland, through New South Wales and Victoria to South Australia, with an additional direct current (DC) link to Tasmania. "NEMLink" would connect the existing and proposed 500 kV networks across the NEM.

NEMLink has the potential to substantially remove congestion in the NEM and deliver new options for generation investment and transmission development, while addressing the need for a truly national grid.

AEMO's NEMLink modelling demonstrates substantial benefits that warrant further exploration.

Following publication, AEMO will be working with TNSPs and other stakeholders to ensure that the conclusions of the NTNDP are taken into consideration. Regional planners should incorporate the findings in their annual planning reviews to enhance the national benefits arising from the NTNDP.

I am pleased to present AEMO's first National Transmission Network Development Plan. I sincerely thank all our stakeholders for their invaluable input. I also acknowledge the foresight of the policymakers whose vision for energy planning helped to make this document a reality.

I look forward to continuing to work with you to secure Australia's energy future.

Yours sincerely

Matt Zema
CHIEF EXECUTIVE OFFICER/MANAGING DIRECTOR
AUSTRALIAN ENERGY MARKET OPERATOR

THE NATIONAL TRANSMISSION NETWORK DEVELOPMENT PLAN (NTNDP)

AEMO developed this NTNDP in collaboration with the electricity industry, governments and key stakeholders.

The NTNDP provides a transparent and independent resource for the energy industry, policy makers and investors to better understand Australia's energy needs and transmission requirements for its eastern and south eastern states over the next 20 years.

The plan outlines the impact of increased demand for gas-powered electricity. The trend towards greater reliance on gas is highlighted in AEMO's Gas Statement of Opportunities (GSOO) to ensure that our planning encompasses the new demand.

Investment in energy infrastructure is vital to the long-term provision of cost-effective, reliable power. Efficient investment in transmission means that market benefits outweigh the initial cost of investment and contribute to reducing the overall cost of electricity to consumers.

AEMO has considered the whole National Electricity Market (NEM) transmission system, including regions and interconnections, and impacts on other fuels such as gas. We explore five scenarios in detail, ranging from a high growth, high carbon price scenario (fast rate of change) to a low growth, low or no carbon price scenario (slow rate of change). Two carbon price outcomes are examined in each scenario, giving us 10 possible energy futures to consider in energy planning.

AEMO's modelling indicates that:

- Large-scale interconnection could deliver significant operational benefits.
- Extensive investment in renewable energy technologies is driven by climate change policy and occurs at sites where the renewable resources are located closer to the transmission network.
- The Large-scale Renewable Energy Target (LRET) is materially achieved in all scenarios except those with no carbon price.
- There is a strong move to both peaking and base load gas-powered generation. The peaking capacity can potentially occur at various locations around the NEM without major augmentation. However, in some scenarios, base load gas-powered generation is clustered in gas-rich areas and necessitates significant augmentation.

The key challenge for the transmission network is to select the most efficient investments and establish a framework to guide future investments, both nationally and within the regional power systems.

AEMO's modelling demonstrates that the electricity industry has built a sound foundation to deliver cost-effective, reliable electricity transmission in the immediate future. The groundwork is laid for industry to continue delivering one of the most reliable electricity supplies in the world.

AEMO'S PLANNING FRAMEWORK

The NTNDP is one of a suite of key planning documents that AEMO publishes annually.

The Electricity Statement of Opportunities (ESOO) and the Gas Statement of Opportunities (GSOO) provide information about investment opportunities for the supply and demand of electricity and gas.

The Victorian Annual Planning Report (VAPR) and the VAPR Update provide electricity and gas demand forecasts for Victoria. They outline AEMO's detailed plans for developing the Victorian gas and electricity transmission networks.

The South Australian Supply and Demand Outlook (SASDO) provides additional forecast and supply side information.

AEMO's publications provide investors and other stakeholders with a nationally consistent view of where investment may be needed to ensure a stable ongoing supply of energy.

NTNDP DEVELOPMENT

AEMO developed the NTNDP in collaboration with a wide range of stakeholders.

Ongoing engagement with NEM TNSPs gave us a full understanding of the committed and proposed projects in each of the NEM states, enabling us to promote an effective NTNDP.

A stakeholder reference group worked with AEMO to develop and validate the market development scenarios included in the NTNDP.

In January 2010, a consultation document outlining the key parameters, costs, data and assumptions was made available for comment on the AEMO website. Workshops were also held with industry stakeholders.

AEMO believes that the consultation process and the contents of the NTNDP fulfil its commitment to seeking, and responding to, feedback from stakeholders. Feedback from our consultations resulted in AEMO:

- Investigating more scenarios, with carbon price sensitivity studies undertaken for each scenario.
- Updating the market simulation model, including simulation data, energy consumption, peak demand and fuel costs.
- Using a new and faster market model to co-optimise generation and transmission at the regional level.
- Initiating a national five-year assessment of Network Support Control Ancillary Services' (NSCAS) needs.
- Incorporating nationally consistent values for customer reliability for use in planning studies.

BUILDING THE PLAN

The NTNDP considers the whole of the NEM power system and assesses transmission requirements for each of the scenarios. This approach includes consistency checks of the regional transmission plans developed by the state-based planning authorities in their annual planning reports. Outcomes were also tested with the state-based planners to confirm feasibility and consistency with local planning requirements.

AEMO believes that the NTNDP adds considerable value to:

Policy makers

The NTNDP models the impact of different policy settings on the economic development of the industry and how transmission costs will be affected (for example, the effect of carbon pricing). It also provides cost estimates on the nature and size of benefits associated with large-scale interconnection (AEMO's "NEMLink" concept).

Market participants

The NTNDP consolidates the regional transmission plans outlined in the TNSP Annual Planning Reports. It also provides network congestion information and a database of modelling inputs to facilitate individual analysis.

The gas industry

The NTNDP shows where and when new gas-powered generation emerges in each scenario. This same information has been used to develop the GSOO gas consumption forecasts. The NTNDP and GSOO are therefore based on a consistent set of scenarios, forecasts and assumptions.

Potential investors and financiers

The NTNDP consolidates TNSP Annual Planning Reports and also shows locations of generation clusters from a least cost modelling perspective. It includes types of new entrant generation under differing future conditions (for example, base load, intermediate and peaking). It provides information on residual network congestion after the least cost expansion of the network, and a database of inputs to enable individual analysis.

Transmission Network Services Providers (TNSPs)

The NTNDP models five nationally consistent market development scenarios. It examines location and timing of network limitations for these scenarios, providing the foundation for more detailed studies. It includes 'least cost' generation expansion plans for these scenarios so that TNSPs can investigate the consequence of variations around these generation expansion plans.

Market institutions

The NTNDP includes a range of 'least cost' market developments to enable assessment of future revenue requirements, and the risks and benefits associated with specific bulk transmission augmentations.

NATIONAL TRANSMISSION NETWORK

The National Transmission Network carries power from generators to major industrial users and local electricity distributors throughout the National Electricity Market. The NEM supports the provision of power to Queensland, New South Wales, the Australian Capital Territory, Victoria, Tasmania and South Australia.

