Survey of Evidence on the Implications of Climate Change Policies for Energy Markets.

Supporting paper to 1st Interim Report - Review Of Energy Markets in light of Climate Change Policies

AEMC Staff Paper

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Inquiries

The Australian Energy Market Commission

PO Box A2449

Sydney South NSW 1235

E: aemc@aemc.gov.au

T: (02) 8296 7800

F: (02) 8296 7899

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About the AEMC

The Council of Australian Governments, through its Ministerial Council on Energy, established the Australian Energy Market Commission (AEMC) in July 2005 to be the Rule maker for national energy markets. The AEMC is currently responsible for Rules and policy advice covering the National Electricity Market and elements of the natural gas markets. It is an independent, national body. Our key responsibilities are to consider Rule change proposals, conduct energy market reviews and provide policy advice to the Ministerial Council on Energy as requested, or on AEMC initiative.

This report has been prepared by AEMC staff to support the analysis of issues for the Review of Energy Markets in light of Climate Change Policies. The content of this paper does not necessarily represent the views of the Commission.

Executive Summary

Scope

This document surveys and summarises a range of available quantitative evidence on how behaviour in energy markets might change as a result of the Australian Government's proposed Carbon Pollution Reduction Scheme (CPRS) and the 20 per cent national Renewable Energy Target (expanded RET). It collates a range of modelling studies and other analytical work, including work commissioned by the AEMC.

This document does not comment on the quality or robustness of the different sources of evidence. Nor does it imply any particular weighting of the evidence by the AEMC in formulating its views.

Purpose

The primary purpose of this survey of evidence is to inform stakeholders and facilitate effective consultation on the AEMC's review of energy market frameworks. The AEMC will continue to analyse this evidence, and new evidence that emerges over time, to inform its review findings. Stakeholders views on the relevance and appropriate interpretation of the available evidence will help the AEMC in developing its thinking and formulating its recommendations.

The AEMC has been directed by the Ministerial Council of Energy (MCE) to undertake a Review of the need to amend energy market frameworks in light of the CPRS and expanded RET. This work therefore has been undertaken to assist the AEMC understand the range of potential scenarios that may occur following the implementation of CPRS and expanded RET.

The Review is looking at implications up to 2020, however, we do appreciate that potential development post 2020 may influence investment decisions in this period. We are particularly focusing on scenarios that are credible but place the existing frameworks under pressure against their objectives of promoting efficiency, security and reliability. This document is supporting material to the 1st Interim Report for the Review.[1]

The 1st Interim Report identifies those priority issues where it is considered that there is a potential need for amendments to the existing energy market frameworks. Based on stakeholder feedback and further analysis, this will form input into the second stage of the Review and the development of the 2nd Interim Report, expected to be published in June 2009.

The 2nd Interim Report is intended to outline what changes the AEMC considers may need to be made to address the issues identified. The AEMC will provide our final advice regarding the Review to the MCE in September 2009.

1 A copy of the 1st Interim Report can be found at www.aemc.gov.au.

White Paper

The Australian Government released the White Paper on the design of the CRPS on 15 December 2008.[2] To help inform the Government's decision making in relation to the Electricity Sector Adjustment Scheme for the CPRS, the Department of Climate Change commissioned ACIL Tasman Pty Ltd and ROAM Consulting Pty Ltd to undertake specific electricity sector modelling to supplement the work undertaken by MMA.

These reports were released in conjunction with the recently released White Paper on CPRS and shed light on the questions being addressed under this Review. Due to the time constraints, we have not incorporated this new evidence into the body of this document. Instead we provide a summary of its key results in chapter one. The AEMC will give careful consideration to this new information, and would welcome views from stakeholders on its implications, as well all the evidence presented in this paper, for the issues discussed in the 1st Interim Report.

Sources and modelling approaches

This document brings together and surveys the range of modelling and analysis that has been undertaken to understand the impact of the Carbon Pollution Reduction Scheme (CPRS) and the expanded Renewable Energy Target (RET), on the existing energy market frameworks. The information includes modelling undertaken by:

- McLennan Magasanik Associates (MMA) for the Australian Government Department of The Treasury (this is referred to as the MMA Treasury modelling in this paper)
- ACIL Tasman for the Energy Supply Association of Australia (ACIL Tasman); and
- CRA Ltd for the National Generators Forum.

The AEMC has not undertaken specific modelling of the implications of the CPRS and expanded RET but has commissioned analysis from ROAM Consulting, Frontier Economics and MMA (MMA/AEMC).[3] Relevant aspects of their advice are also included in this survey.

All modelling had a common purpose, that is: to understand the impact of the CPRS and expanded RET on the electricity/gas industry, electricity prices and emissions from electricity generation, compared to a business as usual scenario. The architecture of the models are similar in a number of key areas:

- they all involve calculations that seek the least costly way to meet a defined level of demand; and

2 Australian Government, *Carbon Pollution Reduction Scheme – Australia's low Pollution Future*, White Paper, Volume 1 and 2, 15 December 2008.

3 These reports are available on the AEMC website.

- involve a mathematical representation of the power system and require assumptions on the behaviour of market participants, and expected costs of existing and future generation technologies.

There are some differences in the modelling approaches.

- The MMA Treasury modelling exercise allowed for the importation of carbon permits into the Australian CPRS. Without a binding limit on international permits the Australian Treasury modelling found that the Australian carbon price was set equal to the international price. This international carbon price applied across all covered sectors in the CPRS, not just the electricity generation sector.

- The ACIL Tasman modelling and CRA modelling set a target for the quantity of emissions reduction to be provided by the domestic electricity sector and determines the permit price necessary to achieve that reduction. Their models only applied a carbon price to the electricity sector.

- The CRA and ACIL Tasman models used the emission price as an input variable. This price was progressively increased until the 2020 emission reduction targets for the electricity sector were met. The emission prices in the CRA and ACIL Tasman models can therefore be interpreted to be the prices needed to deliver the specified emissions reductions in the sector.

The specific CPRS modelling scenarios that are featured in this report are as follows. All scenarios assume the expanded RET is in place:[4]

- MMA Treasury: CPRS -5: This scenario assumes that Australian net emission allocation is 5 per cent below 2000 emission levels by 2020.

- MMA Treasury: CPRS -15: This scenario assumes that Australian net emission allocation is 15 per cent below 2000 emission levels by 2020.

- ACIL Tasman: 10 per cent: This scenario is designed to ensure that emissions from the electricity sector in Australia are 10 per cent below 2000 levels in 2020.

- ACIL Tasman: 20 per cent: This scenario is designed to ensure that emissions from the electricity sector in Australia are 20 per cent below 2000 levels in 2020.

- CRA: –7 per cent: This scenario is designed to ensure that emissions from the electricity sector in Australia are 7 per cent below 2000 levels in 2020.

4 The MMA Treasury modelling also model scenarios for the emission trading scheme starting in 2013, with reductions in net Australian emission allocations of either 10 per cent or 25 per cent below 2000 levels by 2020 (Garanut -10 and Garanut -25), and also a scenario with the emission trading scheme starting on 2010, with 5 per cent reductions and the expanded RET excluded (CPRS only).

Survey of the Evidence

It is important to note that each piece of modelling was undertaken for a different specific purpose and as noted, generally using different assumptions and approaches. Also, the modelling undertaken is an attempt to understand and predict the future. However for a number of reasons, modelling can fail to accurately predict future outcomes. For example, the modelling assumes that new generation entry will occur in a timely manner in response to the wholesale price signals. However there is a risk that the required investment may be delayed. A report prepared by Sinclair Knight Mertz for the Commission details the timing, steps and issues involved in commissioning new generation in the NEM.[5]

Therefore, the value of the evidence given the inherent uncertainty of economic modelling, is in defining ranges of possible but potentially significant impact outcomes, rather than providing a definitive answer.

Key factors

The CPRS will place a price on emissions of greenhouse gas emissions. These emissions are currently unpriced. This will have significant impacts in energy markets because of the carbon-intensity of the activities involved. The expanded RET will subsidise eligible renewable energy. Under the proposed arrangements, most of the subsidy will be borne by electricity users. This also has a direct impact on energy markets and how they operate.

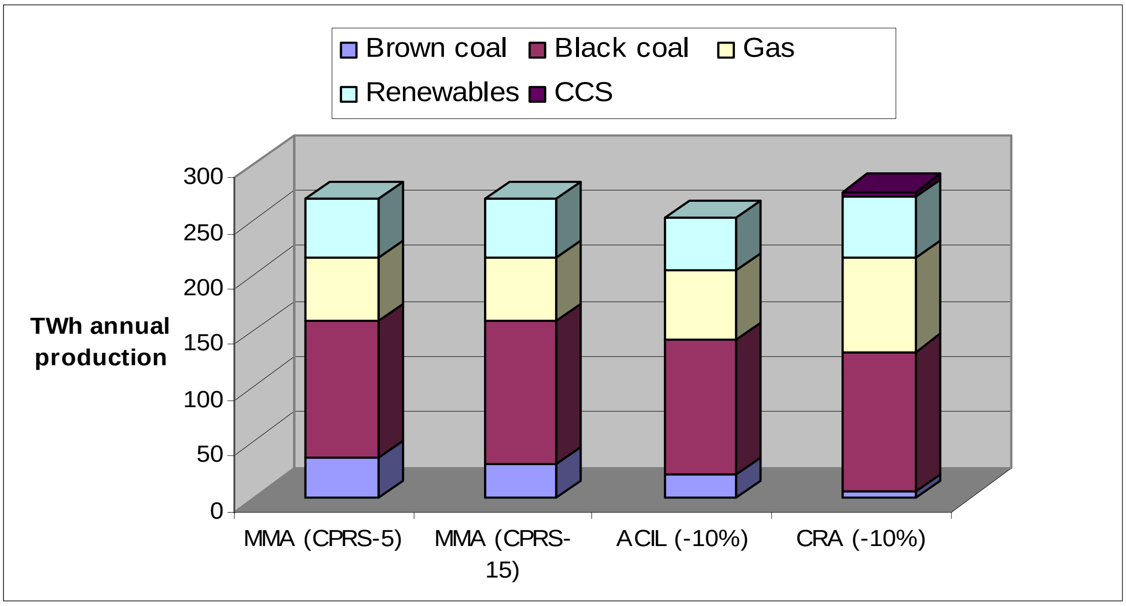
From the range of evidence, a number of key factors emerge that influence the extent of impacts on the energy markets caused by the introduction of the CPRS and expended RET. These include the:

- extent and timing of international linkage in trading of carbon permits;
- relative cost of abatement across the different sectors in Australia;
- ability of carbon emitting generators to pass through the permit price;
- magnitude of any demand reduction in response to increase energy prices;
- type and location of increased renewable generation in response to the expanded RET; and
- relative fuel costs and technology developments in electricity generation.
- Generation output and investment

Changes in generation will be caused by either switching output between existing plants or by changes in the generation stock through investment and retirement. All three models came to similar conclusions on the likely mix of electricity production in 2020. This is summarised in Figure 1.

5 SKM 2008 New Generation Timelines paper.

Figure 1. Electricity generation mix



There is general agreement that the CPRS over time will lead to increased operation of gas-fired plant and lower output from coal fired plant although there are differing views on the scale of the impact. Also, there is less consensus on the impacts on generation investment in the period up to 2020. The main difference is that ACIL Tasman and CRA envisage a more rapid decline in generation from coal sources – particularly brown coal. ACIL Tasman concluded that there would be closure of 6645 MW of coal plant (mostly brown coal) in its 10 per cent emission reduction scenario, and 10425 MW in its 20 per cent emission reduction scenario. CRA produced larger reductions in coal generation than ACIL Tasman and quantified this in terms of capacity reductions, although they did not specify that such reductions would result in closure.

Similarly, the MMA Treasury modelling did not specify closure, instead it referred to reduced production. However, MMA Treasury suggest that there would be a greater role for coal generation, than either CRA or ACIL Tasman, and suggested that a brown coal power station was not likely to close before 2020.

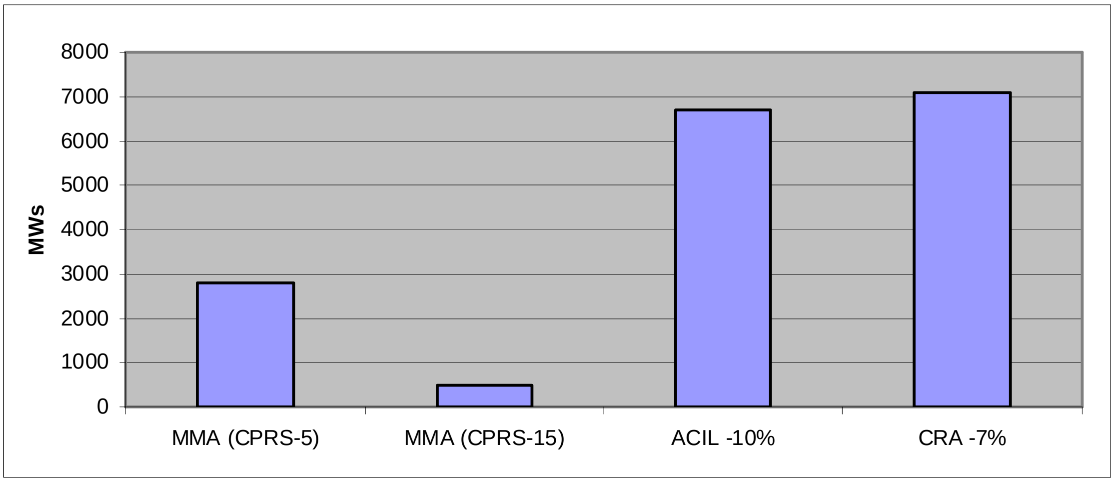
In its report, ROAM Consulting suggested that a limited number of existing coal generators would substantially decrease production by 2020. ROAM Consulting considered that transmission limitations between regions will ensure that some coal-fired base load generators will remain competitive in each region, irrespective of the emissions intensity of the plant.

The impact on the profitability of a generator will depend upon its respective ability to pass-through the carbon costs. This will depend upon not a range of factors including the emission intensity of the marginal unit, the demand elasticity, the costs of new entrants and the ability for strategic bidding. Transmission congestion can influence the ability to bid strategically however, at this stage, the evidence on transmission congestion under CPRS is inconclusive.

All the modelling generally suggests that as a result of climate change policies there will be no new investment in coal-fired generation, until new generation technologies are developed.

Both ACIL Tasman and CRA produced similar results on new entry in gas generation. MMA Treasury modelling however, envisaged much lower investment in gas generation, as shown in Figure 2.

Figure 2. Additional investment in gas generation between 2010 and 2020



The MMA/AEMC report provides the following as potential reasons for the lower levels of retirements in coal plant in the MMA Treasury study:[6]

- higher gas prices would defer the need for new gas plant, which would be the main competitor to brown coal generation.
- higher levels of renewable energy would also defer the need for new gas plant.
- larger demand response (fall in demand) delays the need for new plant to compete with brown coal plant.
- over the period a average lower carbon prices and a more gradual trajectory in carbon prices in the MMA Treasury modelling compared to ACIL Tasman.
- analysis conducted over the long term (to 2050), which affects investment patterns before 2020. In particular, the increasing gas prices and the successful development of CCS technology for coal generation limits the early entry of new gas plant as the economics of this new plant is affected by carbon prices and market developments beyond 2020.

6 MMA Report to AEMC 2008 Initial Market Issues paper, p.22.

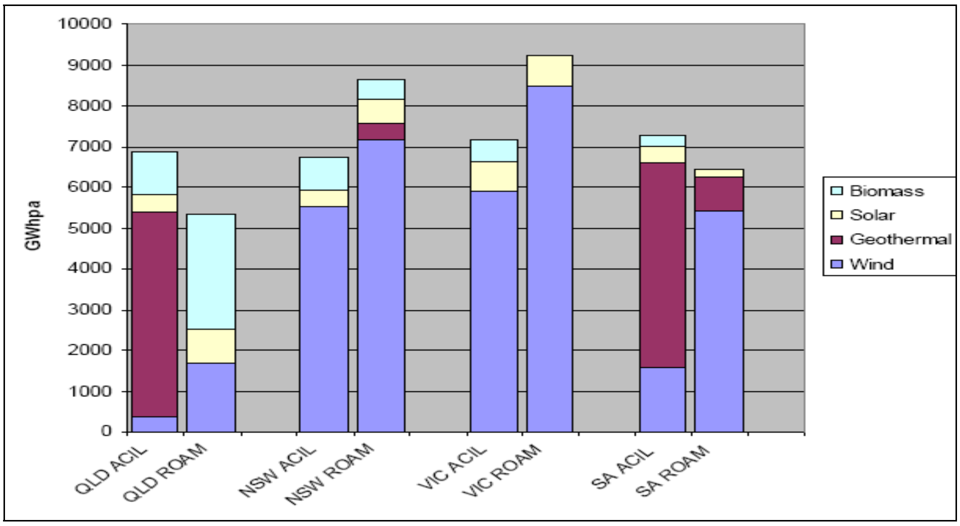
- Adoption of a unit by unit closure regime which results in improved prices for remaining units.

We note that the White Paper has released further modelling into the impact of the CRPS on coal plant retirements. This new modelling indicated that while the pattern of impacts on individual coal fired generators in uncertain, the transition of the sector as a whole is likely to be manageable.

The expanded RET subsidy is expected to result in a large increase in renewable generation. All the modelling suggested around 8000 MW of new renewable capacity will be built by 2020. There is general agreement that the largest share of this additional capacity will be intermittent wind generation and that in early years there will be a high share of that wind generation in South Australia and Victoria. There is less consensus on how rapidly other technologies will become viable on a large scale, and on future trends in the location of renewable generation. Figure 3 compares the results on investment in renewable technologies by 2020. This shows that ACIL Tasman and ROAM Consulting have broadly similar results on the level of aggregated production from renewable sources. However, there are different views on the mix of geothermal, biomass and solar sources.

The ROAM Consulting modelling showed that following the introduction of wind farms in north and south east South Australia, transmission congestion may cause significant curtailment and shortfall between actual wind output and target output. ROAM Consulting considered such wind farms will not be constructed in these areas unless transmission upgrades alleviate the problem.

Figure 3. Investment in renewable generation by state

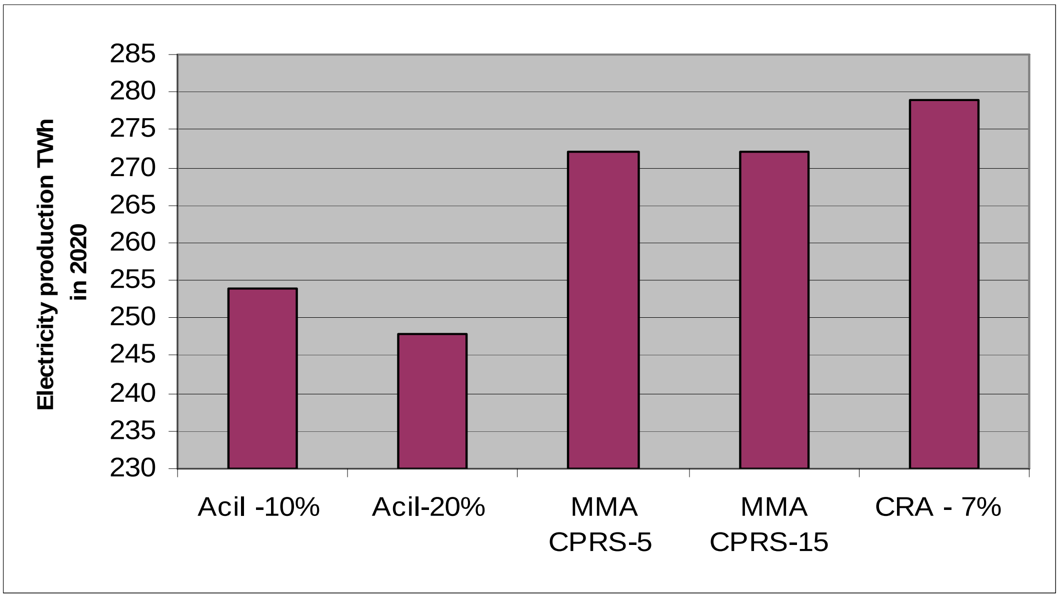


The Review will need to assess the ability of energy market frameworks to accommodate both an increased use of gas-fired generation, and a large increase in intermittent generation. Under some but not all scenarios the framework will also need to be able to accommodate a relatively rapid fuel switching in the installed capacity.