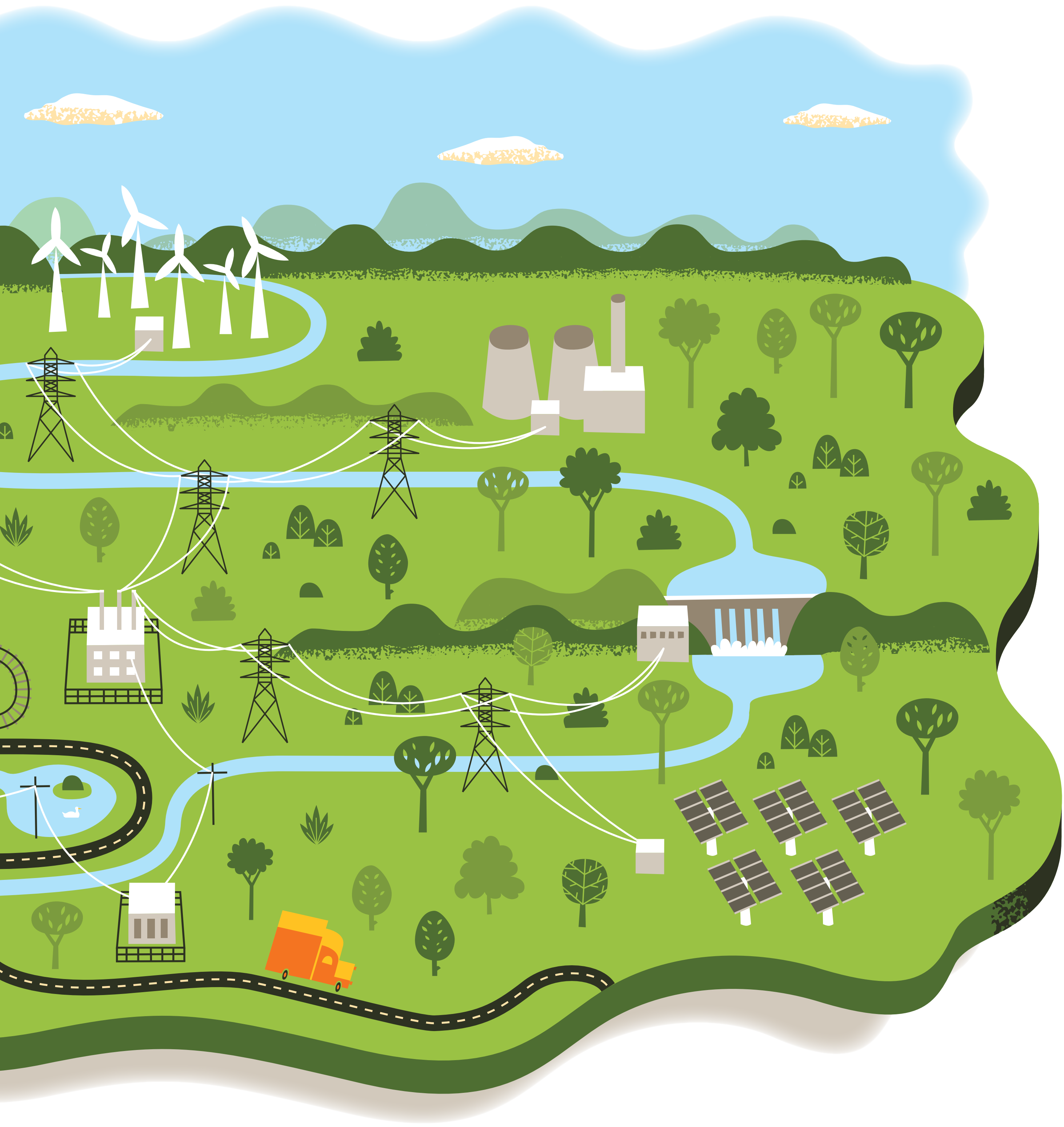
The NEM's National Transmission Network:

- Supports 19M residents.
- Supplies 200,000 GWh of energy to businesses and households each year.
- Extends over 5,000 km from far north Queensland to Tasmania, and westward to Adelaide and Port Augusta and has about 40,000 km of transmission lines and cables.
- Is the longest alternating current (AC) system in the world.
- Comprises strong regional transmission networks connected with modest cross border transmission capability.
- Is long and linear compared to Europe and North America where the power systems are generally more strongly meshed.
- Can be costly to upgrade because of the large distances and resulting high capital costs of new transmission investments.
- Presents challenges for transmission investment because comparatively priced fuels often present efficient alternatives.

Given proposed NEM transmission investment over the next five years, the power system is robust and relatively impervious to many of the potential challenges the energy industry faces. A whole-of-system approach to transmission investment is now required to support the needs of industry, investors and consumers.

The NTNDP examines the future through market development scenarios. These scenarios outline a range of plausible outcomes for key issues and policy settings facing the energy industry and investors.

The power system supports our communities through a fully integrated generation and transmission system which transports power to electricity distributors who deliver it to our homes and businesses. The way we generate electricity will continue to change with increasing demand and new technologies such as smart grids



THE FIVE SCENARIOS

A number of important drivers differentiate the scenarios AEMO modelled. Two of these drivers are carbon price and demand growth. The former is affected by climate change policies while the latter is affected by economic and population growth.

AEMO examined scenarios with various carbon prices. The carbon price evolution in each scenario can range from zero carbon price to high. Commonwealth Treasury carbon price projections were used as inputs.

Figure 1 shows how the carbon price varies over time.

The scenarios consider whether new generation investment will be in the form of larger, centralised power stations or smaller, distributed generation located close to load centres.

Customer choices and responses to price signals are also considered. These will affect investment strategies as they change the nature and extent of consumption. Introduction of new demands, such as electric vehicle charging, can similarly alter the patterns and extent of consumption.

All of the scenarios include the Renewable Energy Target objectives. The modelling incorporates investment strategies where the cost of Renewable Energy Certificates acts to support investment in renewable generation technologies.

Other scenario drivers include technology and fuel costs, both of which are expected to have a material impact on costs, energy demand growth rates and investment.

Table 1 shows how important drivers manifest in each scenario.

Figure 1: Carbon Price Projection

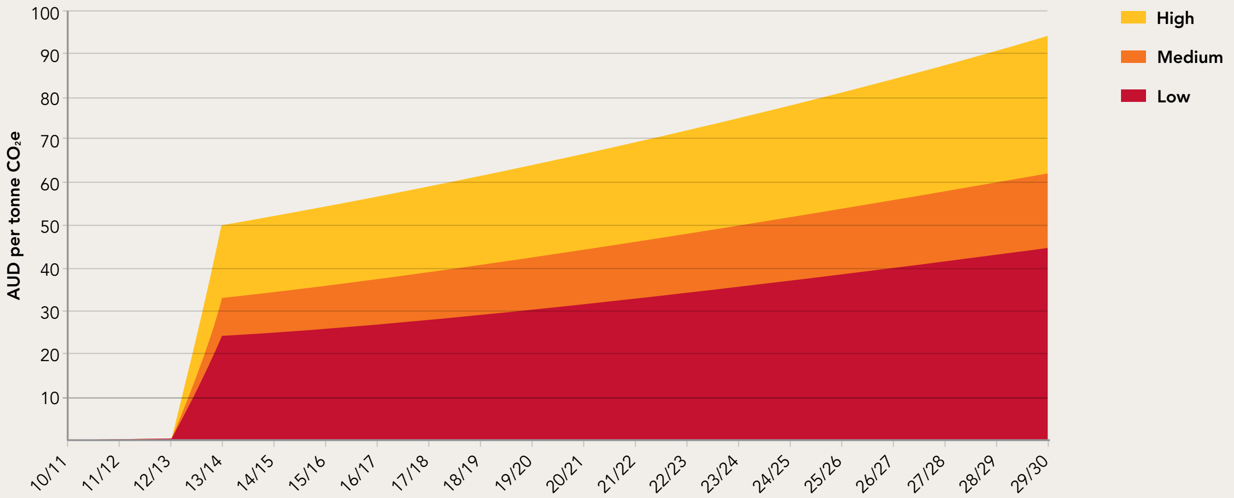


Table 1: Scenario Drivers and Emission Targets

Scenario	Economic growth	Population growth	Global carbon policy	Centralised supply-side response	Decentralised supply-side response	Demand-side response	Emission targets below 2000 levels
Fast Rate of Change	high	high	strong	strong	strong	strong	-25%[3] (sensitivity -15%[2])
Uncertain World	high	high	weak	strong	weak	weak	-5%[1] (sensitivity no carbon price)
Decentralised World	medium	medium	strong	weak	strong	strong	-15%[2] (sensitivity -25%[3])
Oil Shock and Adaptation	low	medium	moderate	moderate (renewable)	weak	weak	-15%[2] (sensitivity -5%[1])
Slow Rate of Change	low (mixed)	low	weak	moderate	weak	weak	-5%[1] (sensitivity no carbon price)

1. The -5% carbon emissions target (low carbon price) is associated with a carbon price trajectory from AUD0 to AUD44 per tonne CO_2e.
2. The -15% carbon emissions target (medium carbon price) is associated with a carbon price trajectory from AUD0 to AUD62 per tonne CO_2e.
3. The -25% carbon emissions target (high carbon price) is associated with a carbon price trajectory from AUD0 to AUD93 per tonne CO_2e.

THE FIVE SCENARIOS

Two important drivers which differentiate the scenarios are carbon price and demand growth.

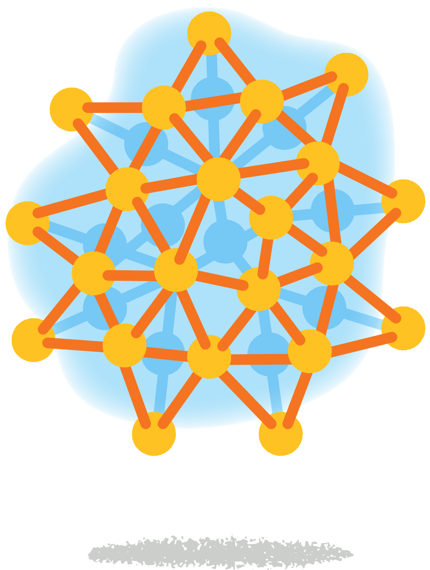
SCENARIO 1
FAST RATE OF CHANGE

In this scenario, the electricity sector transforms rapidly to meet strong emissions targets. Australia remains globally competitive, benefiting from strong international growth. Governments have agreed on targets internationally, which are met by 2030. The transition to a carbon-constrained future has been smooth, and there is sustained high economic and population growth. Demand for electricity is high, energy sources have diversified, emissions have reduced, energy efficiency has improved, and other forms of demand-side participation have emerged.

SCENARIO 2
UNCERTAIN WORLD

In this scenario, carbon policy uncertainty creates barriers for emerging technologies. Strong international demand for Australia's resources drives high economic and population growth, resulting in high energy demand. Emissions targets have been agreed internationally but are constantly reviewed and debated. By 2020, a 20% target for renewable energy generation has been met but not significantly exceeded. Overall, demand for electricity continues to grow and, while consumers support the notion of a low-carbon future, they remain resistant to change.

SCENARIO 3
DECENTRALISED WORLD



Demand-side technologies and distributed generation emerge as low-cost alternatives. All sectors of the Australian economy do well, with intermediate economic growth and medium population growth. Moderate emission reduction targets have been implemented and met in Australia and internationally. Australia's energy network is highly decentralised by 2030 and there has been significant new investment in demand-side technologies. Overall, low gas prices, demand for fuel cells and increased distributed generation result in high domestic gas demand.

SCENARIO 4
OIL SHOCK AND ADAPTATION

A global oil shortage creates high oil and gas prices, leading to low international and domestic economic growth. Higher than expected Carbon Capture and Storage (CCS) costs create greater reliance on centralised, renewable-energy options. Carbon policy is internationally agreed, with moderate emissions reduction targets set for 2050. A weak economy provides consumer incentives to improve energy efficiency, while price responsive demand-side participation remains at average levels and electricity demand is moderate to low.

SCENARIO 5
SLOW RATE OF CHANGE

The electricity sector transforms slowly due to a low rate of international and domestic economic growth, and low population growth. Australia moves towards a service economy, with some manufacturing and energy-intensive industry moving offshore. Australia does not remain globally competitive. Boosting economic activity becomes a priority. Carbon policy is internationally agreed, with low emissions reduction targets set for 2050. Slow demand growth and a low carbon price produce low distributed generation investment and less incentive for governments to set ambitious emissions targets or for consumers to change their behaviour.

ELECTRICITY DEMAND

There is growth in annual energy consumption and peak demand in all of the scenarios AEMO modelled as shown in **Figure 2**.

The growth in energy consumption stems from a number of key factors including economic and population growth.

Figure 3 shows the extent of growth in the number of households expected across the NEM from 2010 to 2030.

Figure 2: Energy Demand

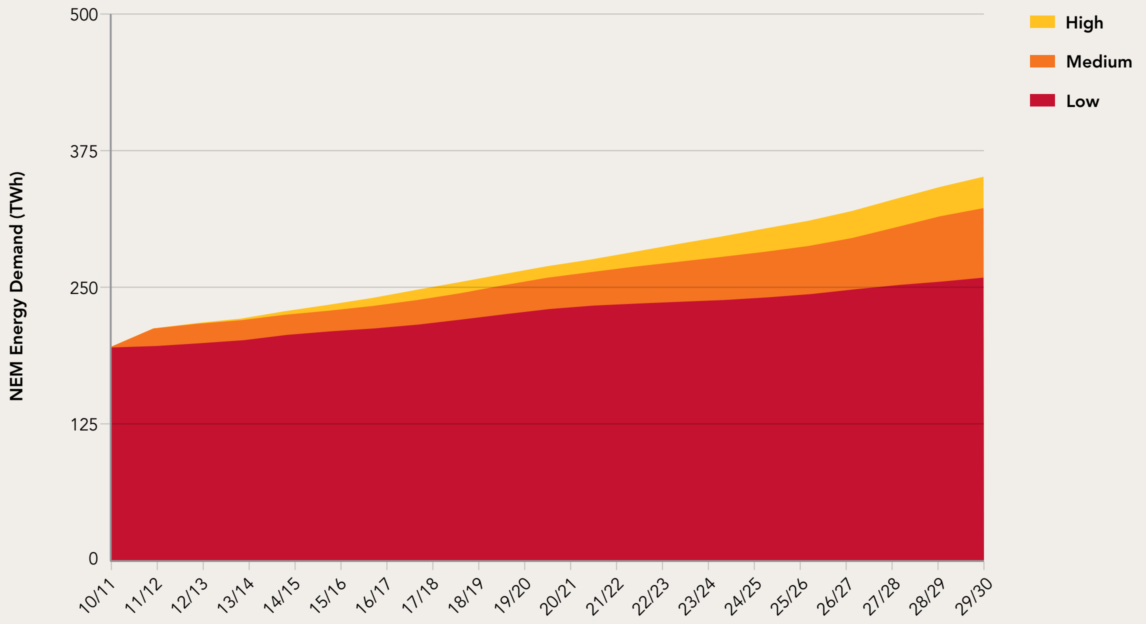
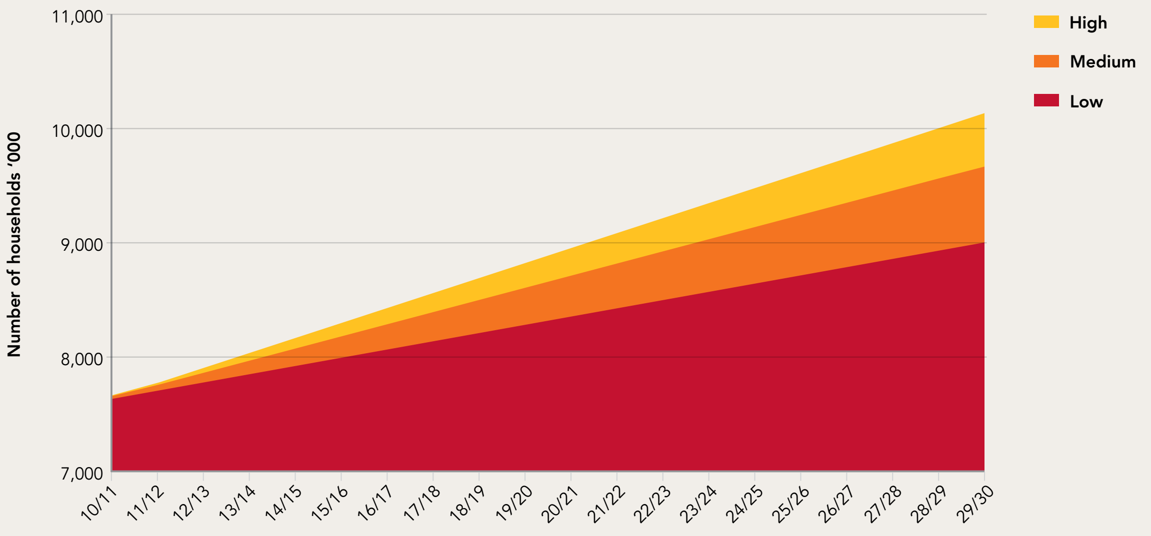


Figure 3: NEM Household Forecasts



GENERATING THE POWER

Gas-powered generation will form the bulk of new generation in the first 10 years, as shown in **Figure 4.**

Over the 20-year study horizon, the generation is typically gas but, in several locations, coal plant is also built.