Aggregate Demand

All models show a fall in electricity demand relative to the reference scenario after an emission price is introduced. This is due to contraction in economic activity (relative to the reference scenario). Increased electricity prices also subdue demand. The reduction in electricity demand leads to immediate emissions mitigation. There is differences across the modelling reports in the likely level of future demand in the electricity sector. As shown in Figure 4, ACIL Tasman assumes the lowest demand by 2020, while CRA assumes the highest. Also the profile of demand reduction is different between the models. The MMA Treasury has a big drop after 2010, and then an increase again, whereas ACIL Tasman sees a gradual decline and then very low growth over the period. Therefore by 2020 ACIL Tasman estimated demand is substantially below MMA Treasury.

Figure 4. Expected demand by 2020



The ACIL Tasman model estimated a 12 per cent reduction in demand by 2020 in the 10 per cent emissions target case and a 14 per cent reduction in demand in the 20 per cent target scenario compared to the reference scenario.

There is also the possibility that a switch to electricity in other activities may offset this estimated demand reduction. For example, a switch to electric vehicles in response to higher permit prices or industrial plant switching to electricity away from direct combustion. These potential switches will put upward pressure on emissions in the electricity industry, however this is not expect this to significant by 2020.

Wholesale and Retail Prices

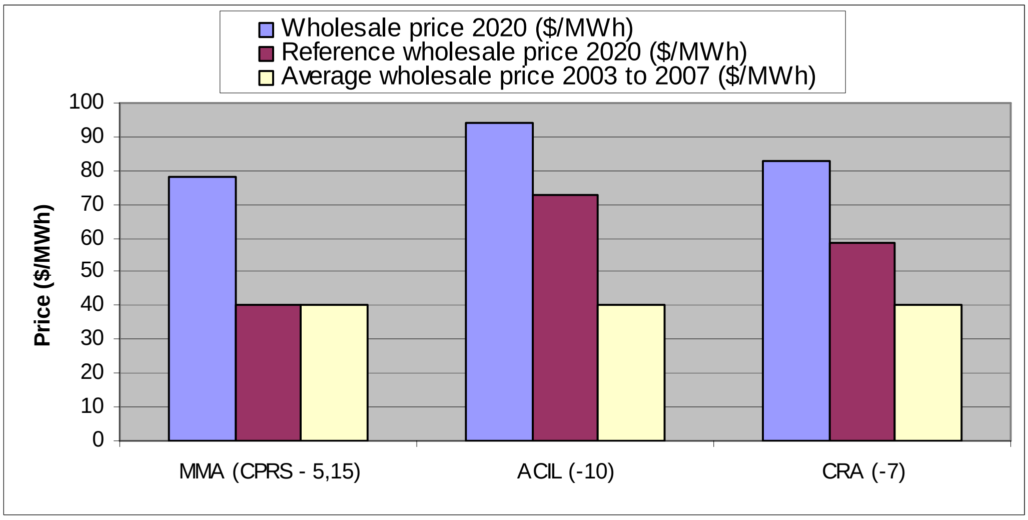
The evidence has produced similar estimates of wholesale prices with the forecast average price in 2020 around $70 to $80 per MW (2008 prices), depending on the emission target. The larger the emission target the greater the permit price has to increase to trigger the required changes. ROAM consulting expected that wholesale prices will increase by more than the value of the permit price in the period up to 2020. However this will depend upon the respective ability of the generator to pass through the carbon cost.

The models have different views on what prices under the business as usual scenario. Both ACIL Tasman and CRA suggest that prices would increase significantly even if the CPRS and RET were not implemented. MMA Treasury modelling suggested that prices remain stable.

In its report to Treasury, MMA noted that another factor responsible for the relatively high price increase in the period to 2020 is the fact that wholesale prices in the NEM in the reference case are depressed by the subsidies provided by the NSW Greenhouse Gas Abatement Scheme, which it calculates will subsidise low emission generation by between $10/MWh to $20/MWh. It assumed that the CPRS will replace this scheme and therefore removes this subsidy.

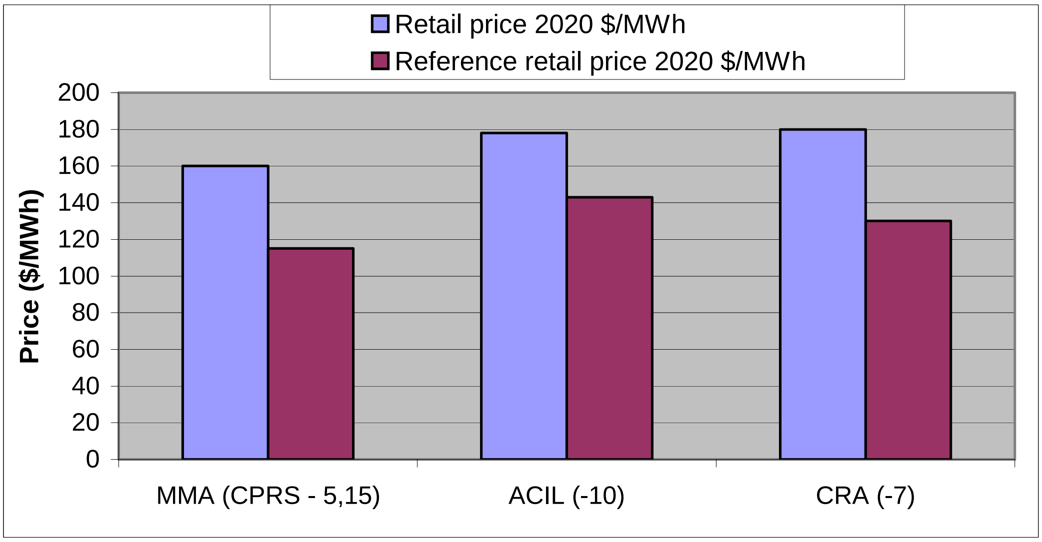
Another factor in MMA Treasury modelling of future prices is the assumption that commodity prices and engineering costs would not remain at the cyclical highs of recent years. The unwind in the cyclical high prices is important for considering about the cost of building new infrastructure in Australia.

Figure 5. Expected Wholesale price by 2020



On retail electricity prices, ACIL Tasman and CRA suggested that average retail prices would rise to around $180/MWh, from a reference price of $130 to $140/MWh. By comparison, MMA Treasury suggested that average retail prices would rise to around $160/MWh from a reference price of around $115/MWh. This is shown in Figure 6.

Figure 6. Expected Retail Prices by 2020



The MMA Treasury modelling showed an expected increase in retail prices of between 28-29 per cent on average from reference prices for the CPRS -5 and CPRS –15 scenarios over the period up to 2020.[7]

The increase in retail prices will be caused by a mixture of increasing in the cost of energy due to carbon pricing; an increase in network costs to reflect additional investment required, and an allowance for the impact of the expanded RET. ACIL Tasman estimated that the additional network investment will result in an extra 0.5 cent per kWh and the RET will lead to an extra 0.9 cent per kWh.

Price Volatility

It is unclear whether the climate change policies will increase the volatility of prices. There will be other additional influences on wholesale price volatility under the policies however the net effect is unclear. Analysis by ROAM consulting found that the expanded RET would increase volatility due to the large increases in intermittent wind generation. However, it suggested that the impact of the CPRS is unclear due to uncertainty over the amount of market power that generators may hold under varying levels of carbon price. As noted, the Review will need to assess if the current regimes under the energy market frameworks will need to be able to accommodate these changes while maintaining the effectiveness of retail competition and viability of retailers.

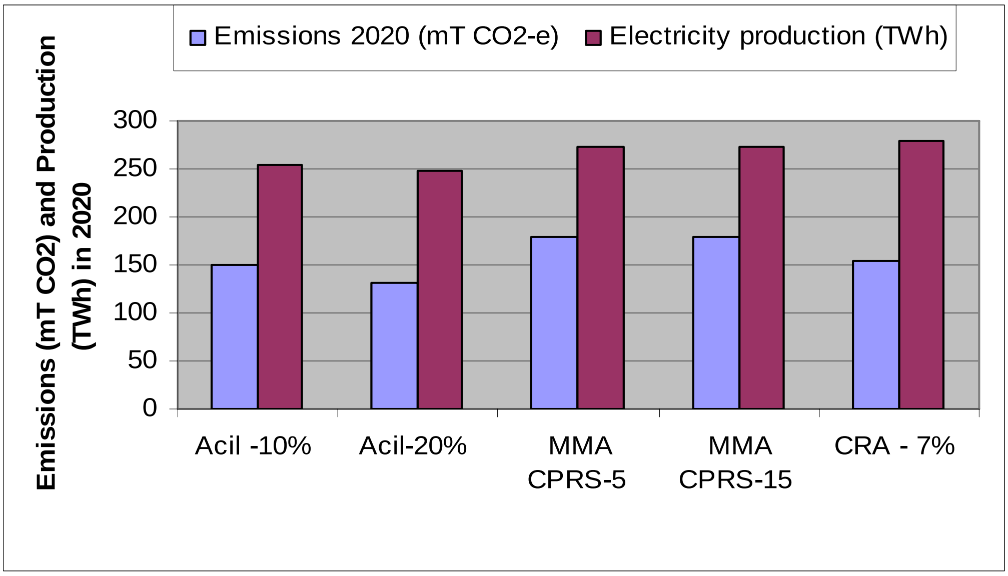
Emissions

The models also have different views on emission reductions in the electricity sector by 2020 (Figure 7). This can be attributable to different views on a range of factors, including future demand, capital costs, and assumptions about CCS. It is clear from this that there is a reasonable correlation between electricity production and emissions, as would be expected. The main difference is between CRA and MMA Treasury,

7 MMA 2008 Treasury Paper, p.8.

where CRA's results delivered considerably less coal generation than MMA Treasury by 2020, and thus significantly lower emission intensity.

Figure 7: Emissions and electricity production in 2020



The work by ACIL Tasman suggests that the abatement costs in the electricity sector are lower than those suggested by the MMA Treasury modelling. This is a reflection of the different assumptions used between the different models. The MMA Treasury modelling did perform a feasibility assessment of its results and it analysis suggests less change over of capital stock, higher pass-through as a result and less emissions abatement from the sector, compared to the ACIL Tasman results.

Investment in Energy Networks

The differences in the forecast of new gas generation will have implications for gas supply infrastructure. There is agreement that the use of gas for electricity generation will increase under business as usual and that climate change policies will further increase this demand. However, there are differences of view over the scale and speed of change. Current utilisation of gas for electricity generation is around 200 PJ per year. Under some high carbon price scenarios the use of gas for electricity generation could rise to 600 PJ per year by 2020.

To date limited analysis has been undertaken of the implications of climate change policies for electricity networks. As noted, the expanded RET will lead to a rapid increase in renewable generation capacity which will require connection to the grid. The extent of these impacts will depend upon the changes in the generation mix, and its location on the grid, caused by the climate change policies. At this stage, it is not clear whether material and persistent congestion will arise as a result of these policies.

The Review will need to assess whether energy market frameworks can ensure that both generation and network issues are efficiently managed to minimise the overall costs of responding to climate change policies.

Further Work

A number of the aspects of the design of both the CPRS and the expanded RET were unknown when the range of modelling was undertaken. Now that the White Paper has been released, it will be necessary to re-visit the evidence in light of the proposed policy design. The Review will also take into consideration the additional modelling released with the White Paper in December 2008. Furthermore, the AEMC intends to do further modelling of some of the impacts under the demanding yet credible scenarios.

This work will inform the AEMC 2nd Interim Report due for release in June 2009.

Contents

Acronyms

ACCC	Australian Competition and Consumer Commission
AEMA	Australian Energy Market Agreement
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
CMR	Congestion Management Review
CO_2–e	Carbon dioxide equivalent
COAG	Council of Australian Governments
CPRS	Carbon Pollution Reduction Scheme
CRR	Comprehensive Reliability Review
CSM	Coal seam methane
DSP	Demand Side Participation
ENA	Energy Networks Association
GWh	Gigawatt hour
IMO	Independent Market Operator
LNG	Liquefied Natural Gas
NCC	National Competition Council
NEL	National Electricity Law
NER	National Electricity Rules
NEM	National Electricity Market
NEMMCO	National Electricity Market Management Company Ltd
NEO	National Electricity Objective
NGL	National Gas Law
NGR	National Gas Rules
NTNDP	National Transmission Network Development Plan
NTP	National Transmission Planner
MCE	Ministerial Council on Energy
MoU	Memorandum of Understanding
MRET	Mandatory Renewable Energy Target
MWh	Megawatt hour

NWIS	North West Interconnected System
STEM	Short Term Energy Market
STTM	Short Term Trading Market
SRMC	Short Run Marginal Cost
SWIS	South West Interconnected System
OECD	Organisation for Economic Co-operation and Development
REC	Renewable Energy Certificate
RET	Renewable Energy Target
PJ	Petajoule
PV	Photovoltaic
TEC	Total Environment Centre
WEM	Wholesale Electricity Market

1 Introduction

This document surveys modelling and analysis that has been undertaken by a range of organisations to understand the impact of the Carbon Pollution Reduction Scheme (CPRS) and the expanded Renewable Energy Target (RET) on the current energy market frameworks. The modelling has been undertaken by:

- McLennan Magasanik Associates (MMA) reports for the Federal Treasury of the Australian Government (MMA Treasury);
- ACIL Tasman for the Energy Supply Association of Australia (ACIL Tasman); and
- CRA Ltd for the National Generators Forum (CRA).

The AEMC also commissioned the following reports from ROAM Consulting, Frontier Economics and MMA (available on the AEMC website):

- MMA Report, "An Initial Survey of Market Issues Arising the Carbon Pollution Reduction Scheme and Renewable Energy Target" (MMA Report to AEMC 2008 Initial Market Issues paper)[8];
- Frontier Economics, "*Impacts of climate change policies on generation investment and operation*" (Frontier 2008 Generation Investment and Operation paper); and
- ROAM Consulting, "Market Impacts of Carbon Pollution Reduction Scheme and Renewable Energy Target" (ROAM 2008 Market Impacts paper).

Additional modelling conducted by ACIL Tasman, ROAM and MMA has also been released with the Australian Government's White Paper. There has not been sufficient time to fully incorporate this new modelling in this document. Instead a summary of the key findings of the modelling is contained in chapter 2. The AEMC will take into consideration this new evidence during the course of the Review.

This document is structured as follows:

- The first chapter provides the background and context. This describes the AEMC's approach; the modelling that has been surveyed; the climate change policies, theoretical relationships between various prices; and caveats to be considered in evaluating the results of the modelling.
- Successive chapters then survey the results of the modelling and analysis, covering in turn:
  - change in generation mix including investment in new plant and unit retirement;
  - change in demand;

8 In this paper, this report by MMA is referred to as either MMA 2008 Initial Market Issues paper or as MMA AEMC paper to avoid any confusion with the MMA reports for the Federal Treasury.

- change in energy prices;
- gas infrastructure; and
- electricity transmission infrastructure.

2 Background and context

The purpose of this chapter is to provide background and context to the survey of the results of the market modelling that has been undertaken by a variety of modellers.

The chapter starts by describing the approach to the survey of the evidence on market modelling, and how we suggest the results should be considered. The next section then describes the evidence that has been surveyed. This is a summary description of the methodologies of the main models reviewed in this paper. The final sections describe the climate change policies and presents a brief overview of the theoretical relationship between the price of emissions, electricity, gas and renewable energy certificates.

2.1 AEMC approach

The Review is required to identify any amendments necessary to energy market frameworks as a consequence of, or in conjunction with, the CPRS and expanded RET policies.

Climate change policies will create a positive price for emissions and a negative price (or subsidy) for eligible renewable generation. Electricity and gas markets regularly adjust in response to price changes. However, the changes as a result of climate change policies have characteristics which may affect the efficiency of that adjustment:

The impact of the CPRS on variable operating costs is likely to be major and rapid. An initial permit price of $20/T would increase the variable operating cost of a brown coal generating unit around five-fold at the start of the scheme. Energy markets are not usually exposed to price changes of this magnitude and rapidity.

The price signal under the expanded RET differs from existing price signals for new investment. For example, prices in the NEM vary by region and by time of day. This provides a signal to potential investors on where they should locate new generation. It also guides the choice between baseload plant (with high capital costs but low operating costs) and peaking plant (with low capital costs and high operating costs). By contrast the expanded RET subsidy will not vary by location or time of day. Unlike other price signals, it will be specific to a particular technology.

The price impacts of the CPRS and expanded RET have substantial uncertainty. Spot market and fuel prices are also uncertain. However, market participants have evolved sophisticated approaches to managing and reducing these risks. The uncertainty over climate change policies reduces the ability of market participants to hedge risks through long term contracts or through a liquid forward carbon market. The difficulties in managing risk should decline as the final design of the policies is completed and as liquid forward markets emerge. However some transitional problems may arise in the interim while policy uncertainty remains.

Changes in the dispatch and the level of new generation investment will place pressures on the electricity networks.

The Review is considering the performance of the energy market frameworks in response to climate change policies. Our starting point is to consider the impact of climate change policies, by considering the likely scale and timelines for changes to prices, demand and the level and operations of the capital stock.

We have drawn on four main sources to assess the possible impact of climate change policies:

- existing reports in the public domain. References to these reports are given in relevant sections;
- additional analysis of the impact of climate change policies commissioned by the AEMC to assist this Review;
- analysis by the Reliability Panel of the possible impact of climate change policies on reliability in the short term and long term; and
- submissions to the Scoping Paper.

The AEMC is seeking to understand the impact of climate change policies in comparison with business as usual (BAU). Many of the sources that we have drawn on have addressed this question. However, they are likely to be inconsistent in some way in four respects.

First, the reports may differ in their assumptions on the nature of climate change policies. The most material difference is the level of international linkage with other emissions trading schemes and the resulting level of net emissions reductions in the energy sector in Australia. Under full international linkage, Australia will be a price taker and the quantity of abatement in the electricity sector will be determine by the relative costs of abatement.

Most other analysis has assumed that the permit price is set domestically rather than through international trade. A number of these studies have allowed for domestic offsets and considered international offsets. However the marginal cost of abatement has generally depended on abatement costs within the Australian electricity sector.

The White Paper confirmed that the CPRS will permit the importing of international permits which are recognised under the Kyoto protocol and that the Australia Government's emission reduction targets will be based on net national emissions, that it imported units will be counted as contributing to the national target while exported units will not be counted.

International linkage should result in more efficient abatement. If the marginal cost of abatement abroad is relatively lower it will deliver a lower permit price and less impact on the Australian energy sector. There are also likely to be more complex effects on the interaction between the permit price, the gas price and the expanded RET. These impacts are described further below.