In relation to gas-powered generation, Southwest Queensland, northern New South Wales and the Latrobe Valley in Victoria are expected to have significant new entry as these zones have relatively low fuel prices.

Coal new entry occurs where carbon capture and sequestration technology is assumed viable or in scenarios with high gas prices and low or no carbon prices.

A moderate to high carbon price will result in significant levels of retirements of brown coal plant in the Latrobe Valley, with replacement gas-powered generation at the location of retired plant. There is significant new entry of gas-powered generation in the Latrobe Valley in the high demand / 25% carbon emission reduction target scenario. This is expected to have a significant impact on Victorian gas reserves. AEMO is further exploring this in the Gas Statement of Opportunities.

AEMO's modelling suggests that retirement of the older and less efficient black coal plant in Queensland (Collinsville) and New South Wales (Liddell and Wallerawang) occurs under a high carbon price, though not to the same extent as retirement of brown coal generation in Victoria.

Figure 5 shows generation retirements across three of the scenarios.

Figure 4: NEM Energy By Technology (TWh) - Fast Rate of Change Scenario

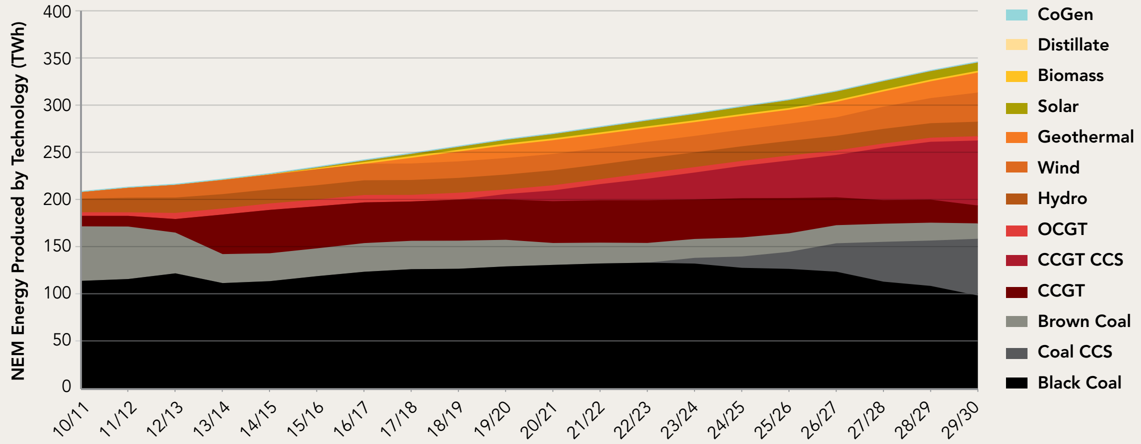
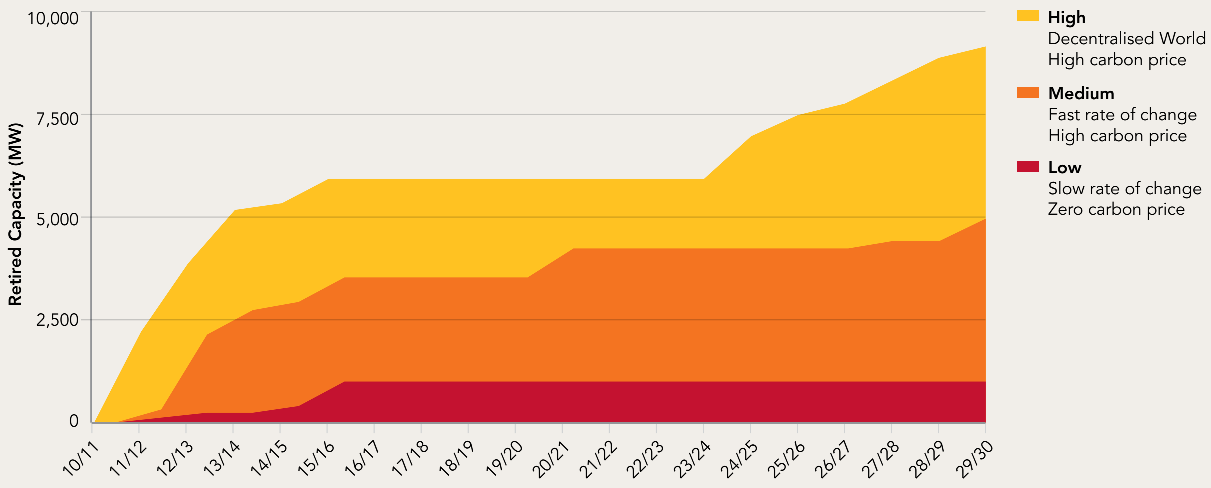


Figure 5: Retirements



OUTCOMES OF THE NTNDP

The NTNDP builds on committed regional transmission network projects and incorporates analysis of future transmission network requirements across the modelled scenarios. The 20 year outlook from this analysis is summarised below. AEMO has identified 4 key areas for consideration.

1. NETWORK OUTCOMES

In Queensland, all scenarios show transmission driven by significant generation investment from south west Queensland to south east Queensland. Investment in south west Queensland is due to:

- Proximity to fuel supplies.
- Plant retirements in south east Queensland. Energy needs require intermediate and base load plant in addition to open cycle gas turbine plants providing peak capacity.
- The potential for air quality requirements to restrict how much generation is located closer to load centres in south east Queensland.

Half the modelled scenarios show potential economic benefits to upgrading the power transfer capability of the Queensland-New South Wales interconnector (QNI).

In New South Wales, many scenarios underscore the need for augmentations to complete the main 500kV transmission ring which circles and supports the major load centres of Sydney, Wollongong and Newcastle. The drivers for this transmission infrastructure include:

- The need to meet increasing demand in the major load centres.
- The 500 kV ring passes through several resource rich areas.
- The cost effective connection of renewable and non-renewable generation plants.

In Victoria, investment will be required to bring more power from south west Victoria and the Latrobe Valley to the metropolitan area (greater Melbourne and Geelong). This investment is driven by:

- Expected demand growth in metropolitan and central Victoria.
- Availability of gas and wind resource, which leads to increased generation in south west Victoria.
- New generation in the Latrobe Valley which replaces plant retirements in the same location.

In South Australia, investment will be required to reinforce the supply from Torrens Island (in the greater Adelaide area) to central Adelaide and to establish significant amounts of wind generation. The drivers for this development include:

- Expected demand growth impacting the Adelaide area (which accounts for 70% of the load).
- 60% to 70% of peak generation capacity is located in the Adelaide area.
- New wind generation plants.

In Tasmania, investment is required to bring more power from the north west and the north east of the state to load centres. The drivers for this include:

- Demand growth (including growth at the major load centre of Hobart).
- New gas fired generation to address peak demand growth.
- New wind generation plants.

In the NTNDP we provide detailed lists of the transmission network developments identified over the first 10 years through our modelling and analysis. This information is summarised by scenario and by zone, including how each zone develops generation and transmission capacity from scenario to scenario.

To link back to the TNSPs' annual planning review processes, AEMO has identified developments that require:

- Early attention to assess economic merit.
- Preparatory work to ensure the need can be addressed should conditions unfold in line with the driving scenarios.
- Monitoring and consideration in future NTNDPs.

A list of these developments is included at the end of this document.

AEMO's analysis focuses on the ability of the main transmission network to support major power transfers between generation and demand centres in the NEM. AEMO's methodology aims to approximate the various jurisdictional planning criteria. However, we have confined the scope to thermal limitations on the main transmission network that arise during diversified regional peak demands, providing an appropriate balance for a long-term, NEM-wide view.

In addition to the augmentations identified in the NTNDP, investment will be required to address more localised supply issues, replace aged assets and address other issues such as providing voltage support.

Transmission Network Augmentations Identified Under Fast Rate of Change Scenario

2. GENERATION CLUSTERS

The NTNDP also provides a NEM-wide view of the areas where future generation may be clustered to make the best use of both renewable (biomass, solar, geothermal and wind) and non-renewable (coal and gas) resources.

This NEM-wide view, coupled with wide ranging scenarios, enabled AEMO to develop a comprehensive information resource on potential future development of the NEM and where generation can be clustered to make use of previously unexploited resources or to significantly increase the use of existing resources.

The location of these generation clusters is an important outcome of the national planning process, allowing planners to develop efficient connecting transmission and minimise overall costs to both customers and generators.

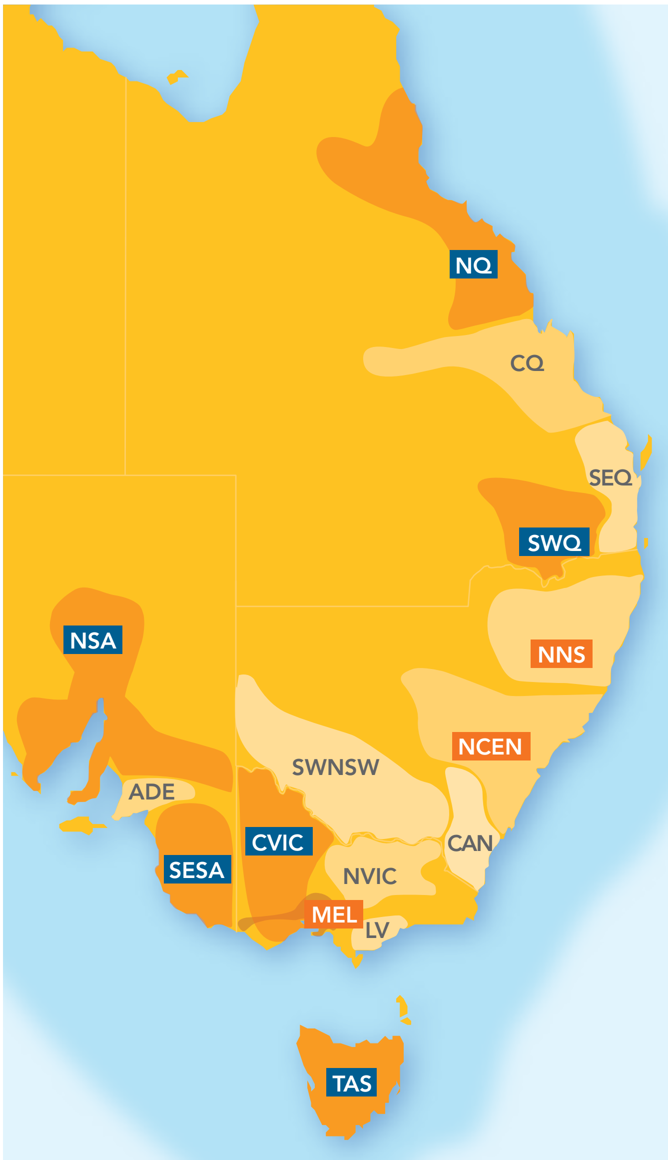
Based on new-entry generation from NTNDP modelling, the leading development zones are:

- North Queensland
- Southwest Queensland
- Country Victoria
- Southeast South Australia
- Northern South Australia
- Tasmania

AEMO also modelled development zones based on connection enquiries and current interest shown by investors. This modelling identified the following additional zones:

- Northern New South Wales
- Central New South Wales
- Melbourne

Generation Clusters



Leading zones based on NTNDP results

NQ	**NTNDP results (max): 1800 MW** 11 Units; Biomass and Solar **Generation interest (max): 390 MW** 7 Units; Hydro and Wind
SWQ	**NTNDP results (max): 8650 MW** 15 Units; Coal, CCGT, Geothermal and Wind **Generation interest (max): 2585 MW** 6 Units; Coal, Gas, Wind and Solar
CVIC	**NTNDP results (max): 2250 MW** 11 Units; Geothermal and Wind **Generation interest (max): 2090 MW** 15 Units; Wind and Solar
SESA	**NTNDP results (max): 1500 MW** 9 Units; Biomass, Geothermal and Wind **Generation interest (max): 1395 MW** <5 Units; Wind
NSA	**NTNDP results (max): 2400 MW** 12 Units; Geothermal and Wind **Generation interest (max): 5315 MW** 27 Units; Coal, Gas, Wind, Solar and Geothermal
TAS	**NTNDP results (max): 2350 MW** 13 Units; Wind and Biomass **Generation interest (max): 998 MW** <5 Units; Wind and Biomass

Zones with significant investor interest

NNS	**Generation interest (max): 4000 MW** 20 Units; Wind and Solar **NTNDP results (max): 7100 MW** 15 Units; CCGT and Biomass (also Wind in other scenarios)
NCEN	**Generation interest (max): 9700 MW** 28 Units; Coal, Gas, Wind and Solar **NTNDP results (max): 1600 MW** 3 Units; Coal and Biomass (also CCGT in other scenarios)
MEL	**Generation interest (max): 6260 MW** 23 Units; Gas and Wind **NTNDP results (max): 2100 MW** 11 Units; Wind

3. LARGE-SCALE INTERCONNECTION – NEMLINK

As part of a longer term vision and to initiate discussion on the topic, AEMO modelled the impact of significantly increasing transmission capacity between the NEM regions. "NEMLink" has the potential to allow a largely unconstrained and reliable interchange of energy across the entire NEM by extending and connecting the existing and planned 500 kV networks, and developing a second DC link to Tasmania. The resulting 500 kV network would extend from Queensland, through New South Wales and Victoria to South Australia.

Benefits of NEMLink include greater operational flexibility, an ability to locate new generation more effectively, and enhanced opportunities to share reserves. A concrete example of NEMLink's operating benefits would be its capacity to balance the variability of wind or solar generation in one part of the NEM with hydro in the centre of the NEM and Tasmania.

AEMO modelled NEMLink as being fully implemented in 2021. As this is a high level analysis, the assessment of costs and benefits is limited and we have not attempted to optimise the timing or assess which parts of the project deliver greater benefits.

The NEMLink project has an estimated cost of around $8.3 billion in 2010 dollars. The benefits were assessed for two of the scenarios – a high demand growth, high carbon price scenario (Fast Change) and a high growth, zero carbon price scenario (Uncertain World). The results of the high-level analysis are shown in **Table 2**, which uses discount rates reflecting the economic conditions assumed for the scenarios.

NEMLink challenges the current regional character of the NEM, addressing the need for a truly national grid. NEMLink could also provide for secure inter-regional trade and enhance competition.

The NEMLink project was developed with input from TNSPs and represents one view of a logical future extension of existing and planned 500 kV regional networks. As such, it could form a useful framework for future regional developments that could serve dual roles of meeting regional requirements and forming a link in the NEMLink chain.

Table 2: NEMLink transmission costs, gross market benefits, and cost benefit ratio

Scenario	PV Transmission Costs (+/- 30%) ($B)	PV Gross Market Benefits ($B)	Cost Benefit Ratio
Fast Rate of Change (FC-H)	4.4	3.9	0.9
Uncertain World (UW-0)	3.3	1.7	0.5

The NEMLink Concept

4. RENEWABLE ENERGY

The future energy framework is crucial to meeting local and international expectations of cleaner energy. AEMO has incorporated the Federal Government's Renewable Energy Target (RET) in the NTNDP modelling. The RET scheme is designed to deliver on the Government's commitment to ensure that 20 per cent of Australia's electricity supply will come from renewable sources by 2020.

The Large-scale Renewable Energy Target (LRET) is the prime driver of renewable electricity generation over the next 10 years across all scenarios.