Second, the analysis may differ in the scenarios analysed for climate change policies. In most cases analysis has considered scenarios for reduction in emissions by 2020 in relation to emissions in 2000. Except where there is full international linkage, the focus has generally been on emissions in the domestic electricity sector. However reports vary in whether they are looking at reductions of 5, 10, 15, 20 or 25 per cent. Also it important to note that only ACIL Tasman and CRA has 2020 targets in mind, while the MMA Treasury modelling looked at targets ending in 2050. Also the MMA Treasury modelling looked at emission abatement in the energy sector as a piece of the Australian economy as a whole.

Third, the reports differ in their assumptions on inputs such as the growth in demand in the absence of climate change policies, the capital costs of different technologies, the cost of different fuels and changes in these costs over time.

These assumptions can materially affect the conclusions. The forecast of gas prices will affect the substitution between gas-fired generation and other technologies as a result of the CPRS. The gas price assumption would also affect the carbon permit price in the absence of international linkage. The assumptions on the capital costs of different renewable technologies will determine the type and quantity of generation capacity which enters as a result of the expanded RET. Many other assumptions can affect the conclusions on the nature and cost of the impact of climate change policies.

A fourth difference is the approach taken to modelling the impact of climate change policies. Most analysts have used proprietary models. These models are likely to differ in the way in which they convert a number of input assumptions to outcomes in gas and electricity markets.

The AEMC considers that it would be prudent to allow for outcomes that create greater stress for energy markets. For example, if a domestic abatement scheme with low levels of international linkage would result in higher permit prices and greater adjustment within the Australian energy sector, it would be prudent to allow for this possibility until it was clear that international linkage could be achieved.

Finally, the AEMC considers that the surveys of such market modelling need to take account of the uncertainty of results from the models.

The modelling that has been done by a number of consultants in publicly available reports, and also privately by many organisations, aims to replicate what happens in real energy markets. However there are a number of reasons why such modelling can fail to accurately predict future outcomes. We have identified four main reasons for this:

- **Simplified representation of the power system:** Electricity generators are complex machines that have very different efficiencies (heat rates) as a function of their operating regimes. Many generating units are inflexible, take a long time to start-up and shut down, and have uncertain maintenance costs. Transmission networks are complex and their capability is affected by the weather, how the assets are operated and the disposition of generation and load around the system. Demand is unpredictable, particularly in the short term, and uncertain rapid changes in demand or supply are impossible to represent in models. To ensure analytical tractability, models rely on a highly simplified and stylised characterisation of the system. As a result of this, some of the essential character of the system is lost. This can significantly affect the ability of models to predict future outcomes.

- **Formulaic characterisation of market behaviour:** Market participants are constantly seeking ways to maximise their income and minimise their risk. They do this by adopting trading strategies and entering into forward contracts or similar hedge contracts. This affects how they bid into the market, and their ability to influence short term market prices. Electricity models have a limited ability to represent such behaviour. Some assume the market is fully competitive and so participants always bid their short run costs. Others try to account for the ability of some participants to exercise market power through formulaic expressions of bidding behaviour. But the complexity of these relationships is not amenable to formulaic representation for the purpose of long term market modelling.

- **Inability to account for imperfect foresight**: Models need to make assumptions on technologies and their costs. But technologies and costs change unpredictably. This is particularly true at the moment when there is an intensive global effort to develop and commercialise new low emission technologies. Models also assume that market participants have the same view of future revenues, and will react to investment opportunities in the same way. But the evidence is that the electricity market, like other commodity markets, is cyclical, driven by responses to emerging sources of information and changing perceptions about the market.

- **Inadequate accounting for commercial reality**: A very large investment is needed to deliver the renewable generation expected under the expanded RET. Similarly, some analysts suggest a very rapid rate of investment in combined cycle gas generation. There are many reasons why such rapid investment may not be delivered in time including blockages in supply chains, funding, planning approval, connections, acquisition of easements and so on. Even if profitable investment opportunities exist, investment may not occur or will be delayed. Models usually fail to account for such commercial reality, unless specific attention is given to the effect of such matters on the assumptions about the input data.

For these reasons, while it is worthwhile to analyse and understand the results of the market modelling that has been done, we suggests that these results provide useful context, but not determinative input to the Review. They indicate what might happen under a range of market conditions rather than what will happen for any specific set of assumptions.

2.2 Description of the evidence surveyed

To date, the AEMC has not to date commissioned additional modelling of the impact of climate change policy. Rather we have drawn on three reports for an assessment of overall impacts and supplemented this by further studies.

One source for sector wide impacts is a report by MMA as an input to the Australian Treasury modelling of Australia's Low Pollution Future.[9] The second is a report by ACIL Tasman to the Energy Supply Association of Australia.[10] The third is a report prepared by CRA International for the National Generator's Forum (NGF). This has not been released by the NGF but is reported on extensively in a publicly available report prepared by Port Jackson Partners for the Business Council of Australia.[11]

These three studies consider the impact of climate change policies on prices, demand, investment and production. There are differences in how these consultants have approached this task. The studies themselves should be consulted for a full understanding of the approaches taken. A brief description of the main differences is given in this section.

The MMA Treasury analysis addresses the question of the cost to the Australian economy of participating in global schemes to reduce emissions to target levels in 2050. The MMA Treasury report does provide a description of energy sector impacts and in

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9 MMA 2008 Treasury Paper.

10 ACIL Tasman, The impact of an ETS on the energy supply industry, 22 July 2008.

11 Port Jackson Partners, *Bringing specific company economic perspective to bear on the ETS Design*, prepared for the Business Council of Australia, 21 August 2008.

many cases comments on adjustments on the short to medium period of 2010 to 2020.The MMA was asked to ensure that the analysis for the first 5 to 10 years was consistent with their understanding of the availability and feasibility of developments in the electricity generation industry. The ACIL Tasman and CRA reports were focussed on impacts on the Australia energy sector up to 2020.

All reports developed a base case for expected developments in the energy sector without climate change policies. They then considered a number of scenarios for emissions reduction through a cap and trade system, in some cases combined with an expanded RET.

The MMA Treasury report considers two main scenarios for international linkage. Under the Garnaut scenarios, a global scheme starts from 2013. Under the CPRS scenarios, a scheme between developed countries starts in 2010. Developing countries gradually join over the period up to 2025. From then on, a scheme covering all countries operates.

The MMA Treasury report looks at targets consistent with a reduction in emissions in 2020 against 2000. The Garnaut scenarios allow for 10 per cent and 25 per cent reductions in Australian net emissions allocation by 2020. The CPRS scenarios allow for 5 per cent and 15 per cent reductions in Australian net emissions allocation by 2020. The CPRS -5 scenario and the CPRS -15 scenario includes the expanded RET. The Garnaut scenarios exclude the expanded RET.

The target reductions in the Australian Treasury modelling are for the Australian economy as a whole, rather than the energy sector. As a further important distinction, they are targets for emissions net of trade. Gross physical emissions can increase under the MMA analysis, provided Australia can import permits consistent with its targets. The MMA Treasury modelling shows increased emissions from the Australian electricity sector in 2020 as compared to 2000 for all but one scenario.

The ACIL Tasman analysis looks at two scenarios for emissions in 2020 to be 10 per cent and 20 per cent below emissions in 2000. The ACIL Tasman modelling assumed that measurement problems and transaction costs associated with international trade will limit this to 10 per cent of the required Australian abatement.

These scenarios, therefore, consider a reduction in gross physical emissions in the Australian energy sector, since ACIL Tasman assumes that the energy sector will need to provide a contribution to emissions at least consistent with its share in the economy (and possibly greater).

The CRA modelling is similar to the ACIL Tasman modelling in as far as it too adopts a specific abatement target, and the emission price is an input that is varied in order to achieve the target abatement. The central case described in the BCA report, is a scenario that leads to a 7 per cent reduction on the level of emissions in 2000 by 2020.

The AEMC notes that the Australian Treasury modelling is looking at the cost of meeting an emissions target net of trade and generally shows an increase in physical emissions from the Australian energy sector. The ACIL Tasman and CRA analysis always shows a reduction in physical emissions from the Australian energy sector – as their models were designed to achieve.

While this is a difference in approach it does not necessarily result in a major difference in conclusions. We consider in this report how far conclusions differ.

The AEMC has also commissioned additional work from ROAM Consulting, MMA and Frontier Economics. They do not undertake integrated modelling of the impact of climate change policies on prices, demand, investment and operations. However they do provide additional insight into a number of issues.

2.3 Additional modelling for the White Paper

To help inform Government decision making in relation to the Electricity Sector Adjustment Scheme, the Australian Government Department of Climate Change commissioned ACIL Tasman Pty Ltd and ROAM Consulting Pty Ltd to undertake specific electricity sector modelling to supplement the work undertaken by MMA.

The purpose of this modelling was to assess the impact of the CPRS and expanded RET on the profitability of generators in the NEM and SWIS. The modelling indicated that while the pattern of impacts on individual coal fired generators in uncertain, the transition of the sector as a whole is likely to be manageable.[12]

The different models compared the change in the value of power generation assets following the introduction of a carbon constraint, against a business-as-usual reference scenario. The ACIL Tasman and ROAM Consulting analysis employed broadly similar assumptions to those used by MMA, such as those relating to, for example, electricity demand and generation data; technology costs; gas prices; and emission permit prices. The size and distribution of asset value losses exhibited considerable variability across the models.

The White Paper states that while emissions-intensive generators may lose profitability only a minority of generators are likely to face marked reductions in generation volume.[13] The modelling indicates that while some of Australian 30 major coal fired generators are exposed to material losses, the majority maintain their share and relatively few generators exit the market in their entirety. ROAM Consulting analysis suggest that no additional generator will exit the market compared to the reference scenario. Under both the CPRS -5 and CPRS -15 scenarios, MMA suggests that only one generator will retire in its entirety by 2020. ACIL Tasman suggests that only two brown coal generators and one black coal generators will under the CPRS -5 scenario. This increases to 3 brown coal and four black coal generators under the CPRS -15 scenario.

The White Paper recognises that these conclusions are sensitive to demand assumptions but notes that the as the assumptions used in the modelling is at the lower range of market projections on demand, the modelling has over-estimate the extent of likely losses of generation volumes. The modelling also recognises that the assumed convergence of east coast gas prices to export parity will help coal generators to maintain its competitiveness for baseload generation.

The modelling looked at the rate at which the carbon permit price is pass-through to the retail prices. The modelling found that the rate of pass through varies both between models and within models between states. ROAM Consulting considered

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12 Australian Government, Carbon Pollution Reduction Scheme – Australia's low Pollution Future, White Paper, Volume 1 and 2, 15 December 2008, p.13-10.

13 Australian Government, Carbon Pollution Reduction Scheme – Australia's low Pollution Future, White Paper, Volume 1 and 2, 15 December 2008, p.13-10.

that, excluding the effect that transmission congestion may have on the price of electricity, approximately 70 per cent of the permit price will appear as an increase in the wholesale pool price.[14] ACIL Tasman modelling suggested that carbon price pass through are generally between 50 per cent and 80 per cent although there are some states were the pass through is lower.[15]

Chapter thirteen of the White Paper contains a discussion of the modelling results and their interpretation for the purposes of policy development. As noted earlier this modelling is not incorporated into the following chapters due to insufficient time.

2.4 Description of climate change policies

The review addresses the performance of the energy market frameworks in light of two policies, the Carbon Pollution Reduction Scheme (CPRS) and the expanded Renewable Energy Target (expanded RET).

Carbon Pollution Reduction Scheme

The Government released its White Paper on the design of the CRPS on 15 December 2008. A brief summary of the operation of the CRPS is given below:

- The scheme will start on 1 July 2010.
- The Government has decided on a unconditional medium-term target range to reduce net emissions by 5 per cent below 2000 levels by 2020. This could increase to 15 per cent subject to international agreement.
- The CPRS will introduce a cap and trade scheme for covered businesses. Actual GHG emissions will be monitored and subject to audit. Each liable firm will need to acquire and surrender a permit for every tonne of GHG that they emit, or pay a charge. The number of permits to be issued each year will be limited by the total carbon cap for the Australian economy. These permits will be tradeable.
- The cap on permits will create a carbon price, due to scarcity. The ability to trade should ensure that emissions are reduced at the lowest possible cost, and allow cost effective abatement to be determined through decentralized decision making.
- Permits will be auctioned each month for the next three years.
- The permits can be used in any year on or after the year of issue (known as "unlimited banking"). Liable firms will also be able to meet a small percentage of their obligations using up to 5 per cent of permits from the following year ("borrowing"). Ownership of permits will be tracked in a national registry.

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14 ROAM Consulting, Report to Department of Climate Change, Modelling of carbon pricing cenarios, 15 December 2008, page I of executive summary.

15 ACIL Tasman, Report to Department of Climate Change, Impact of the CPRS and RET –modelling of impacts on generator profitability December 2008, p.vii of executive summary.

- There will be no restrictions in importing certified permits. However the exporting of permits will not be permitted in the early years of the scheme. This will place a ceiling on the permit price.

- Scheme caps will be set five years in advance. Longer term "gateways" will also be established.

- There be an administrative cap on the permit price. The cap shall be set at $40 for the first year of the scheme will be increased by 5 per cent in real terms each year.

- The Australian Government proposes to provide a limited amount of direct assistance to existing coal-fired electricity generators. The green paper suggests this would be through a new Electricity Sector Adjustment Scheme (ESAS). The level of assistance will be based on the generator's level of output over 2004 to 2007 and its emission intensity over a threshold of 0.86. Such generators will be allocated an equal amount of free permits for the first five years of the scheme.

- Generators under the ESAS will be required to keep its June 07 level of capacity available unless the relevant market operator agrees that there is no energy security risk in the next two year. Also these generators will be subject to a windfall gains review to be conducted by the scheme regulator in 2013.

- Fuel taxes will be cut on a cent for cent basis to offset the impact of the CPRS on fuel prices, with this support subject to periodic review.

- A Climate Change Action Fund will be established to assist businesses to transition to a cleaner economy with the funding arrangements to be decided during CPRS final design.

- Emissions-intensive trade-exposed industries will also be allocated free permits.

- An independent scheme regulator will be established to monitor and enforce compliance with the scheme, run auctions for permits, allocate permits in accordance with defined rules and maintain the national emissions registry. The scheme will be subject to independent public review every five years.

- The Australian Government confirms its commitment to a long-term goal of reducing Australia's greenhouse gas emissions to 60 per cent below 2000 levels by 2050. Draft legislation on the scheme will be released in early 2009.

Expanded Renewable Energy Target

The Government has committed to implementing an expanded national renewable energy target (expanded RET) of 45 000 GWh by 2020. This will ensure that at least 20 per cent of Australia's electricity supply is generated from renewable energy sources by 2020. This is expected to be approximately 60 000 GWh.

Australia has around 15 000 GWh from existing renewable energy capacity. The existing RET requires a further 9 500 GWh. The expanded RET is therefore expected to require an additional 35 500 GWh above existing commitments.

The expanded RET will bring both the existing national renewable energy target and state-based schemes into a single national scheme. It will retain the eligibility of all renewable energy projects that have been approved under existing state-based schemes. The expanded RET will be phased out between 2020 and 2030.

The existing schemes operate by imposing a requirement on liable parties, such as electricity retailers, to procure defined volumes of renewables-based electricity each year. These parties do not need to directly generate the electricity. Rather they are required to surrender Renewable Energy Certificates (RECs) purchased from accredited renewable energy generators or from traders.

Each REC is equivalent to one MWh of eligible renewable energy. A liable party is required to surrender RECs or pay a charge or penalty price. The penalty price sets a cap on the possible price of the REC, other than to the extent that retailers may wish to pay above the penalty to avoid the risk of adverse market reaction.

In June 2008, the Government released a consultation paper seeking submissions on aspects of the design of the expanded RET scheme. On 17 December 2008, the Government released its draft legislation on the design of the expanded national Renewable Energy Target scheme for public comment.

Other policies

There is a wide range of other, smaller policy initiatives at the national and jurisdictional levels which relate to the objective of reducing greenhouse gas emissions. Some of these have particular relevance to energy markets. Examples include financial support for the uptake of solar photovoltaic (PV) cells on domestic premises and the National Framework for Energy Efficiency, which has been operating for a number of years. The MCE has stipulated in its Terms of Reference that this Review examine the impacts of the CPRS and expanded RET. Hence, we do not consider the impacts of these other policies to be within the scope of the Review.

2.5 Theoretical relationships between prices

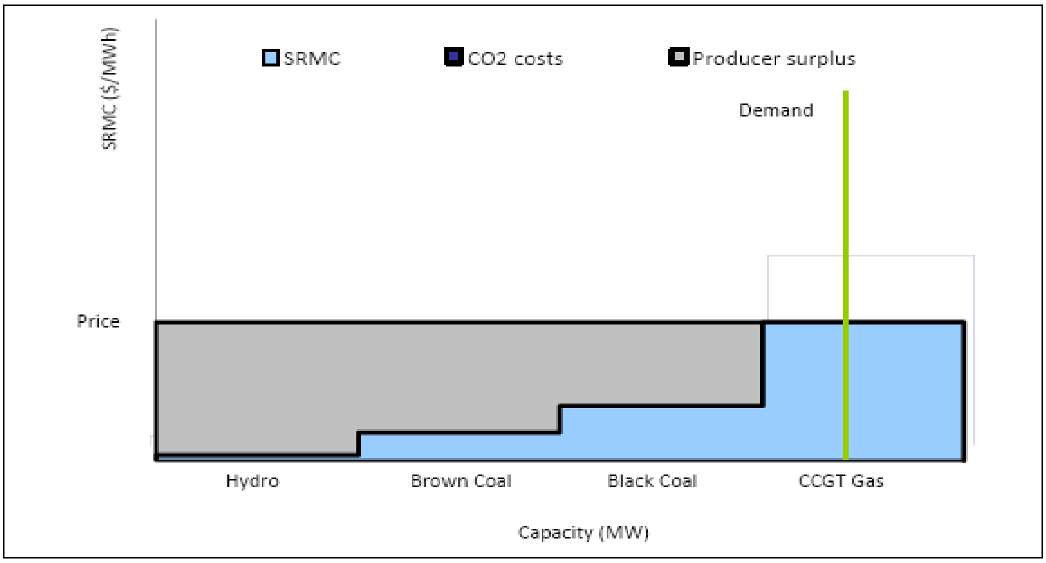
Electricity prices and permit prices

The CPRS will increase variable operating costs for generating plant depending on their emissions-intensity. This will increase wholesale prices above BAU. However the scale of the impact will depend on demand and the bid of the marginal generator.

Frontier Economics illustrated this point under a situation where a CCGT plant is the marginal generator.[16] The merit order before the introduction of the CPRS is shown in diagram 1.1. The CCGT plant sets the price. All other plant that is dispatched is lower cost. These plant receive a producer surplus, shown in grey. The surplus is the difference between the price they receive and their short run marginal costs.

16 Frontier 2008 Generation Investment and Operation paper, p.24.

Diagram 1.1: Merit order without an emissions trading scheme

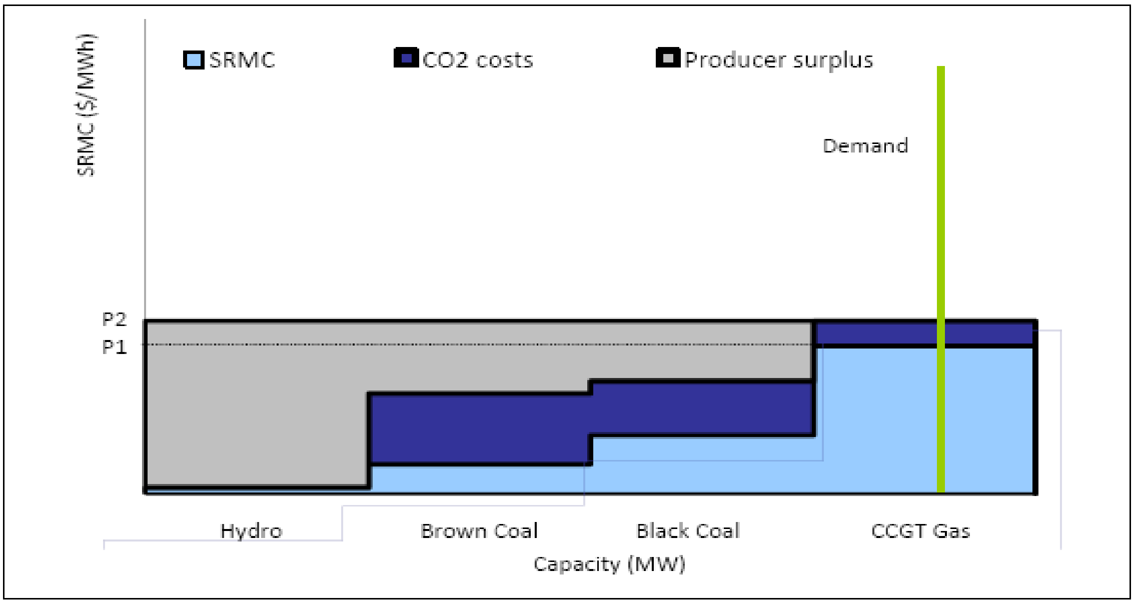


Data source: Frontier 2008 Generation Investment and Operation paper, p.24.

When an emission trading scheme (ETS) is introduced, generators will add the carbon cost to their bids.

The new wholesale price will depend on the carbon price and the emissions intensity of the marginal plant. Diagram 1.2 presents the situation where the merit order is unchanged. Gas remains the marginal generator. The emissions intensity of the gas plant determines the change in wholesale price (P2-P1).

Diagram 1.2: Merit order with an emissions trading scheme (low carbon price).

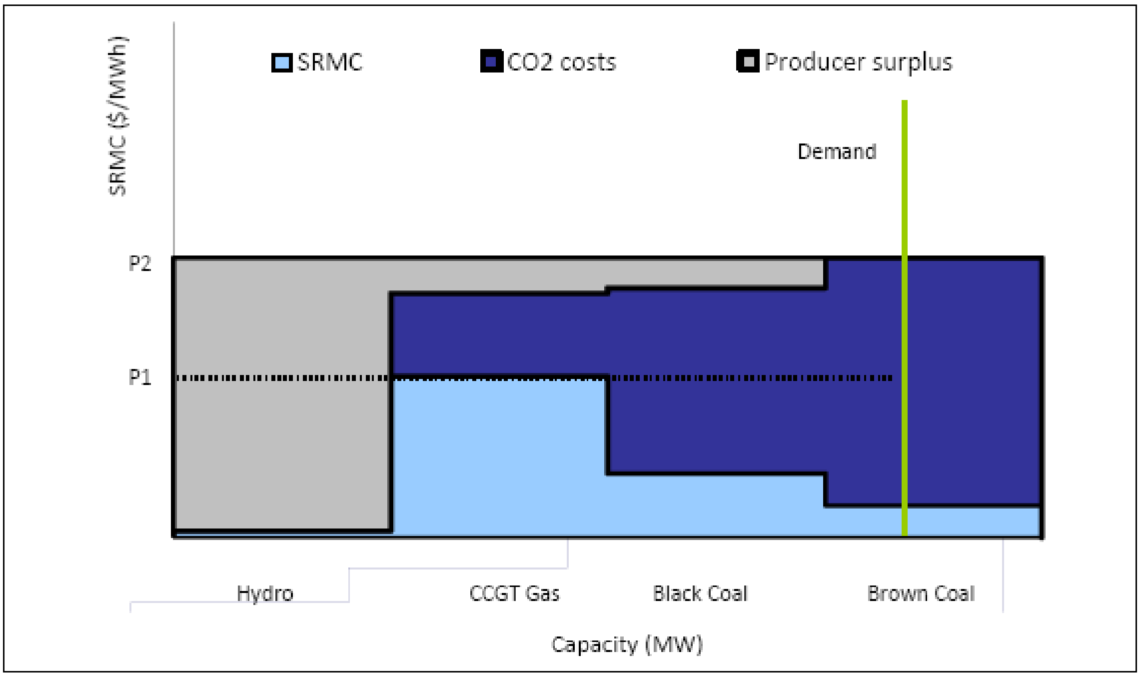


Data source: Frontier 2008 Generation Investment and Operation paper, p.25.

The impact of a high carbon price may be to change the merit order. This is illustrated in diagram 1.3. Frontier Economics point out that this will still not maintain the margins for the plant which is now marginal:

At a higher carbon price the merit order changes and the emissions intensity of the market is reduced, as in diagram 1.3. Estimating cost pass-through in this instance is more difficult since the marginal plant changes when the ETS is introduced. In this instance, the change in price is P2-P1, or the difference between the marginal cost of CCGT without an ETS and the marginal cost of Brown Coal with an ETS. This is still less than the full carbon cost of brown coal plant, which was previously receiving a price above its SRMC. In this case, gross margins for high emissions plant will still be reduced, which will constrain their ability to recover their capital costs. However, so long as gross margins are positive they should continue to operate. Existing Hydro plant earn higher gross margins since prices increase but costs do not.[17]

Diagram 1.3: Merit order with an emissions trading scheme (high carbon price)



Data source: Frontier 2008 Generation Investment and Operation paper, p.26.

The possible impact of climate change policies on wholesale market prices outlined above is conceptually clear but requires modelling to determine the expected impact. In addition to the impact of the CPRS on the merit order, the expanded RET will provide additional low cost energy at the bottom of the merit order. In some cases this will be sufficient to alter the marginal plant and so reduce prices. In addition the higher prices due to both policies will reduce demand, which may also alter the marginal plant.

17 Frontier 2008 Generation Investment and Operation paper, p.22.

Electricity prices and REC prices

Renewable generation earns revenues through the sale of electricity and from the sale of Renewable Energy Certificates (RECs).

If revenue from these two sources is below efficient entry costs for renewables then the expanded RET will not stim45

If spot market revenues are sufficient to cover efficient entry costs for the level of renewable generation capacity required to meet the target then the REC price would sink to zero. Sufficient renewable generation would enter in response to spot price signals alone. There is no medium term prospect of this happening. It may happen in time in response to increases in spot prices and reductions in the costs of renewable generation.

In between these two extremes, new renewable generation will require some degree of income uplift, short of the penalty price. For a constant real cost of new renewable generation, the REC price will then be determined by the spot price. The higher the electricity price, the lower the subsidy required to renewable generation to make it viable.

The CPRS will increase wholesale prices. This will reduce the gap between entry costs for renewable generation and average market prices. As a result, REC prices will fall for a given quantity of renewable generation.

In theory, in the absence of supply constraints in the renewables market, REC prices will fall as permit prices rise until average wholesale prices are equal to the LRMC of the marginal renewable plant. However, if there are constraints in the supply of REC-eligible plant, the price of RECs will not be influenced by changes in electricity prices.

RECs subsidise renewable generation. The costs of renewable generation entry will be reflected in the REC market and not in wholesale prices. The impact will be more renewable plant with very low operating costs.

This capacity will enter at the bottom of the merit order. It will displace plant with higher operating costs and higher bid prices. In some cases the impact will be to alter the marginal plant and reduce prices. The Treasury modelling states that implementation of a renewable energy target can reduce prices by up to around 10 per cent in the short term but has little impact in the long term.[18]

Although expanded RET can reduce wholesale prices, it will increase retail prices. The expanded RET will encourage entry of additional higher cost generation. These costs will be borne by retailers and passed on to consumers. MMA Treasury modelling suggests these costs may be significant, stating:

> The impact on GNP of the expanded Renewable Energy Target, taking into account both the increased GDP costs and the reductions in international

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18 MMA 2008 Report to Federal Treasury, p.44.

income transfers, is $5.0 – 5.5 billion, when estimated as a net present value using real discount rates of 4-8 per cent. The average cost of the mitigation per tonne of CO2-e from expanding the renewable energy target is around three times the average permit price from 2010 to 2020.[19]

Permit prices and gas prices

The obligation to acquit emission permits will create a competitive advantage for low emission generation sources.

Switching between existing or new gas plant and coal plant is the most significant source of abatement for the short to medium term. In the absence of internationally linked emission markets, this might create a correlation between the gas and permit prices. Frontier Economics suggests that:

> Fuel-switching is an important abatement option in the electricity sector in the near term. Fuel switching refers to either increasing output from existing gas plant (displacing output from existing coal) or potentially increased investment in new gas plant. Given the importance of fuel-switching, in the short-term the price of permits can be expected to be correlated to the difference in cost between coal and gas plant, which is otherwise known as the Spark-Dark Spread. To induce the necessary abatement from this sector, permit prices will rise to the point where sufficient abatement becomes viable. It is possible that the increased output from gas plants may lead to higher gas prices. However, if gas prices increase (and the Spark-Dark spread is wider) then permit prices would need to increase to achieve the same level of abatement. The correlation between the two will also depend on the extent of abatement options in other sectors, which may set the carbon price. However, most studies estimate that electricity will provide the most significant source of abatement.[20]

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19 Australian Government, Australia's Low Pollution Future: The Economics of Climate Change Mitigation, p.181.

20 Frontier 2008 Generation Investment and Options paper, p.19.

3. Changes in generation mix, investment and retirement

Climate change policies will affect the capital stock in generation. They will increase prices and reduce demand, as discussed in other sections. Reduced demand will decrease the need for new investment. However significant investment may nevertheless occur to replace generation that is no longer competitive.

The expanded RET provides a subsidy to investment in eligible generation. This may lead to generator entry at a faster rate than demand growth, and an increase in the level of installed capacity in relation to demand.

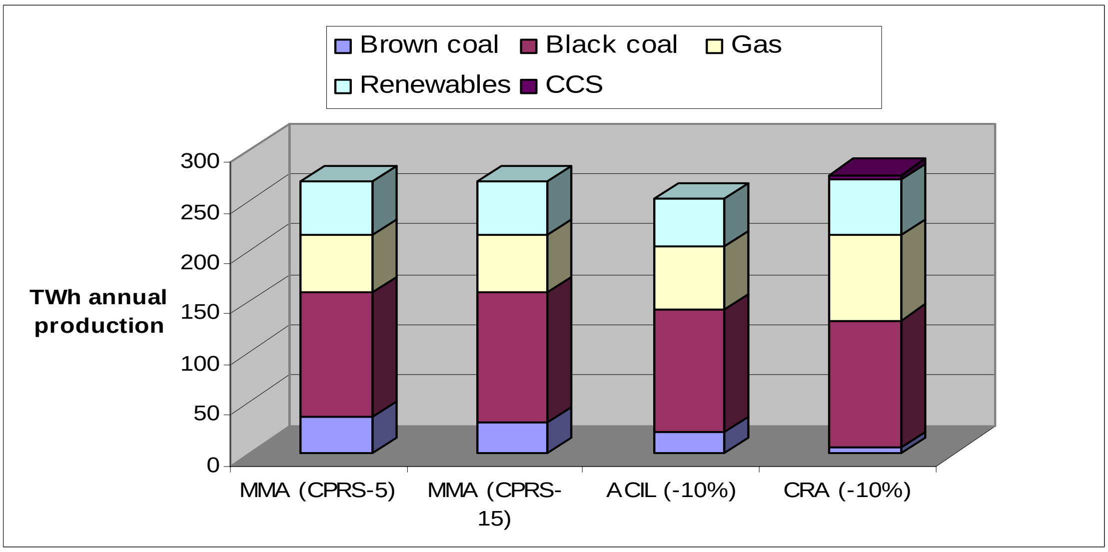
The CPRS will significantly increase variable costs for coal thermal generators. This may lead to early retirement of generating plant. It will also alter decisions on new generation investment.

These different impacts are discussed in this section. After summarising the overall changes in the generation mix, we look in turn at investment in renewable generation, retirement of coal-fired generation and investment in gas-fired generation. We then summarise the range of views on the overall changes in generation.

3.1 Overall changes in generation mix

The forecasts for predicted sources of electricity generation in 2020 are summarized in Figure 3.1. This shows the results of three modelling studies. These studies adopted different modelling approaches. The ACIL Tasman and CRA studies were based on achieving a specific level of electricity sector emission reduction relative to year 2000 (10 per cent and 7 per cent respectively). The MMA Treasury modelling used emission price assumptions provided by Treasury. The objective in that modelling was to achieve a specific level of net emission reduction for the Australian economy and not just the electricity industry by 2050. The emission prices in these three studies are different.

Figure 3.1: Projected generation mix in 2020



Sources: MMA Treasury, 2008a, p.38; ACIL Tasman, 2008, p.75; Port Jackson Partners, 2008, p.113.

The main points are:

- The three models project similar levels of production from renewable resources by 2020 (all assume that the expanded RET will be met);
- There were different views on expected share of gas generation, but these differences are not large. MMA Treasury modelling and ACIL Tasman produced almost exactly the same level of gas generation[21], while CRA projected the highest share of gas generation;
- All studies showed increased gas generation as emission prices (or emission reduction targets) rise;
- Projections of the rate of decline in brown coal and black coal generation differed significantly. MMA Treasury modelling suggests a significantly slower decline than ACIL Tasman, CRA or the MMA AEMC modelling. As explained later this is attributed to the higher demand predicted by the MMA Treasury than that predicted by ACIL Tasman.

These analyses, and other studies produced for the AEMC, by ROAM Consulting and MMA on projected generation investment and closure, are reported in this section. As noted above, the supporting modelling documentation released with the White Paper looks at these issues. Such modelling will add value to the discussion on these questions and will be considered in this Review.

Renewable generation

All analysts agree that climate change policies will lead to a large increase in renewable energy. There is also agreement that the additions to renewable generation capacity will be dominated by wind, at least in the early years.

There was less consensus on the point at which other renewable generation technologies may become viable, and the level of investment in these technologies by 2020. There were also different views on where renewable generation would be located.

Existing renewable energy is predominantly hydro capacity. Over the long term this has provided around 150 000 GWh of energy per year, on average. However over the recent past (the last five years) this has decreased considerably. It is unlikely that production from existing hydro facilities will return to their long run averages unless rainfall patterns revert to their long-term historical averages.

The existing mandatory renewable energy target required an additional 9500 GWh. The new target is for 45 000 GWh of renewable capacity to be built between 1997 and 2020. This will require around 39 000 GWh more than current levels, excluding renewable investment needed to meet demand for Green Power.

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21 After adjusting for the Darling Katherine Interconnected System which was included in MMA's and CRA's but not in ACIL Tasman's study, the differences are slightly larger. Also note that MMA's and CRA's results are based on sent-out electricity, while ACIL Tasman's results are on generated electricity. Also MMA's gas generation reflects a correction for the CPRS -15 case.

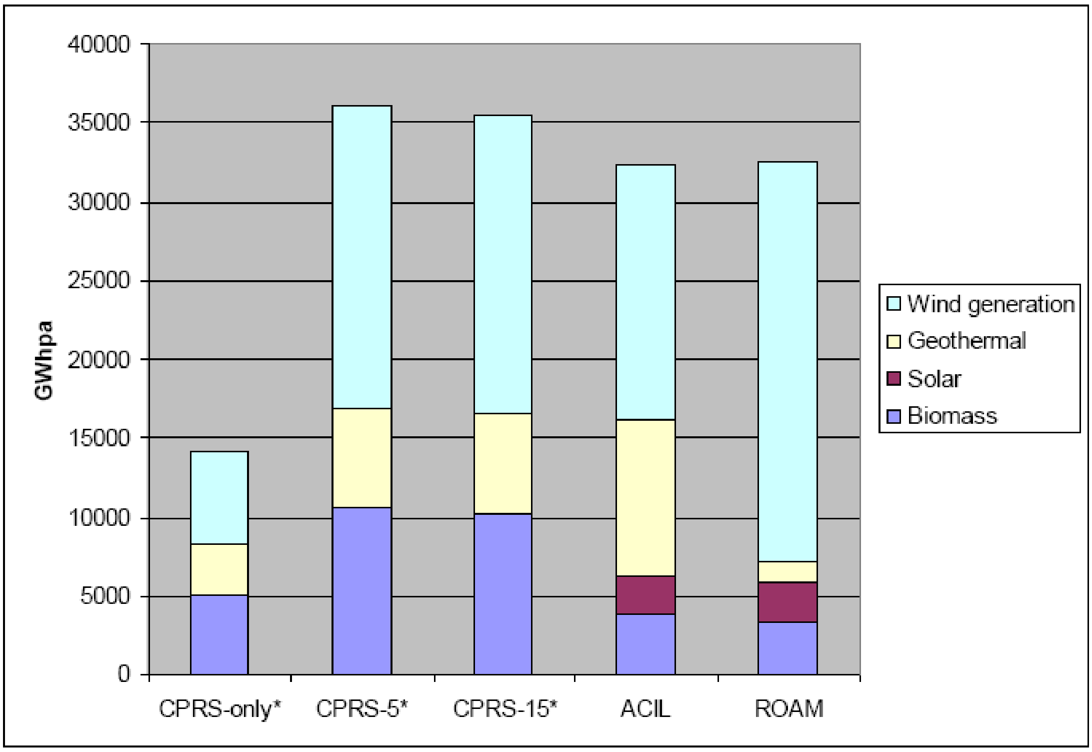
Quantity and mix of renewable generation

The CPRS -5 and CPRS -15 scenarios result in substantial additional renewable generation capacity (additional 36 TWh production from renewable sources in both cases) due to the higher wholesale market prices and income from Renewable Energy Certificates. Other scenarios have a lower level of renewable generation.

The MMA Treasury modelling shows that wind generation is expected to increase markedly in the period to 2020. The capacity factor for wind is assumed to vary by location, from 25 per cent to 43 per cent. The modelling limits wind penetration in any state to 25 per cent of maximum demand.[22] This reduces growth of wind generation after 2020 and increases the share of geothermal and solar thermal.

Figure 3.2 shows energy output in 2020 from different renewable technologies according to MMA Treasury modelling. Most analysts project that wind will dominate because it is a proven technology with lower unit costs than other renewable generation. There is less consensus on the contribution from geothermal, biomass and solar generation up to 2020. This may be attributable to uncertainty about the cost and size of the geothermal and biomass resource.