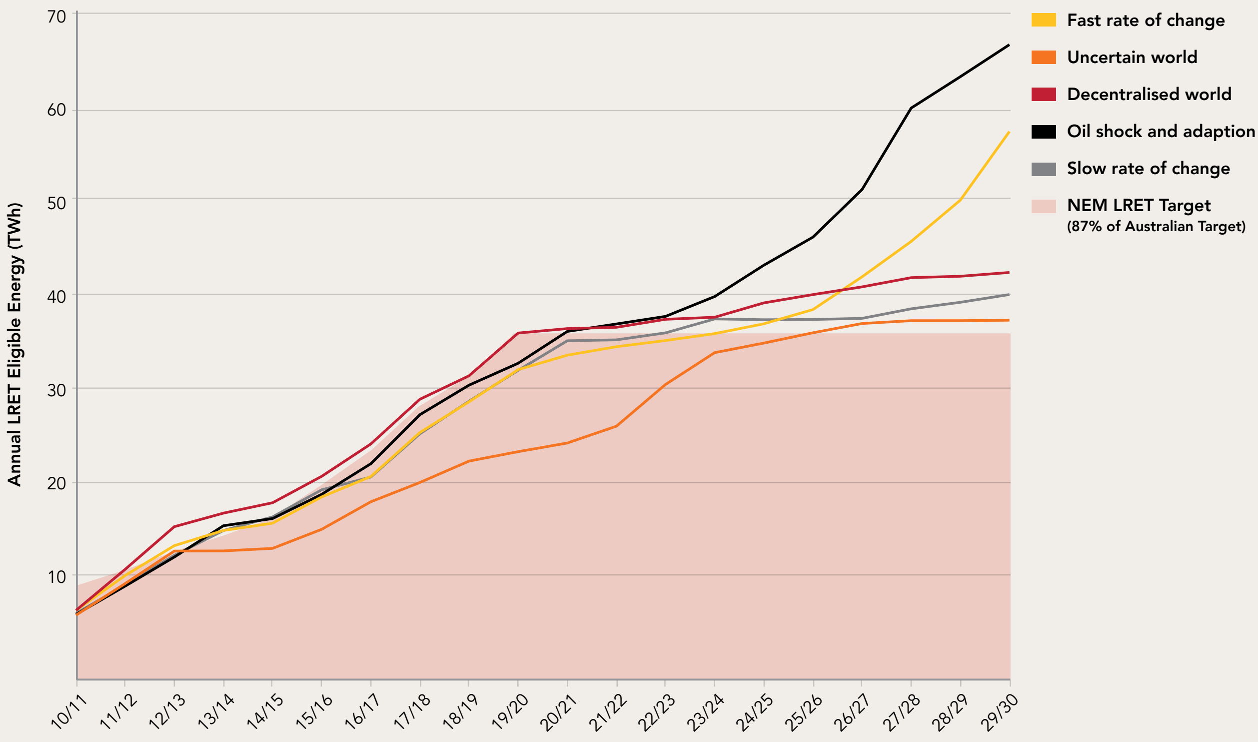
Wind power is the main technology in the first 10 years. The second 10 years will see the emergence of new technologies like geothermal and solar thermal power.

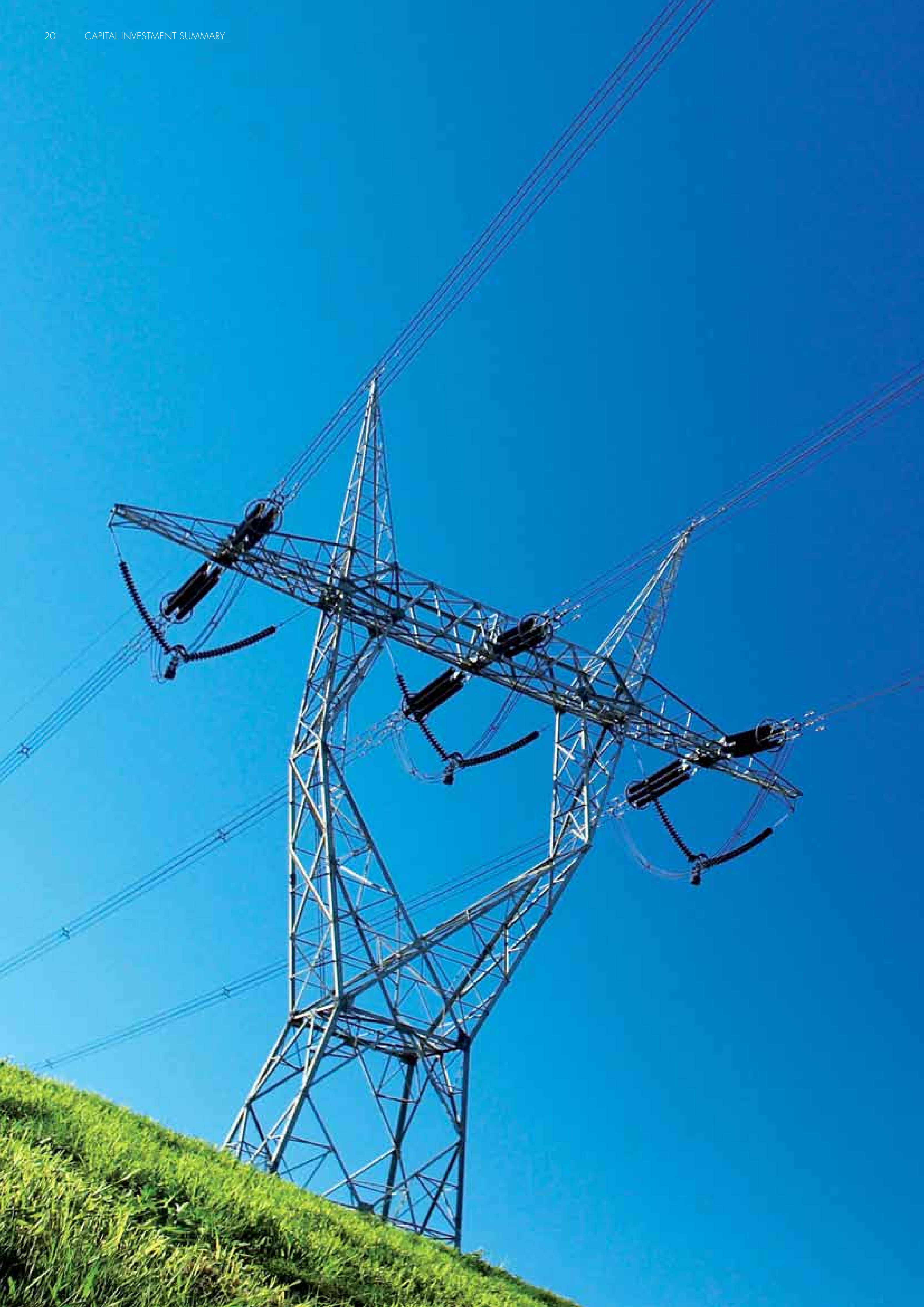
Where there is an assumed carbon price, LRET achieves its objectives largely through new wind and biomass generation but later through commercially viable technologies like geothermal and solar thermal. Most of the geothermal generation is built in country Victoria and South Australia.

Figure 6 shows the rate of renewable investment over 20 years. Once the LRET scheme is fully subscribed there is an investment pause of about six to seven years before carbon prices and technology costs make wind and other renewable generation competitive in its own right.

North and central Queensland benefit from solar power due to ideal conditions for this power source.