Figure 3.2: Predicted mix of new generable generation in 2020 (GWh)



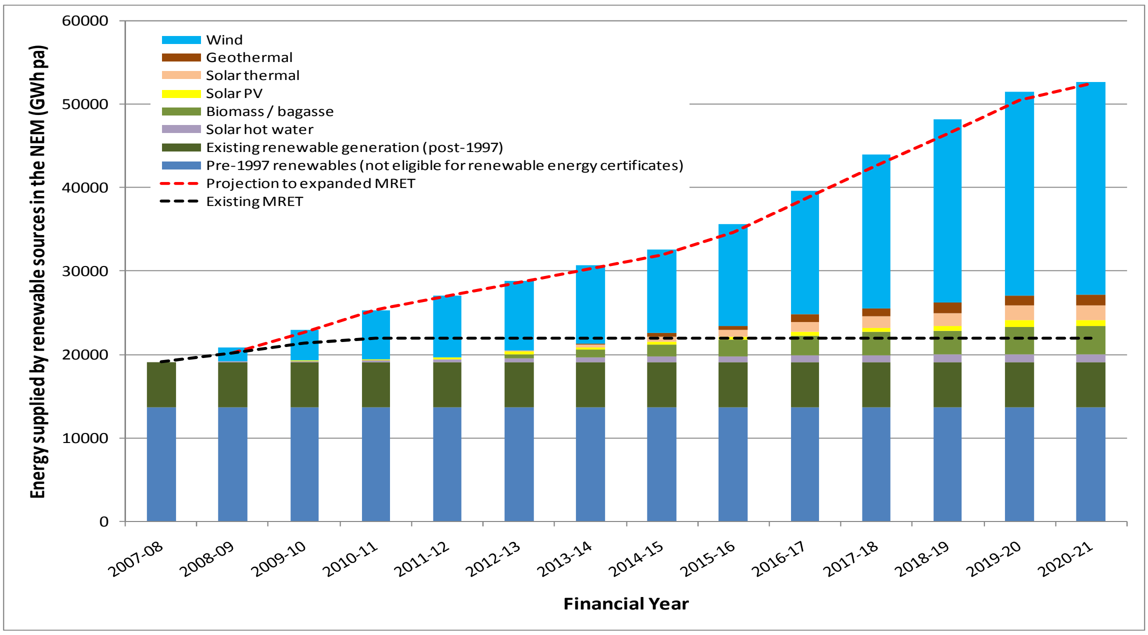
* These values refer to total renewables excluding hydro, while the ACIL and ROAM data refers to new generation above 2008 levels.

Source: ROAM 2008 Market Impacts paper, p. 37.

22 The model allows this cap to be exceeded in South Australia if the transmission network to Victoria is upgraded.

ROAM's forecast of the contribution of different renewable technologies is shown in Figure 3.3. The forecast shows a base of existing renewable generation pre and post-1997. Additional renewable investment is forecast to be dominated by wind.

Figure 3.3: ROAM forecast of contributions to expanded RET by technology



Source: ROAM 2008 Market Impacts paper, p.32

Location of new investment

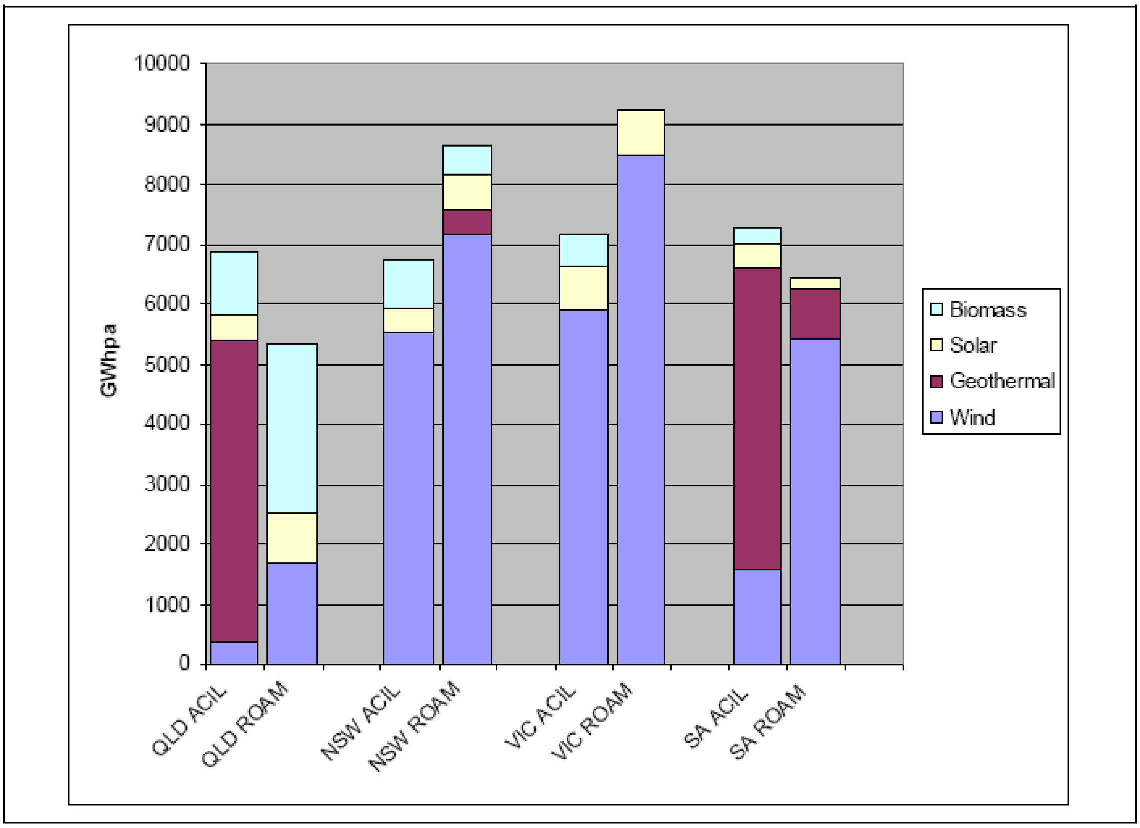
Figure 3.4 shows forecasts for the level of output from different types of renewable technology in 2020 for four States in the NEM. The forecasts are drawn from ACIL Tasman and ROAM models.

South Australia has had a large share of new renewable (wind) generation investment to date. However both ACIL Tasman and ROAM Consulting predict that Victoria and New South Wales will overtake South Australia on installed wind generation by 2020.

The majority of renewable investment to date has been wind generation. ACIL Tasman are forecasting large volumes of energy from geothermal plant by 2020 in Queensland and South Australia. ROAM forecast a much lower share. ROAM's research "suggests that solar thermal technology shows great promise and could be a significant contributor to the expanded RET".[23]

23 ROAM 2008 Market Impacts paper, p.40.

Figure 3.4: Location of new renewables in 2020 by State



Source: ROAM 2008 Market Impacts paper, p.39.

The level of wind capacity installed is most sensitive to the capacity factor (which measures the level of plant utilisation), capital costs and the cost of capital.

Figure 3.5 provides ACIL Tasman's forecast of wind investment by State and by year. ACIL Tasman assumed a 30 per cent capacity factor but noted that capacity factors may decline over time as the best sites are used up. ACIL Tasman also noted that the assumed penetration of wind in South Australia was conservative, reflecting their concerns over the impact of higher penetration on system operations.

Figure 3.5: ACIL Tasman forecast of wind investment (MW of installed capacity)

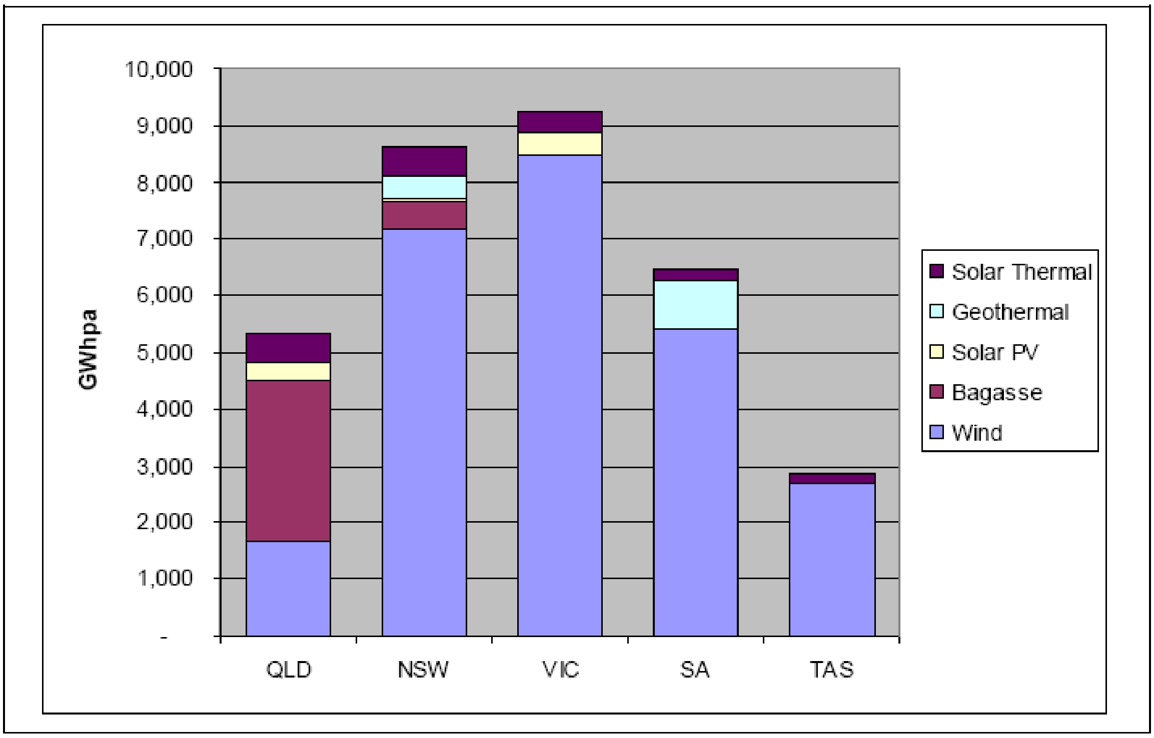
	NSW	Vic	SA	Tas	WA	Total
2008	0	0	0	0		0
2009	151	0	255	140	191	737
2010	181	0	506	140	191	1018
2011	318	139	609	140	241	1447
2012	667	529	609	140	341	2286
2013	967	879	609	140	391	2986
2014	1,267	1,229	609	140	491	3736
2015	1,567	1,579	609	140	541	4436
2016	1,727	1,779	609	140	591	4846
2017	1,855	1,939	609	140	641	5184
2018	1,957	2,067	609	140	691	5464
2019	2,039	2,169	609	140	741	5698
2020	2,105	2,251	609	140	791	5896

Note: Does not include wind generation in 2007 SOO load forecasts

Source: ACIL Tasman, 2008, p.35.

ROAM Consulting considered that wind would be the largest contributor of new renewable generation followed by bagasse (with the vast majority located in Queensland).

Figure 3.6: ROAM forecast of likely contributions to new renewable energy generation by 2020

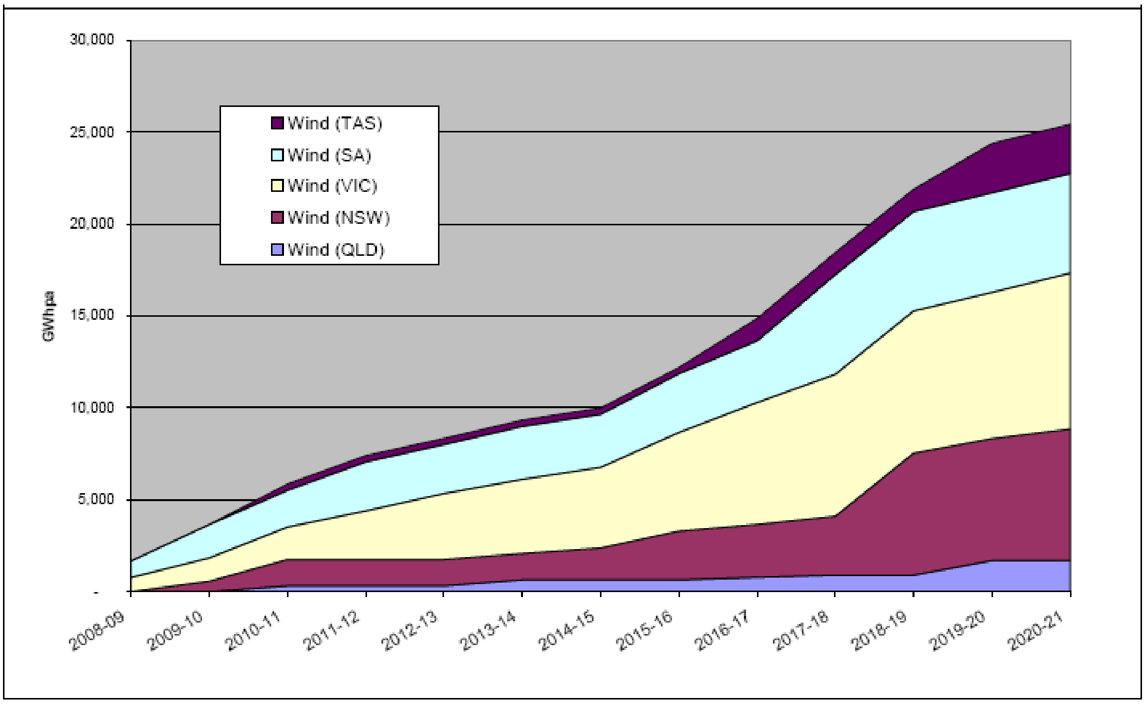


Source: ROAM Consulting, 2008, p.33.

Figure 3.6 shows ROAM Consulting projections of likely contributions to new renewable energy in 2020 by technology and by State. Wind is projected to provide by far the greatest additional renewable energy, of which South Australia is currently the largest producer. However, as noted above it is projected that it will be overtaken in volume within a few years by output from wind generation in Victoria and New South Wales. ROAM Consulting projections for the location of wind generation are shown in Figure 3.7.

In its report to the AEMC, ROAM consulting considered that wind developments in Tasmania may not proceed in the same proportion as the mainland despite the superiority of Tasmania's wind resources. This is because Tasmania ancillary service costs – which need to be imported across Basslink, will escalate to uneconomic levels with increasing proportions of wind in the generation mix.[24]

Figure 3.7: ROAM projections of likely locations of wind generation by State under RET



Source: ROAM Consulting, 2008, p.34.

Impact of network constraints on renewables investment

MMA Treasury modelling assumed that entry of wind generation in the NEM was limited to 25 per cent of maximum demand (although it allowed this to be exceeded if additional interconnector capacity was built between SA and VIC).

24 ROAM 2008 Market Impacts paper, p.45.

Analysis by ROAM Consulting suggested that there may be difficulties in absorbing the energy output of wind generators when there is also likely to be negative bidding by thermal generators and limits on export capacity. The analysis suggested these impacts are likely to be most material for South Australia, in the absence of reinforcement of the transmission network.

Coal-fired generation

There was general agreement that climate change policies will weaken the competitive position of coal-fired generation and that this impact will be most marked for older brown coal generation with high unit emissions. Some reports considered there would be a level of fuel switching between coal-fired generation and gas-fired generation.

There was less consensus on the timing and scale of any retirement of brown coal plant. There was also less consensus on the implications for other coal-fired generation. However, after adjusting for difference in the demand projections, these differences are not significant.

Several reports have analysed the possible early retirement of coal-fired generation plant. In most cases this has been done using a modelling framework that forecasts both variable operating costs and revenues.

ROAM Consulting analysis for the AEMC looked at the impact of a high price of $60/t. Their conclusion was that some brown coal generators would suffer severe reductions in volumes and revenue. However even at this high price, others would not lose volume and would still be able to pass on price increases to their customers.

Their analysis showed small decreases of volume for the older, higher emissions black-coal fired plant in New South Wales and Queensland. However there was an increased or stable output for the majority of coal-fired generators in both regions. ROAM concluded that the most efficient coal plants in these regions will not lose volumes and will be able to fully pass on increased costs to consumers.

ROAM Consulting noted that there are transmission limitations for imports into Victoria. This requires that substantial proportions of Victoria's electricity are sourced within the region. As a result, any reduced output by the most affected brown coal plant in Victoria would be expected to increase market power for other plants in the region.

ACIL Tasman and CRA suggested significant decreases in the volume of generation from brown coal sources, by 2020. ACIL Tasman forecast 6645 MW of closure by 2020 in their 10 per cent case and 10 425 MW in the 20 per cent case. Its forecast for closure is shown in Table 3.1.

Table 3.1 : Station closures aggregated by region, 2011 to 2020

Region	BAU	10% case	20% case
NSW	-	150	2,250
Queensland	-	890	2,570
South Australia	-	770	770
Victoria	-	4,835	4,835
Total MW by 2020	-	6,645	10,425

Source: ACIL Tasman, 2008, p.9.

ACIL Tasman's modelling withdraws plant when revenue falls below fixed and variable costs. In the 10 per cent case, Energy Brix (195 MW) is the first to be withdrawn followed by Hazelwood (1640 MW) and Yallourn (1480 MW) and Loy Yang B (1020 MW). Newport Power Station is also assumed to close from 2015 onwards.

Projected closures before 2020 outside of Victoria are:

- Playford and Northern in South Australia;
- Redbank in NSW; and
- Collinsville and Callide B in Queensland.

In the 10 per cent case, closures are concentrated in Victorian and South Australian brown coal plant, although some closures are also projected for Queensland and New South Wales. In the 20 per cent case, the higher carbon prices result in an additional 3800 MW of closures from NSW and Queensland. There are no projected plant closures in the SWIS in either the 10 per cent or 20 per cent cases.

In analysis undertaken for the AEMC, MMA suggested that closure of a whole brown coal power station was unlikely by 2020, although individual units may be closed by this time. MMA AEMC also noted that coal used in Leigh Creek is used in the Northern and Playford power station will be exhausted by 2017. It will then be necessary to either import coal or use lower quality coal from Leigh Creek, or close these power stations. Apart from these stations and possibly Munmorah in New South Wales, MMA AEMC paper did not consider closure for black coal stations was likely before 2020 at a permit price below $25/T. MMA 2008 Initial Market Issues paper for the AEMC suggested that black coal generation in Western Australia should benefit from high gas prices and limited competition in coal supply, and noted that black coal plant in New South Wales had to operate in an intermediate role in the mid-1990s and is more able to adapt to weekly intermediate operation.

MMA/Treasury modelling for the CPRS -5 and CPRS -15 did not specifically conclude on plant closure.

The Australian Treasury report comments that:

> Coal-fired electricity's share declines after emissions pricing is introduced, with several existing fossil fuel power plants retiring earlier than in the reference scenario. However, with electricity prices increasing due to the emission price,

most existing power plants continue to operate. The assumed convergence of east coast gas prices to export parity also helps coal-fired electricity maintain its competitiveness for base-load generation.[25]

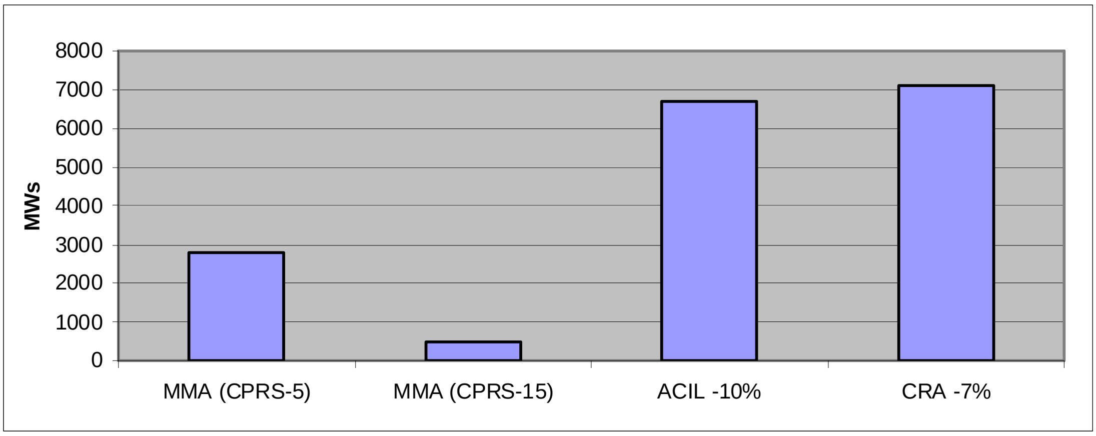
None of the modellers projected new investment in coal-fired generation in the period up to 2020.[26]

Gas fired generation

Climate change policies will increase the level and share of gas-fired generation up to 2020 compared to BAU. The impact is expected to be sufficient to lead to a much larger role for gas. The modellers had similar conclusions on the production of electricity from gas-fired plant, but in some scenarios MMA Treasury projected much less gas generation entry.