Figure 6: LRET Generation





CAPITAL INVESTMENT SUMMARY

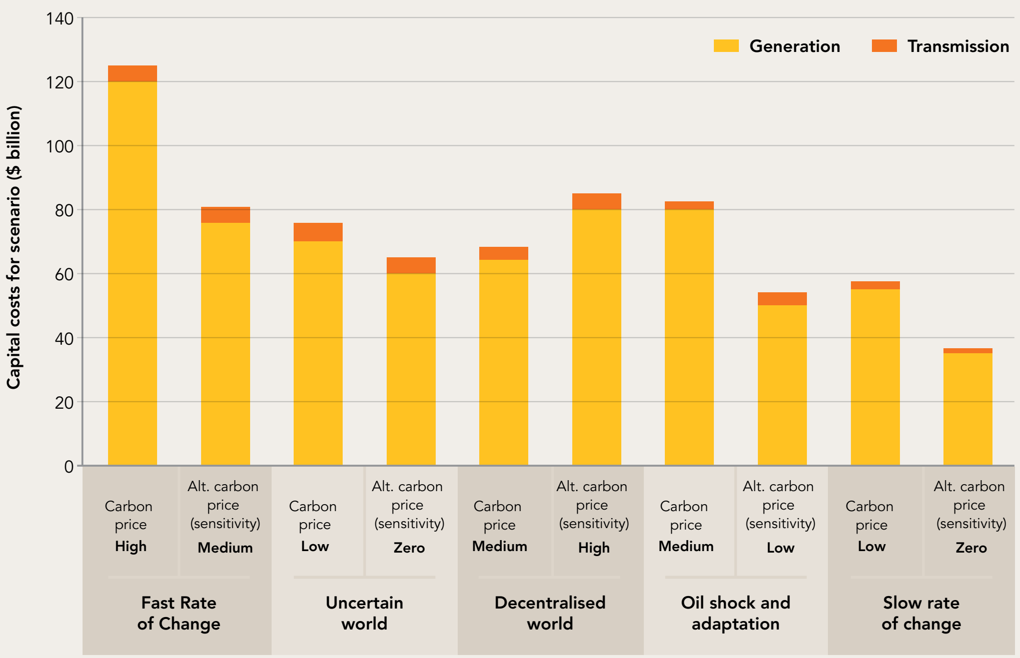
Based on AEMO's scenario modelling, between $4 to $9 billion in investment (which includes the TNSPs' committed expenditure) is required for augmentation of the shared transmission network across the NEM. This transmission, which does not include the cost of NEMLink, is required to support investment of between $35 and $120 billion in development of new generation assets to meet demand over the next twenty years.

The decision to make these transmission investments rests with TNSPs in each jurisdiction. Some of these investments will be regional and handled by one TNSP, but some will be across regions which will require two or more TNSPs to decide on and fund the necessary investments. An example of this would be NEMLink which would require a coordinated effort across five regions.

The key drivers for the range of capital costs are growth in demand and climate change policy. The highest capital expenditure is seen where there is a combination of high economic growth and higher carbon reduction targets. Conversely, the lowest expenditure is seen where there is low economic growth coupled with low carbon reduction targets.

Figure 7 sets out the capital expenditure requirements over the next 20 years.

Figure 7: Scenario Capital Costs



ORIGINS OF THE NTNDP

The inception of the NTNDP follows a report by the Energy Reform Implementation Group (ERIG) to the Council of Australian Governments (COAG) in 2007. COAG endorsed the ERIG report and its recommendations, including the creation of AEMO and strengthened national transmission planning arrangements.

COAG and the Ministerial Council on Energy (MCE) required that:

- AEMO be directly responsible for undertaking the functions of the National Transmission Planner.
- AEMO publish an NTNDP each year outlining the long-term, efficient development of the power system, including future and current capability of the national transmission network and development options.

COAG recognised the importance of AEMO's national transmission planning function and agreed to establish an enhanced planning process for the national transmission network to ensure a more strategic and nationally coordinated approach to transmission network development.

The MCE also required that a transitional document, the National Transmission Statement, be published prior to the first NTNDP. The National Transmission Statement was published in 2009.

SUMMARY OF 10 YEAR TRANSMISSION NETWORK DEVELOPMENTS

The following tables show the transmission network developments identified in the NTNDP over the next 10 years under at least one scenario. AEMO has categorised these developments on the basis of the timeframe over which the triggers were identified, how sensitive the triggers are to future conditions, and the risk and consequence of not doing preparatory work. In categorising the developments, AEMO has applied the following guiding criteria:

Category	Trigger timing	Opportunity cost
Early attention	Development is triggered in the first five-year period under most scenarios and in the second five-year period in most of the remaining ones	High opportunity cost if not done (or have limited or expensive work-arounds)
Preparatory work	Development is generally triggered in the second five-year period in most scenarios but maybe later in others	High opportunity cost if it turns out that it is needed and it requires some long lead-time works (e.g. easement acquisition)
Monitoring	Development is triggered in the first or second five-year period in some scenarios	Likely to have work-arounds if the triggering conditions unfold (i.e. relatively low opportunity cost if the development is delivered late)

QUEENSLAND

Dev No	Transmission development	Rating	Status
QN1	Series compensation on the 330 kV Armidale-Dumaresq circuits and 330 kV Dumaresq-Bulli Creek circuits	Early attention	Powerlink and TransGrid advise they are investigating the economic viability and an optimal timing of a QNI upgrade (Powerlink 2010 APR, Section 5.2.3, TransGrid 2010 APR, Section 6.3.4)
Q1	A new Ross-Chalumbin double circuit line (single circuit strung)	Preparatory work	Powerlink advises that planned works to upgrade the 132 kV system north of Yabulu may also address this issue
Q2	Stringing an additional 275 kV Stanwell-Broadsound circuit	Monitoring	Powerlink 2010 APR, Chapter 4, Section 4.5.3, Appendix G, Table G.2
Q3	275 kV Broadsound-Nebo series capacitors	Monitoring	Powerlink 2010 APR, Appendix G, Table G.2
Q4	A new 275 kV Calvale-Stanwell double circuit line	Preparatory work	Powerlink Regulatory Test Final Report (27/9/10), 'Maintaining a reliable electricity supply within Central Queensland' (http://www.powerlink.com.au/data/portal/00005056/content/06049001285550212538.pdf)
Q10	A new 500 kV Halys-Greenbank double circuit line (initially operating at 275 kV)	Preparatory work	Powerlink 2010 APR, Appendix G, Table G.2
Q11	A new 500 kV Western Downs-Halys double circuit line (northern route first build) initially operating at 275 kV	Preparatory work	Powerlink 2010 APR Appendix G, Table G.2
Q14	A new 275 kV Blackwall-Belmont double circuit line	Early attention	Powerlink's 2010 APR, Chapter 4, Section 4.5.6, outlines a number of projects involving new construction and line rearrangements between Blackwall and Brisbane
Q15	New Blackwall-South Pine 275 kV double circuit line	Early attention	Powerlink's 2010 APR, Chapter 4, Section 4.5.6, outlines a number of projects involving new construction and line rearrangements between Blackwall and Brisbane
Q16	New Loganlea-Greenbank 275 kV double circuit line (one circuit strung)	Preparatory work	Powerlink's 2010 APR, Chapter 4, Section 4.5.6, outlines a number of projects involving new construction and line rearrangements between Blackwall and Brisbane

NEW SOUTH WALES

Dev No	Transmission development	Rating	Status
QN1	Series compensation on 330 kV Armidale-Dumaresq circuits and 330 kV Dumaresq-Bulli Creek circuits	Early attention	Powerlink and TransGrid advise they are investigating the economic viability and optimal timing of a QNI upgrade (Powerlink 2010 APR, Section 5.2.3, TransGrid 2010 APR, Section 6.3.4)
NV1	A new 220 kV, 250 MVA phase angle regulator on the 220 kV Buronga-Red Cliffs line	Preparatory work	AEMO and ElectraNet are intending to investigate the ongoing requirements for South Australian imports over Murraylink, and options to support load growth in the Riverland and other areas. AEMO and TransGrid are intending to investigate the impacts for the New South Wales system from high Murraylink power transfers at time of peak demand.
NV2	A Victoria-New South Wales interconnector upgrade	Preparatory work	AEMO and TransGrid are intending to investigate the benefits of upgrading the Vic-NSW interconnection
N4	A 500 kV Hunter Valley-Eraring (via Newcastle) development	Early attention	TransGrid advises a 7-year time-frame for development of the 500 kV system supporting the Newcastle-Sydney-Wollongong load area (TransGrid 2010 APR, Section 6.4.5, TransGrid Strategic Network Development Plan 2008, Section 3.5)
N5	Replace the 500/330 kV Eraring Power Station transformer with a 1,500 MVA unit, and add a new parallel 500/330 kV Eraring Power Station transformer	Early attention	TransGrid has proposed installing a second 500/330 kV transformer to address stability issues (TransGrid 2010 APR, Section 6.2.9)
N7/8	500 kV Hunter Valley-Northern New South Wales developments	Monitoring	TransGrid describes replacing the 330 kV lines in this area with 500 kV as longer-term plans (TransGrid 2010 APR, Section 6.4.2)

N9	Upgrade terminal equipment on 330 kV Ingleburn-Wallerawang Power Station to achieve full line rating. Address attendant voltage control issues for 330 kV Sydney system	Monitoring line issues and early attention to voltage control issues	TransGrid is addressing this voltage control issue as part of its reactive planning
N10	Additional 330 kV Mt Piper-Wallerawang circuit	Early attention	NTNDP studies indicate the need for this augmentation depends on the retirement/output levels of Wallerawang Power Station generating units. Further planning work is being progressed by TransGrid (TransGrid 2010 APR, Section 6.4)

VICTORIA

Dev No	Transmission development	Rating	Status
V1	A new 500 kV Loy Yang-Hazelwood line	Monitoring	Victorian 2010 APR, Section 9.3.1
V5	A new 500/220 kV 1,000 MVA transformer at Ringwood, Rowville, or Cranbourne	Early attention	AEMO is undertaking an assessment of the available network and non-network options as part of the 2011 APR (Victorian 2010 APR, Section 9.3.4)
V6	An additional 500/220 kV 1,000 MVA transformer at Ringwood, Rowville, or Cranbourne	Preparatory work	AEMO is undertaking an assessment of the available network and non-network options as part of the 2011 APR (Victorian 2010 APR, Section 9.3.4)
V7	Re-conductor the 220 kV Rowville-Springvale line	Preparatory work	This limitation is observed beyond the first 5-year period. AEMO will monitor the load at the Springvale and/or Heatherton terminal stations and identify available network and non-network options including necessary lead-times (Victorian 2010 APR, Section 9.3.4)
V8	A new 500 kV Moorabool-Mortlake/Heywood line (third line)	Monitoring	This augmentation is triggered by new generation connections to the 500 kV Moorabool-Mortlake/Heywood line. AEMO will consider its as part of new generation connection enquiries on the line (Victorian 2010 APR, Section 9.3.2)
V9	A new 330/220 kV 700 MVA transformer at South Morang (third transformer), and a cut-in of the 220 kV Rowville-Thomastown circuit at South Morang to form a third 220 kV South Morang-Thomastown line	Preparatory work	AEMO is undertaking an assessment of the available network and non-network options as part of the 2011 APR (Victorian 2010 APR, Section 9.3.4)
V15	An additional 500/220 kV 1,000 MVA transformer in the western part of the Greater Melbourne Metropolitan Area	Monitoring	This augmentation is triggered in the first 10 years by the combination of high demand growth and lack of new generation south of Geelong. AEMO will monitor the progress of these factors.
NV2	A Victoria-New South Wales interconnector upgrade	Preparatory work	AEMO and TransGrid are intending to investigate the benefits of upgrading the Vic-NSW interconnector
V16	Cut-in on the 220 kV Eildon-Thomastown line at South Morang	Monitoring	This augmentation is triggered in the first 10 years by the combination of high demand growth and increased imports from New South Wales as a result of an interconnector upgrade. AEMO will consider the need for this augmentation as part of investigations into an upgrade of the Victoria-New South Wales capability (Victorian 2010 APR, Sections 9.3.4, Section 9.3.3)
V22	A new 330/220 kV Dederang transformer (fourth)	Monitoring	This augmentation is triggered in the first 10 years by the combination of high demand growth and increased imports from New South Wales as a result of an interconnector upgrade. AEMO will consider the need for this augmentation as part of investigations into an upgrade of the Victoria-New South Wales capability (Victorian 2010 APR, Sections 9.3.4, Section 9.3.3)
V28	A new 220 kV Ballarat-Moorabool line (third line)	Early attention	AEMO is undertaking a detailed assessment as part of the 2011 APR of the constraint that triggers this augmentation (Victorian 2010 APR, Section 9.3.5)
NV1	A new 220 kV, 250 MVA phase angle regulator on the 220 kV Buronga-Red Cliffs interconnection	Early attention	AEMO and ElectraNet are intending to investigate the ongoing requirements for South Australian imports over Murraylink, and options to support load growth in the Riverland and other areas. AEMO and TransGrid are intending to investigate the impacts for the New South Wales system from high Murraylink power transfers at time of peak demand.

V29	Replace the existing, single circuit 220 kV Ballarat-Bendigo line with a 220 kV double circuit line	Early attention	These limitations are triggered by demand growth in CVIC and high power transfers to South Australia via Murraylink. AEMO is intending to undertake an assessment of these limitations (Victorian 2010 APR, Section 9.3.5)
V31	Uprate the existing 220 kV Ballarat-Bendigo line	Early attention	These limitations are triggered by demand growth in CVIC and high power transfers to South Australia via Murraylink. AEMO is intending to undertake an assessment of these limitations (Victorian 2010 APR, Section 9.3.5)
V32	Replace the existing, single circuit 220 kV Bendigo-Kerang line with a new 220 kV double circuit line	Monitoring	These limitations are triggered by demand growth in CVIC and high power transfers to South Australia via Murraylink. AEMO is intending to undertake an assessment of these limitations (Victorian 2010 APR, Section 9.3.5)
V34	Replace the existing 220 kV Kerang-Wemen-Red Cliffs single circuit line with a new 220 kV double circuit line	Monitoring	These limitations are triggered by demand growth in CVIC and high power transfers to South Australia via Murraylink. AEMO is intending to undertake an assessment of these limitations (Victorian 2010 APR, Section 9.3.5)
V30	Uprate the existing 220 kV Geelong-Moorabool lines	Early attention	AEMO is currently undertaking a detailed assessment of this limitation and options to address it (Victorian 2010 APR, Section 9.3.5)

SOUTH AUSTRALIA

Dev No	Transmission development	Rating	Status
S4	Establish the second 275 kV Davenport-Cultana line and reinforce the 275/132 kV transformation capacity at Cultana. Rearrange the 132 kV Davenport-Whyalla and Whyalla - Middleback/Yadnarie lines	Early attention	ElectraNet commenced a Regulatory Test for this project in July 2010 (http://www.electranet.com.au/project_detail.php?id=34) and ElectraNet APR 2010, Section 17.4.
S5	Establish a 275/132 kV injection point in the vicinity of Hummocks with one 200 MVA transformer, and construct a 275 kV double circuit line from the existing west circuit to the substation location	Preparatory work	This augmentation is driven by demand growth in the South Australian mid north region. On the basis of local peak demands in the region, the ElectraNet APR identifies a timing of 2018 (ElectraNet 2010 APR, Section 14.4.1, Table 14-1)
S8	Install 275 kV series compensation between the South East Substation and the Tailem Bend Substation	Monitoring	ElectraNet 2010 APR, Section 11.2.2, Table 11-1
NV1	A new 220 kV, 250 MVA phase angle regulator on the 220 kV Buronga-Red Cliffs interconnection	Early attention	AEMO and ElectraNet are intending to investigate the ongoing requirements for South Australian imports over Murraylink, and options to support load growth in the Riverland and other areas. AEMO and TransGrid are intending to investigate the impacts for the New South Wales system from high Murraylink power transfers at time of peak demand.

TASMANIA

Dev No	Transmission development	Rating	Status
T1	Configure Waddamana switching, and upgrade the 110 kV Palmerston-Waddamana line to 220 kV operation	Early attention	Transend advises it is currently making a detailed assessment of this limitation
T2	Uprate the 110 kV Norwood-Scottsdale line, or connect new generation to the 220 kV transmission network along the Hadspen-George Town corridor	Early attention	Transend advises it is investigating as part of new connection enquiries/applications
T3	Replace the existing 220 kV Burnie-Sheffield single circuit line with a new 220 kV double circuit line	Early attention	This limitation is recognised in the Transend report: 'Future wind generation in Tasmania' published in May 2009
T4	A new 220 kV Sheffield-Palmerston double circuit line	Early attention	Transend 2010 APR, Section 2.3.2, and Transend report: 'Future wind generation in Tasmania' published in May 2009
T5	A new 220/110 kV transformer in the Hobart area	Monitoring	

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