The CPRS and expanded RET will reduce demand, and increase the supply of renewable generation. Both factors will reduce the need for new investment in thermal generation. However the policies may lead to closure of brown coal plant and will improve the economics of new entry for combined cycle gas-fired plant. A summary of the results on gas investment is shown in Figure 3.8 below.

Figure 3.8: Gas generation entry 2010 to 2020



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Source: MMA Treasury, 2008a, p.39; Port Jackson Partners, 2008, p.113.

25 Australian Government, Australia's Low Pollution Future – The Economics of Climate Change Mitigation 2008, p. 177.

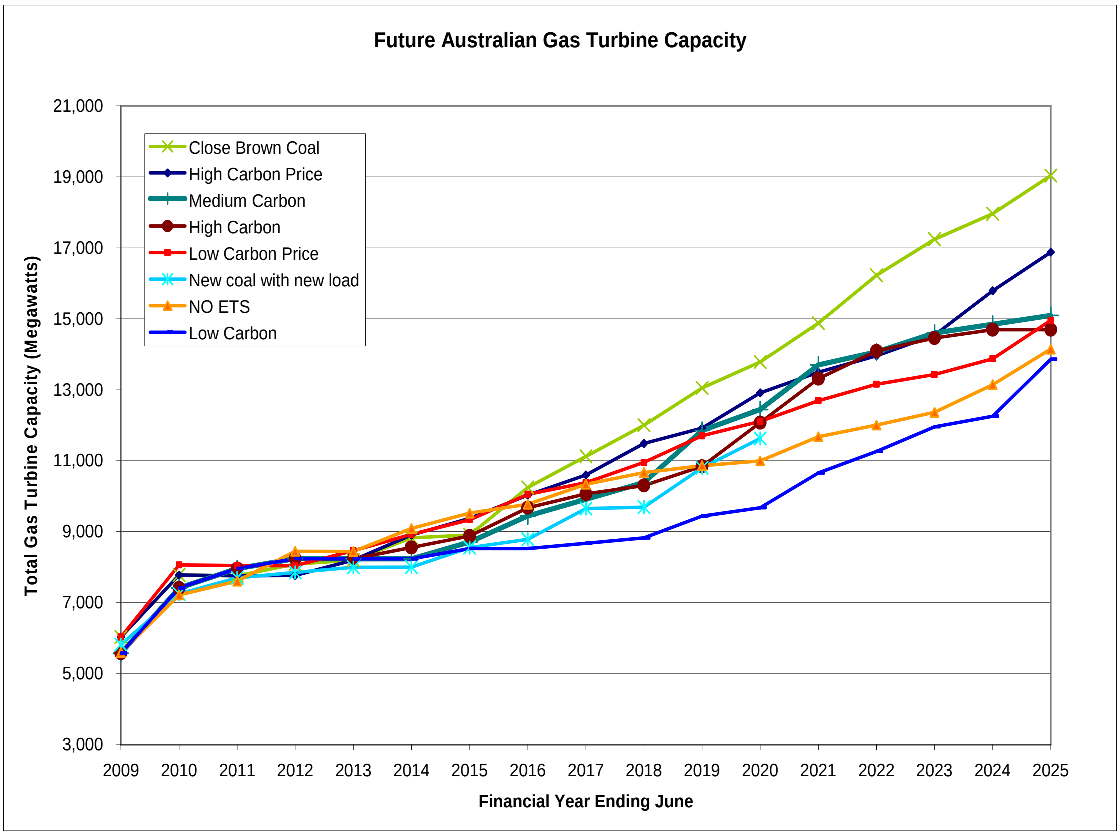
26 There some difference in the cost assumptions between the ACIL Tasman and the MMA Treasury modelling. ACIL Tasman assumed capital costs of $1882 per KW for black coal and $2228 for brown coal. ACIL Tasman used s fixed O&M cost of $40 per MW/year with $1.20 per MWh for non-fuel variable for both brown and black coal plant (see p.88 of ACIL Tasman report). MMA Treasury modelling assumptions are contained in table 2.1 on p.26.

The MMA Treasury modelling of new gas capacity shows an increase of around 2800 MW of gas capacity by 2020, under the CPRS -5 case, and around 500 MW for the CPRS -15 case.

ACIL Tasman forecasts significantly higher new gas entry. Its study showed a requirement for 9490 MW of additional gas capacity by 2020 assuming a 20 per cent emission reduction by 2020, or 6690 MW assuming a 10 per cent reduction by 2020. CRA calculated an increase of 7090 MW to achieve a 7 per cent reduction by 2020.

In a study undertaken for the AEMC, MMA produced projections of investment in gas fired generation and all thermal generation from studies conducted during 2008. Figure 3.9 shows MMA AEMC's forecasts of additional gas-fired generation. Figure 3.10 shows MMA AEMC's forecasts of additional thermal capacity (which will either be open cycle gas turbine or CCGT capacity).[27]

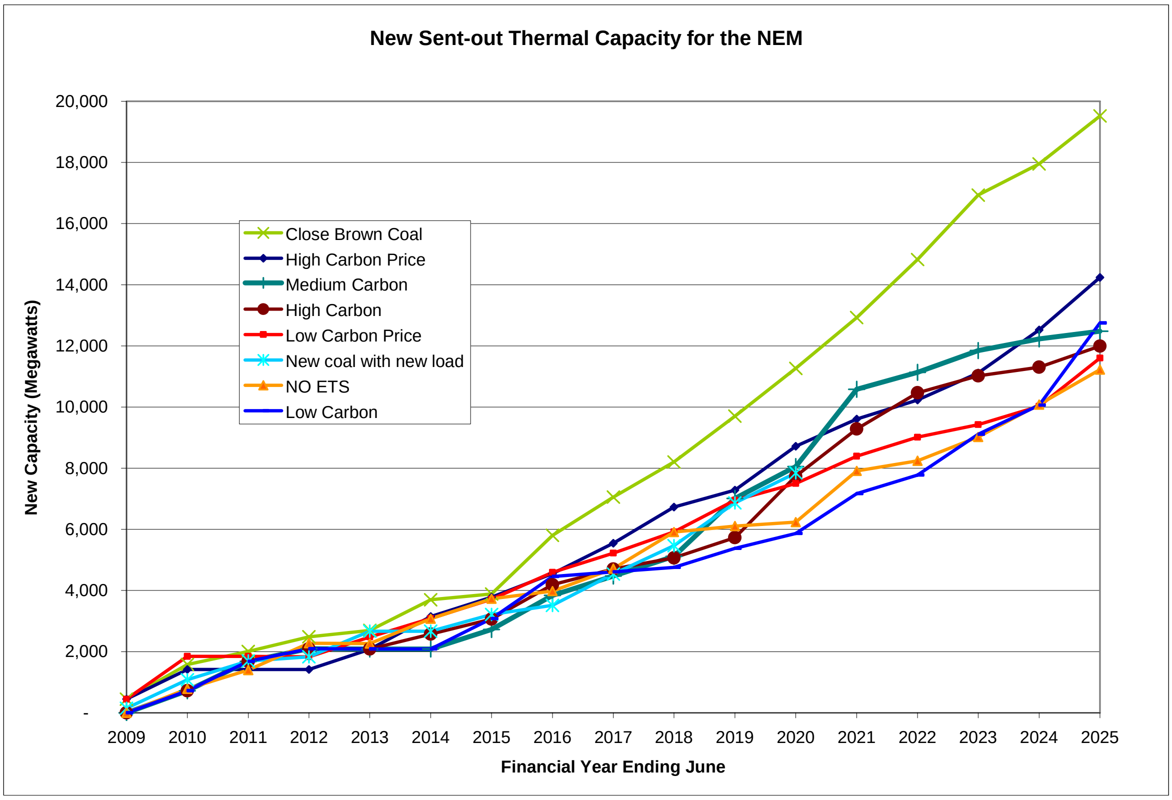
Figure 3.9: MMA projections for the AEMC of new gas turbine capacity in the NEM



Source (MMA 2008 Initial Market Issues paper 2008b, p 25)

27 MMA Report to AEMC 2008 Initial Market Issues paper, pp.24-26.

Figure 3.10: MMA projections for the AEMC of new thermal capacity for the NEM



Source (MMA 2008 Initial Market Issues paper (2008b, p 26)

Both MMA Treasury and ACIL Tasman had similar cost assumptions on gas generation plant. This is shown below in table 3.2.

Table 3.2: Assumptions on costs of gas generation

	Capital costs 2010 ($/kW)		Fixed O&M ($/MW/year)		Non-fuel variable O&M ($/MWh)	
	ACIL Tasman	MMA	ACIL Tasman	MMA	ACIL Tasman	MMA
CCGT (large)	$1,188.00	$1,334.00	$12.80	$20.00	$4.85	$3.00
OCGT	$842.00	$720.00	$7.50	$23.00	$7.50	$5.30

Relationship between gas fired generation and renewables

Only MMA Treasury modelling considered the incremental impact of the expanded RET. That modelling showed that generation from gas sources was essentially unchanged under both the CPRS -15 and CPRS -5 cases, although MMA Treasury did project significantly lower investment in gas generation under the CPRS -15 case. ROAM Consulting and MMA AEMC commented that one of the important roles of hydro power generation in the NEM has been to provide short-term energy reserves during base load plant outages. With the reduced relative size of the hydro resources, this role has been increasingly taken over by gas turbine plants.

With increasing contributions from wind, the energy reserve role will increase beyond the capability of the hydro system and the NEM will depend on gas fired generation on every second or third day to make up for the lost wind contribution. Gas fired peaking plant tends to be OCGT rather than CCGT technology due to OCGT lower capital costs.

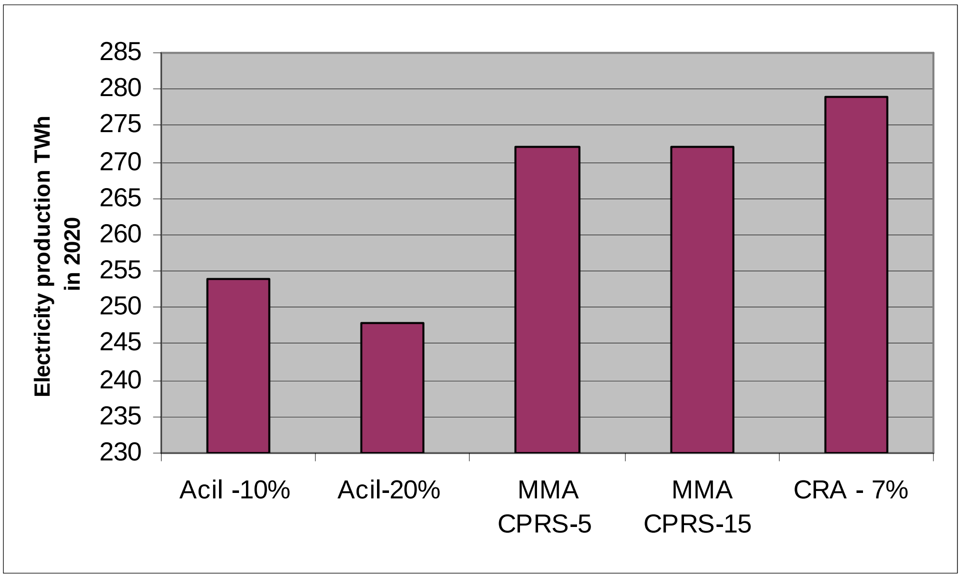
Therefore, the increasing volumes of wind power would create more day-to-day variation in the demand for gas for power generation.

4. Changes in demand

There is a consensus that climate change policies will increase prices and reduce demand.

Modelling by Treasury, ACIL Tasman and CRA project different levels of demand in 2020. A summary of the differences in demand (expressed in terms of electricity produced) is shown in Figure 4.1.[28]

Figure 4.1. Electricity production in 2020



Source: MMA (2008, p37), Port Jackson Partners (2008, p113), ACIL Tasman (2008, p53)

Under BAU, electricity demand will grow in line with population and economic growth. Demand may also be reduced in response to price increases that are not attributable to climate change policies.

With climate change policies, prices will be higher and demand will be lower than under BAU. This will lead to a lessening of demand in the mass market and among commercial and industrial consumers. It may also lead to one-off shifts in demand if electricity prices lead to changes in major industrial loads.

The Treasury modelling forecasts that demand will be 255 TWh per year in 2010 and that under BAU, it will rise to 307 TWh. Table A2 in the appendix to the Treasury modelling indicates that this BAU analysis is within a range of -7.9 per cent to +9.4 per cent of published energy projections by NEMMCO, the IMO and the NT Utilities Commission, after adjustment to make the figures comparable.

The MMA Treasury analysis of energy sector impacts draws on demand forecasts from the MMRF modelling. This model produces large one-off changes in demand as

28 CRA and MMA figures are on a sent-out basis and ACIL Tasman's include auxiliary load.

shown in figure 4.2. In MMA Treasury modelling, the initial changes in demand have been smoothed in over a five-year period.

All scenarios are expected to lead to a reduction in demand from BAU. The reduction is from 11 per cent to 23 per cent in 2020. Table 4.1 shows the demand levels in 2020 for each scenario and the change from BAU.

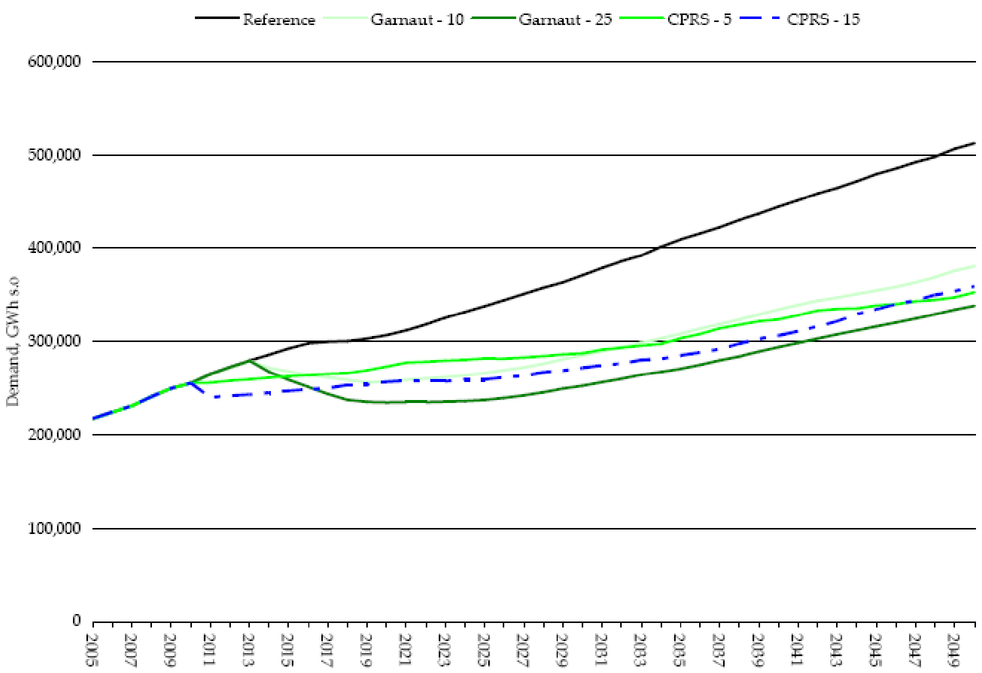
Under most scenarios demand is then forecast to be stable or declining until around 2030. These long-term scenarios are shown in figure 4.2.

Table 4.1: MMA Treasury modelling of change in electricity demand by scenario

	2010 TWh sent out	2020 TWh sent out	2020, % change in output from 2010
Reference	255	307	n.a.
CPRS only	255	272	7%
CPRS -5	255	272	8%
CPRS –15	255	272	10%

Source: MMA Report to Federal Treasury (2008a, p37)

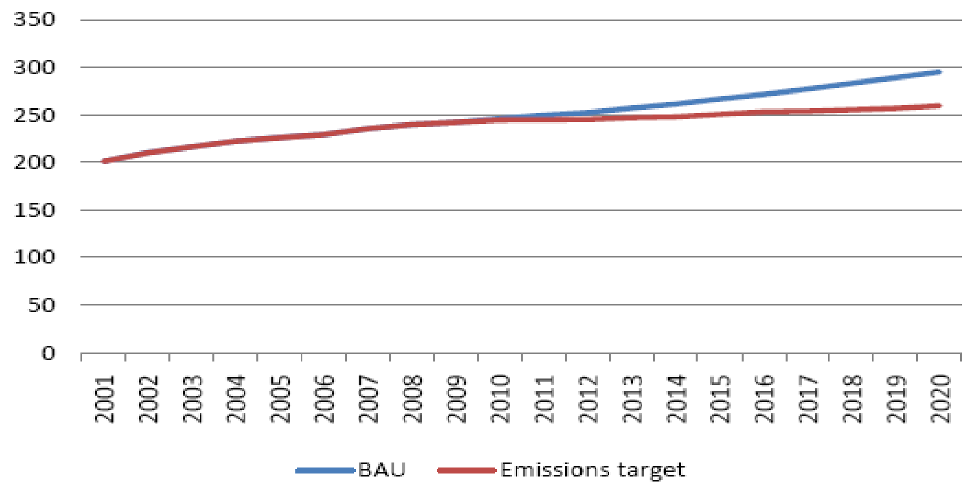
Figure 4.2: Treasury modelling of electricity generation (GWh sent out)



Source: MMA (2008a, p36)

ACIL Tasman's forecast of demand is shown in Figure 4.3. The BAU forecast of demand is similar to the Treasury projections. Demand (measured at the point of production) under the 10 per cent case is a little over 250 TWh in 2020. This is significantly lower than MMA's projection. The modelling by CRA calculated that demand in 2020 would be comparable to the CPRS -15 case in MMA Treasury modelling.

Figure 4.3: ACIL Tasman projections of energy demand (sent-out TWh) BAU and 10 per cent case



Data source: Tasman Global model results

Source: ACIL Tasman (2008, p27)

Demand by industry sector

General Equilibrium modelling suggests there could be significant changes in industry structure in response to the impact of climate change policies on domestic prices in comparison with international prices.

The impact of climate change policies on energy prices may also affect the level of demand by major industrial loads. It is possible that price increases could either reduce the growth in demand by particular industrial sectors or lead to a reduction in demand. The impact on these sectors may be more stochastic than the impact on mass-market demand.

The consolidated report on the Treasury modelling includes gross output by sector in 2050. It shows the change under different scenarios from the reference case (BAU). It also shows the change from 2008 output for the CPRS -5 scenario. The sectors with a reduction in output under the CPRS -5 scenario exceeding 15 per cent under either measure are shown in Table 4.2.

Table 4.2: Treasury modelling of change in output under the CPRS -5 scenario in 2050

Industry	Change from reference scenario	Change from 2008 output
Coal mining	-30.1%	+66%
Oil sector	-0.4%	-75%
Refinery	-37.7%	+88%
Alumina	-16.8%	+73%
Aluminium	-45.2%	-7%
Other metals manufacturing	+21.1%	-71%
Electricity (coal-fired)	-71.5%	-38%

Source: The Australian Government, "Australia's Low Pollution Future" Table 6.11

ACIL Tasman's analysis of the impact of climate change on different industrial sectors is shown in Table 4.3. The table shows percentage changes from BAU demand under two scenarios. The highest impacts on demand in both scenarios are for the household sector.

Aluminium and zinc smelting use about 2 700 MW of baseload power in the NEM which is approximately around 7 per cent of total demand.. The CPRS and expanded RET will increase prices. If this leads to a reduction in domestic production and electricity demand this would have a major impact. The impact would be particularly great in regions where smelter load is large relative to regional demand.

The impact of the CPRS on demand may be offset by assistance to energy intensive trade exposed industries proposed upon the CPRS.

ACIL Tasman assumed that existing trade-exposed energy-intensive industries would be given free permits or offsetting payments. Their analysis assumed that aluminium smelters and other non-ferrous metal industries received this assistance to the point where their demand did not decrease. No assistance was assumed for increased output. Expansion for these industries was therefore lower under scenarios with an emissions trading scheme than under business as usual. However in the design of the CPRS set out in the White Paper, the assistance to Emission intensive Trade exposed (EITE) industries will be link to production and will not be a cap on growth. This may mean that the ACIL Tasman demand forecasts are possible on the high range on the likely extent of any demand reduction.

Table 4.3: ACIL Tasman projections of demand changes from BAU in 2020

Industry	10% case	20% case	BAU 2020 GWh
Primary agriculture	-8.10	-9.45	6,500
Fishery and forestry	-5.64	-6.58	166
Coal	-12.61	-14.71	6,795
Oil	-8.02	-9.36	687
Gas	-9.02	-10.52	629
Other minerals	-10.54	-12.30	8,739
Processed foods	-10.65	-12.43	7,927
Light manufactures	-12.52	-14.61	5,684
Petroleum products	-7.39	-8.62	2,508
Chemicals, rubber and plastics	-10.01	-11.68	8,456
Non metallic minerals products	-9.96	-11.62	6,308
Iron and steel	-13.88	-16.19	9,050
Non ferrous metals	-7.09	-8.27	52,008
Pulp, paper and publishing	-11.58	-13.51	7,818
Motor vehicles & transport equip	-13.35	-15.58	4,991
Electronics manufacturing	-15.91	-18.56	1,820
Other manufactures	-12.78	-14.91	3,874
Water	-12.49	-14.57	2,923
Construction	-6.60	-7.70	153
Wholesale and retail trade	-11.90	-13.88	23,668
Transport	-6.19	-7.22	6,293
Communications	-11.40	-13.30	1,730
Other business services	-12.27	-14.32	14,434
Other services	-11.72	-13.67	21,018
Households	-19.83	-23.14	73,557
Total	**-12.02**	**-14.01**	**277,736**

Data source: Tasman Global model results

Source: ACIL Tasman (2008, p28)

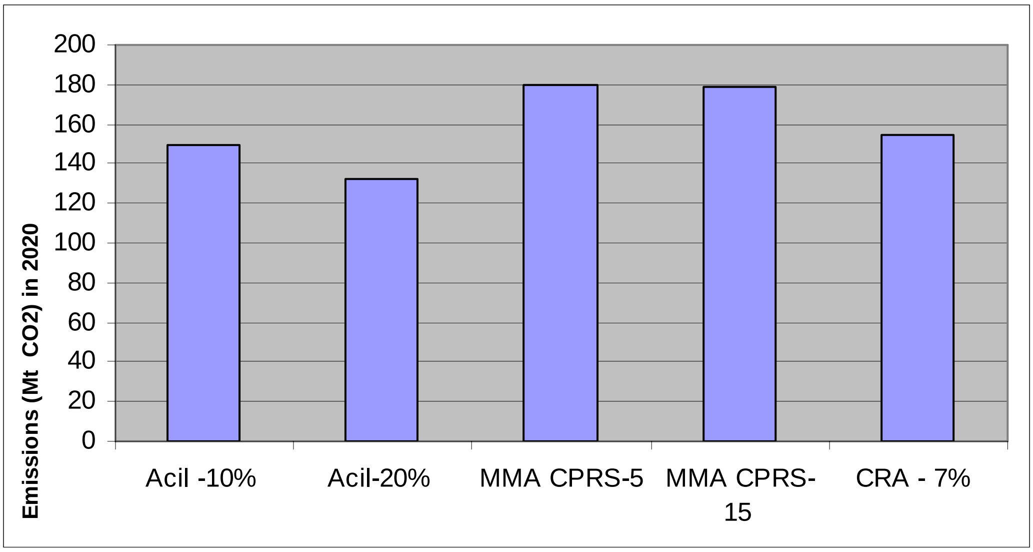
5. Changes in emissions and emission prices

5.1 Changes in emissions and emission prices

The CPRS will establish a price for emissions. Also the CPRS and expanded RET will alter the level of emissions in the Australian energy sector. The change in emissions and emission prices are reviewed in this chapter.

Figure 5.1 summarises the expected emissions from electricity in 2020 according to the different models. Although different levels of emissions are expected by 2020, these differences can be explained by different projections of demand.

Figure 5.1. Expected emissions from electricity in 2020



Source: MMA (2008a, p 34), Port Jackson Partners (2008, p103), ACIL Tasman (2008, p72)

Change in emissions to 2020

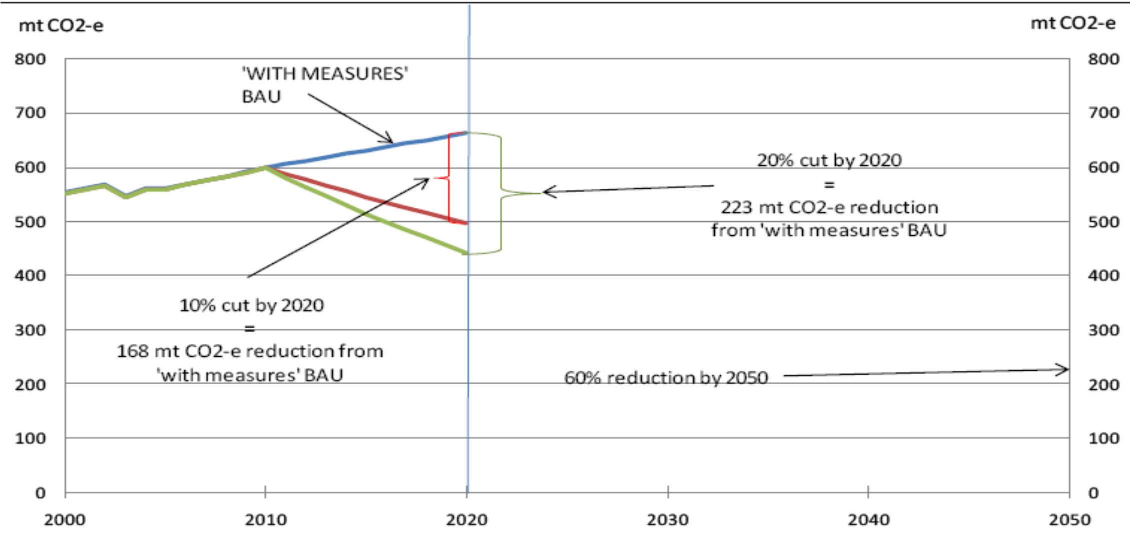
The ACIL Tasman modelling examined scenarios for 10 per cent and 20 per cent reduction in Australian emissions consistent with a target 60 per cent reduction by 2050. This is shown in Figure 5.2. ACIL Tasman assumed that the Australian electricity sector would be required to contribute at least this level of emissions reduction. It might be required to contribute more if abatement could be delivered more cost effectively in this sector. Their work therefore considered the impact of 10 per cent and 20 per cent reductions in Australian electricity emissions (on the levels in 2000). This was modelled for the two main interconnected grids, the NEM and the SWIS. The targets examined are shown in Figure 5.3.

The scenarios examined by Treasury are considered to be consistent with reductions in Australian net emissions allocations of 5 per cent, 10 per cent, 15 per cent and 25 per cent by 2020 (from levels at 2000). These are reductions in net emissions (after allowing for trade in permits). The targets for 2020 are consistent with long-term targets for emissions reduction, and for stabilization of emissions.

The CRA work modelled emission reductions of 7 per cent against the level of emissions in 2000.

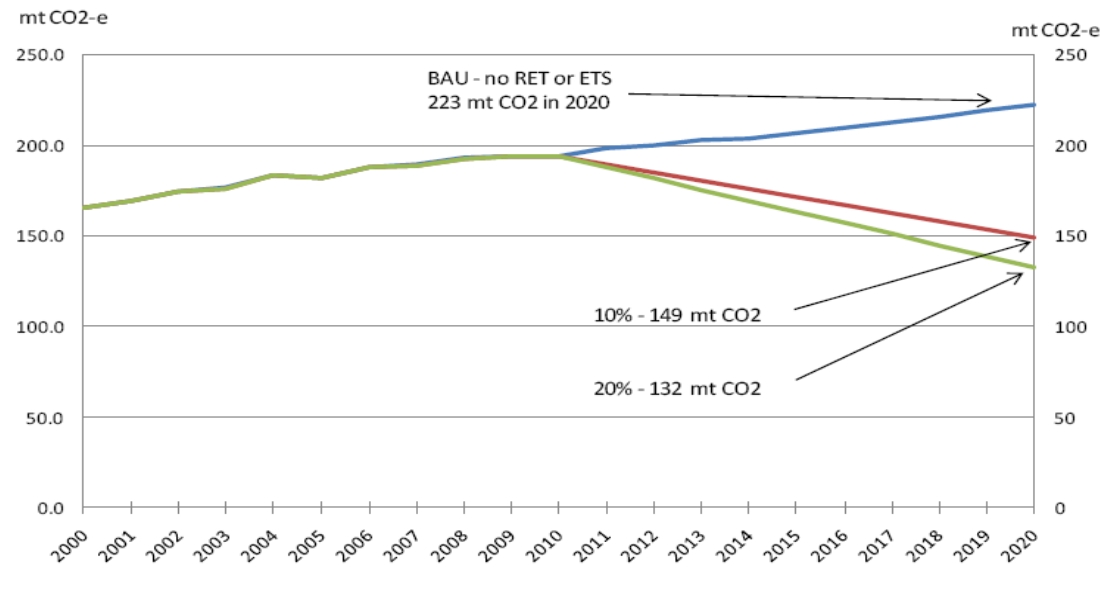
ACIL Tasman and CRA calculated emissions in 2000 to be 165 mtCO2-e. MMA calculated emissions in 2000 to be 175 mtCO2-e. A small part of the difference may be because MMA Treasury included the Darwin-Katherine Interconnected System and off grid generation from other sources.

Figure 5.2: ACIL Tasman scenarios for economy-wide emissions reduction target



Data source: Department of Climate Change (2008), ACIL Tasman calculations

Figure 5.3: ACIL Tasman projection of reductions by the NEM and the SWIS



Data source: ACIL Tasman estimates of NEM and SWIS emissions

Source: ACIL Tasman (2008, p20)

The Treasury modelling establishes five different targets, distinguished by the level of reductions sought by 2020 and by the degree of international action:

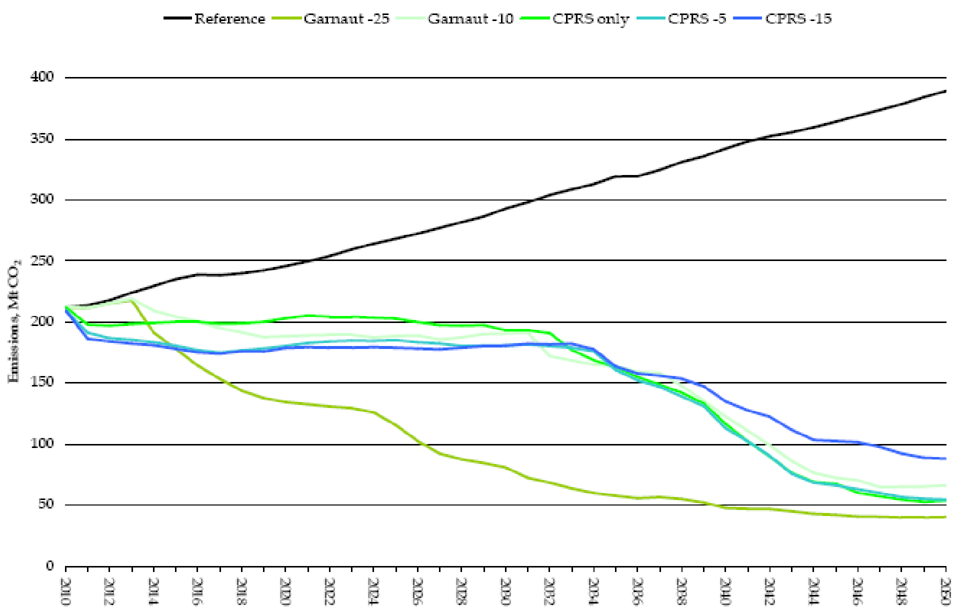
- The Garnaut scenarios allow for full international linkage from 2013 on. The Treasury modelled reductions of 10 per cent and 25 per cent for 2020 under the Garnaut scenarios. These are referred to as Garnaut -10 and Garnaut -25.

- The CPRS scenarios assume linkage between developed economies from 2010 and staged introduction of developing countries up to 2025. The Treasury models reductions of 5 per cent and 15 per cent under the CPRS scenarios. The CPRS scenario sought reductions of 5 per cent without the expanded RET. The CPRS -5 scenario included the expanded RET. The CPRS -15 scenario requires a 15 per cent reduction in Australian emissions allocation, not actual emissions. Abatement can be bought from international sources to meet this target and does not have to be done domestically.

These targets are consistent with long-term targets for stabilisation of greenhouse gas levels. The reductions in emissions under business as usual (referred to as the Reference Case) and under these scenarios up to 2020 is shown in Figure 5.4.

Through the whole period, including the period to 2020, the electricity sector is the *largest* source of absolute abatement of any sector in the Australian economy, and provides more abatement than is bought overseas in the period to 2020.

Figure 5.4: Emissions from electricity generation under Treasury scenarios



Source: MMA Report to Federal Treasury (2008a, p33)

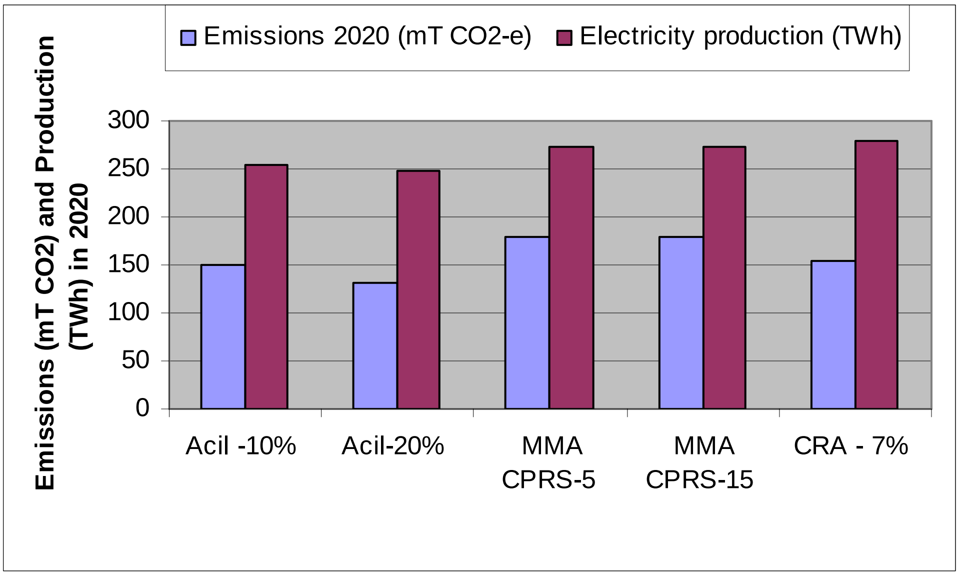
The MMA estimate of emissions from the Australian electricity sector was 175 MT in 2000. The forecast emissions from Australian electricity generation in 2020 are shown in Table 5.1, for MMA's scenarios, ACIL Tasman's –10 per cent and –20 per cent scenario and CRA's –7 per cent scenario. It should be noted in this that the basis for comparison is not the same: MMA has assumed emissions of 175 mT in the electricity sector in 2000, while ACIL Tasman and CRA assumed 166 mT in 2000.

Table 5.1: Projection of emissions from electricity generation in Australia

Scenario	2020 emissions MT	Change from 2000 levels
Garnaut –25	134	-23%
Garnaut –10	188	+8%
CPRS only	203	+16%
CPRS –5	180	+3%
CPRS –15	179	+2%
ACIL - 10%	149	-10%
ACIL - 20%	132	-20%
CRA - 7%	155	-7%

Table 5.1[29] above showed that CRA and ACIL Tasman project similar levels of emission by 2020, while MMA projects much higher emissions. This is despite the fact that they all three studies have similar emission prices in 2020, as discussed in the next section. The difference can be explained by the difference in the demand assumptions. Figure 5.5 shows the 2020 emissions and electricity production (as a proxy for demand). From this it is clear that there is a roughly proportionate relationship between electricity production and emissions. In other words, higher emissions are because of higher demand.

Figure 5.5. Emissions and electricity production projections to 2020



Source: MMA Report to Federal Treasury (2008a, p 34, 37), Port Jackson Partners (2008, p103,104), ACIL Tasman (2008, p53, 72)

The work by ACIL Tasman suggests that the abatement costs in the electricity sector is cheaper than that implied by the MMA Treasury modelling. It is not clear whether the required change to the capital stock to achieve the level of abatement proposed by ACIL Tasman is feasible. The MMA Treasury modelling did perform a feasibility assessment. It analysis suggests less change over of capital stock, higher pass-through as a result and less emissions abatement from the sector.

Permit prices

Permit prices will be sensitive to scheme design, the level of reductions sought and the assumption on international linkage.

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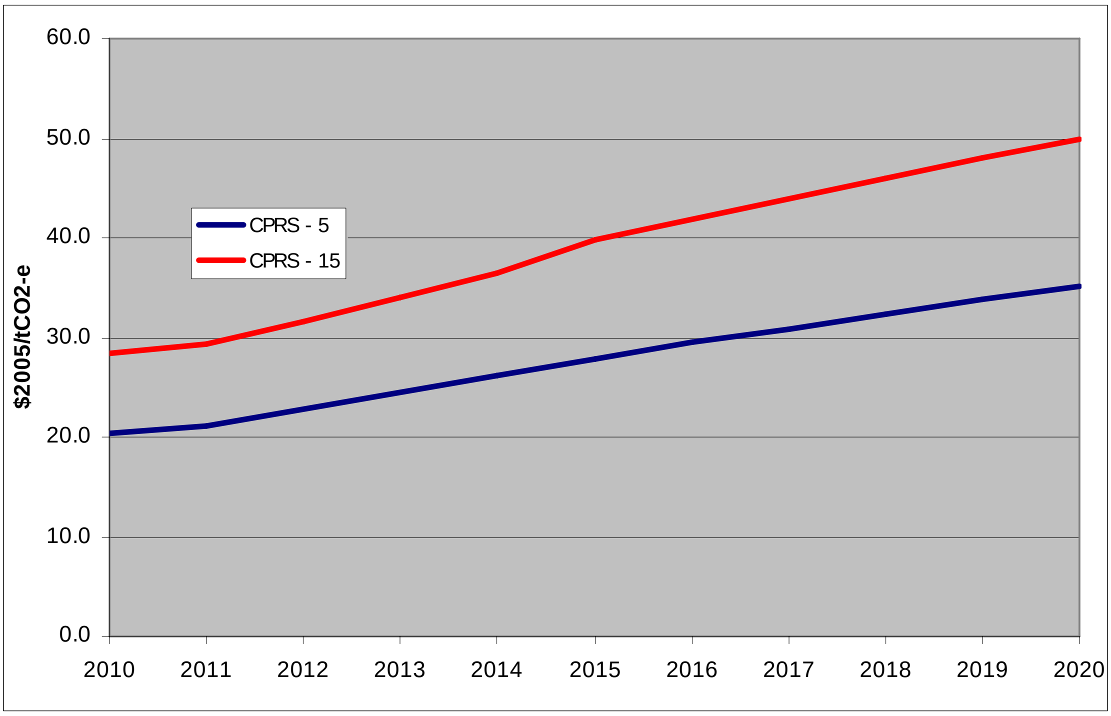
[29] Source: AEMC analysis, MMA (2008, p34), ACIL Tasman (2008, p), Port Jackson Partners (2008, p107)

Under the MMA modelling for Treasury, Australia will take the international carbon permit price.[30] The other models assume that the permit price is set domestically and is determined by the level necessary to achieve the emission target reduction. All the models had a smooth trajectory in permit prices.

The Treasury modelling shows 2020 permit prices of $37.25, $53 and $64 (in $2007 prices) corresponding to the three stabilization targets that they have modelled. [31] For the permit price in Australia, the MMA Treasury report showed the price increasing from $21.7 in 2010 (2007 prices) to $37.45 in 2020 under the CPRS -5 scenario. For the CPRS -15 scenario, the price increases from $30.24 to $53.09 (2007 prices) over the same period. This is shown in figure 5.6.

Figure 5.6 Australian Treasury modelling of Permit Prices ($2005)



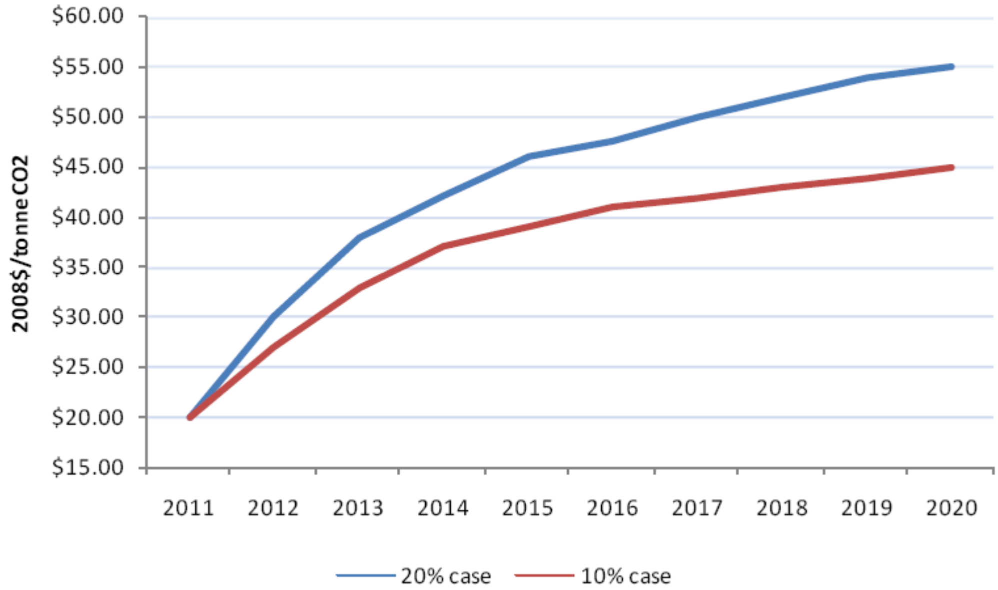
Data source: The Australian Government, Australian Low Pollution Future, The Economics of climate change mitigation report, chart 6.3

30 Although the Treasury modelling includes limitations on the total level of trade, these limits are not binding.

31 Stabilisation of atmospheric concentration requires significant cuts in global emissions. The stabilisation level depends on how soon emissions peak and how quickly they decline. The Treasury report considered that global mitigation action to achieve stabilisation at 450ppm CO_2 –e could limit global average warning to around 2°C above pre-industrial levels, while stabilisation at 550ppm CO_2 –e could limit global average warning to around 3°C above pre-industrial levels. The CPRSCPRS -5 and Garanut -10 were based on stabilisation goal of 550ppm CO_2 –e, while CPRS – 15 was based on a stabilisation goal of 510ppm CO_2 –e, and Garanut -25 based on stabilisation goal of 450ppm CO_2 –e.

The ACIL Tasman model had slighter higher prices. They are forecasting permit prices of $45-55/tonne in 2020 (in $2008) to achieve their abatement objective. ACIL Tasman calculated that permit prices starting at $20/T and rising to $45-$55/T by 2020 will be needed, in combination with expanded RET, to achieve emission reductions of 10 per cent/20 per cent on 2000 levels, by 2020. Their forecast of permit prices is shown in Figure 5.7. ACIL Tasman considered that the price will need to rise fairly steeply at first in order to achieve the necessary level of retirements and replacements and recognised that the permit price in 2020 is likely to be influenced by the emissions target set for 2030.

Figure 5.7: ACIL Tasman forecast of permit prices, 2008$



Source: ACIL Tasman (2008a, p5)

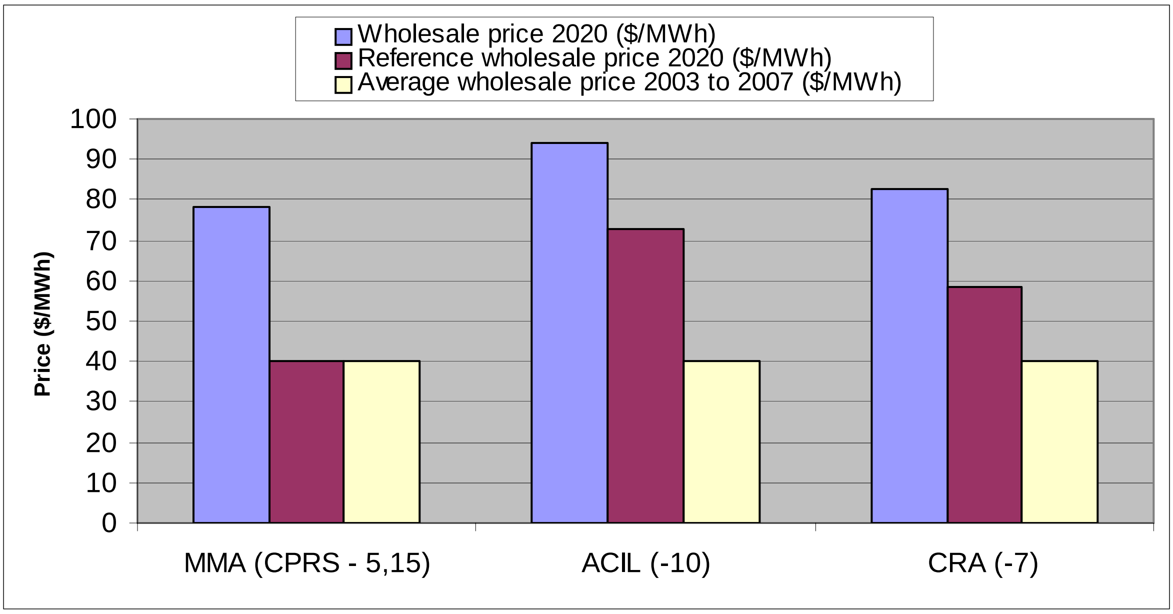
6. Changes in energy prices

Wholesale prices are likely to rise from existing and BAU levels due to the impact of the CPRS on costs. The level of the price increase will depend on the impact of climate change policies on demand; additional supply in response to the expanded RET; the marginal plant; and the ability of that plant to reflect increased costs due to the CPRS in its price. Retail prices will increase due to the impact of the CPRS on wholesale costs and the costs of the expanded RET borne directly by retailers. The impact will be lower than for wholesale prices due to the significant share of network costs in total costs of electricity supply. The White Paper has released further modelling on the pass through of carbon prices and the impact on electricity prices.

Wholesale electricity prices

Figure 6.1 shows the wholesale price projected by MMA Treasury, ACIL Tasman and CRA against both their reference price and the actual average price during 2003 to 20007. From this it is clear that ACIL Tasman project the highest price rises, and MMA Treasury and CRA project similar price rises. MMA Treasury project that the BAU prices (the reference wholesale price) is unchanged between the historic five year average, and the levels at 2020. ACIL Tasman and CRA both project significant increases in the BAU wholesale price of electricity.

Figure 6.1 Wholesale price projections



Under business as usual, wholesale prices may change in response to forecast changes in the capital stock, the level and cost of new investment and changes in fuel costs. As discussed in chapter 1, gas prices are expected to rise significantly on the eastern seaboard under BAU.

The MMA Treasury modelling found very similar retail prices for both the CPRS -5 and CPRS – 15 scenarios. It also noted that implementation of the expanded RET can decreases wholesale prices up to around 10% in the short term due to excess generation capacity entering the market but has little impact on wholesale prices in the long term.

ACIL Tasman's forecast of wholesale prices for the SWIS and for the five regions in the NEM under BAU is shown in Table 6.1. This is compared with the 5 year average for these prices during 2003 to 2007. Prices in the SWIS are forecast to fall by 19 per cent. Prices in the NEM are forecast to rise by 18 per cent to 50 per cent.

Table 6.1: ACIL Tasman forecast of wholesale prices under BAU

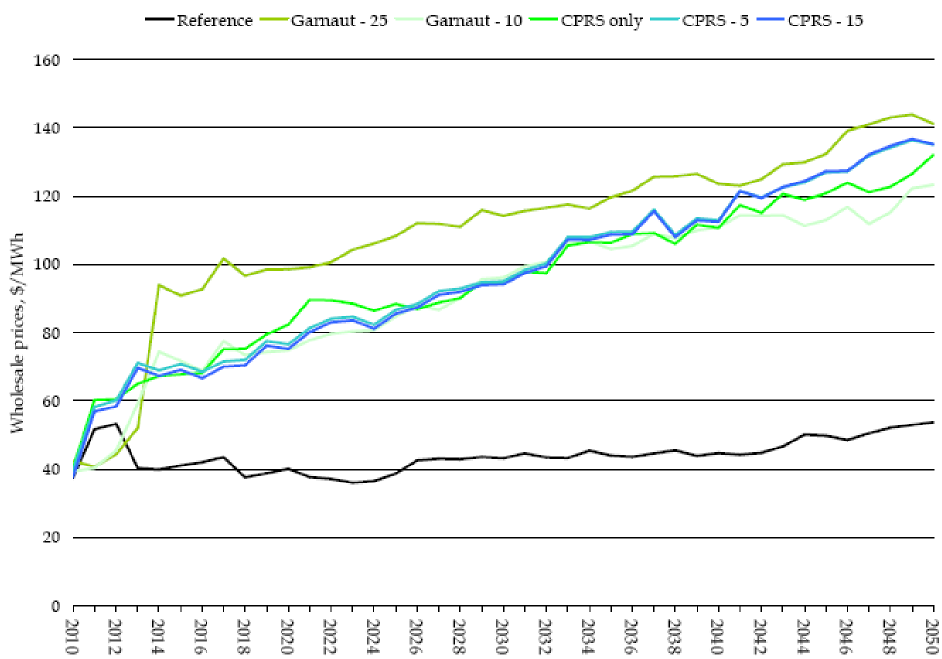
Prices in constant $2008	5 year average (2003 to 2007)[32]	Forecast 2020 prices under BAU
New South Wales	$43.76	$51.65
Queensland	$35.03	$52.68
South Australia	$40.45	$57.34
Tasmania	$46.42	$57.09
Victoria	$36.27	$50.01
WA (SWIS)	$41.25	$33.52

Source: ACIL Tasman (2008, p5)

The MMA Treasury modelling of wholesale price impacts is shown in Figure 6.2. The Garnaut -25 scenario shows an early steep increase in wholesale prices reaching levels above $100/MWh by 2018. Other scenarios also show an early rise in wholesale prices to levels approaching $70-80/MWh by 2020 followed by slower growth.

32 Average price data for Tasmania is a two year average. Average price data for WA is for one year only.

Figure 6.2: MMA Treasury forecast of wholesale market prices



Source: MMA Report to Federal Treasury (2008a, p 44)

The ACIL Tasman projections of real wholesale market prices are shown in Table 6.2. As noted, ACIL Tasman's forecast of wholesale prices under BAU is higher than for the MMA Treasury modelling. The additional impact of climate change policies for the two scenarios examined is as follows:

- Under a scenario with a 10 per cent reduction in emissions by 2020, prices in the different regions in the NEM are predicted to be from $71 to $79/MWh with an increase of 24 per cent to 55 per cent from their BAU levels. The price in the SWIS is forecast to be $64/MWh, or 91 per cent above BAU

- Under a scenario with a 20 per cent reduction in emissions by 2020 prices in the NEM regions are predicted to range from $72 to $88/MWh, increasing by from 25 per cent to 68 per cent from their BAU levels. As with the 10 per cent scenario the lowest price and the lowest increase is in Tasmania and the highest in Queensland. The price in the SWIS is forecast to be $69/MWh, or roughly double the BAU level.

Table 6.2: ACIL Tasman projections of wholesale prices

Real (2008 $/MWh)	5 year average	2020	2020	2020
NSW	$43.76	$51.65	$78.73	$84.76
Queensland	$35.03	$52.68	$79.12	$88.27
South Australia	$40.45	$57.34	$77.15	$80.09
Tasmania[1]	$46.42	$57.09	$70.82	$71.51
Victoria	$36.27	$50.01	$77.44	$81.73
WA (SWIS)[2]	$41.25	$33.52	$63.92	$69.08

Source: ACIL Tasman (2008, p5)

Wholesale gas and other fuel prices

Assumptions on gas and other fuel prices will alter the BAU projections. The CPRS will also increase gas prices (due to the pricing of fugitive emissions) and coal prices (due to the pricing of methane released during black coal mining). These pricing impacts are expected to be relatively minor however.

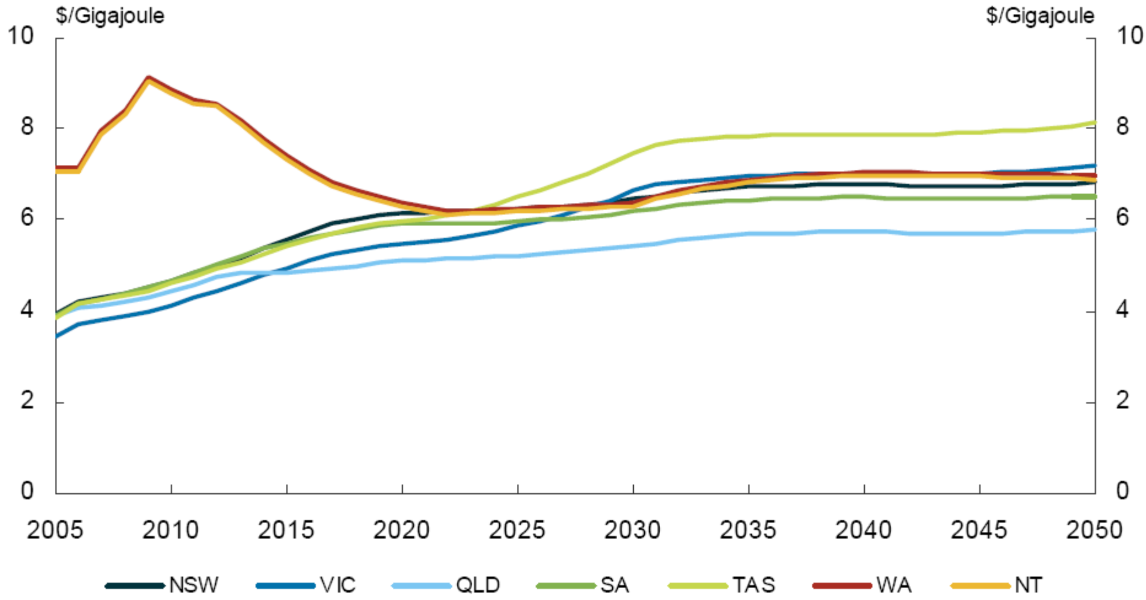
The MMA Treasury modelling used MMA's database of current prices and Treasury's forecast of future international price movements, consistent with each scenario. The impact of fugitive emissions in the MMA analysis is reported in the documentation released with the White Paper.

Results for the modelled scenarios use the assumption of constant real prices for brown coal and mine-mouth black coal prices. Black coal that is not mine-mouth was assumed to be more exposed to the international price. .

The most material assumptions relate to gas prices. West coast gas prices were assumed to be influenced by international price movements from the start of the modelling. East coast gas prices were assumed to move gradually to international parity. Prices at Gladstone in Queensland were predicted to reach export parity in 2025. Prices in the southern states were predicted to converge with the Queesland price by around 2030.

The resulting forecast of Australian gas prices is shown in Figure 6.3.

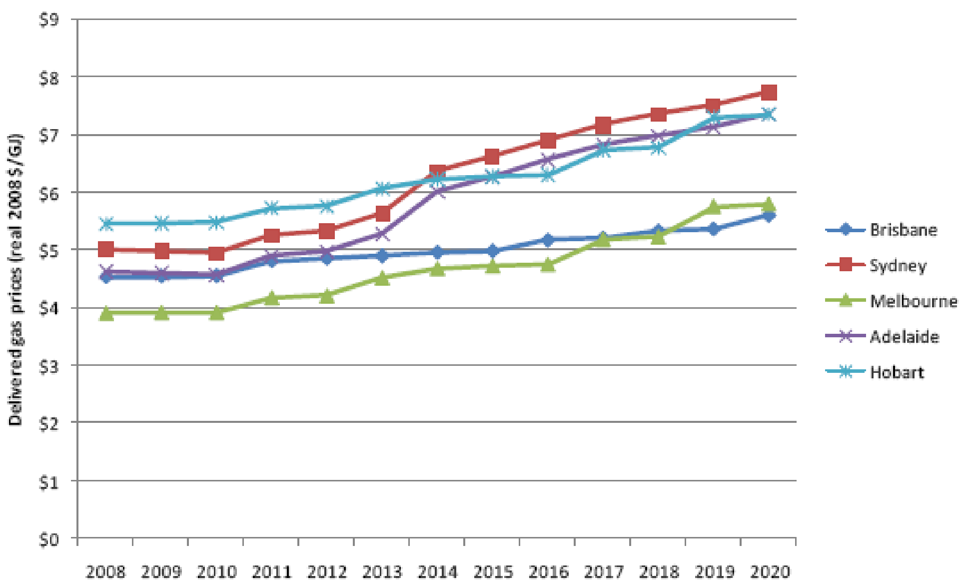
Figure 6.3: Assumptions of Australian domestic gas prices



Source: Australia's Low Pollution Future p. 243

ACIL Tasman's forecast of real gas prices up to 2020 is shown in Figure 6.4. The forecast is for the eastern seaboard up to 2020.

Figure 6.4: ACIL Tasman gas price forecast



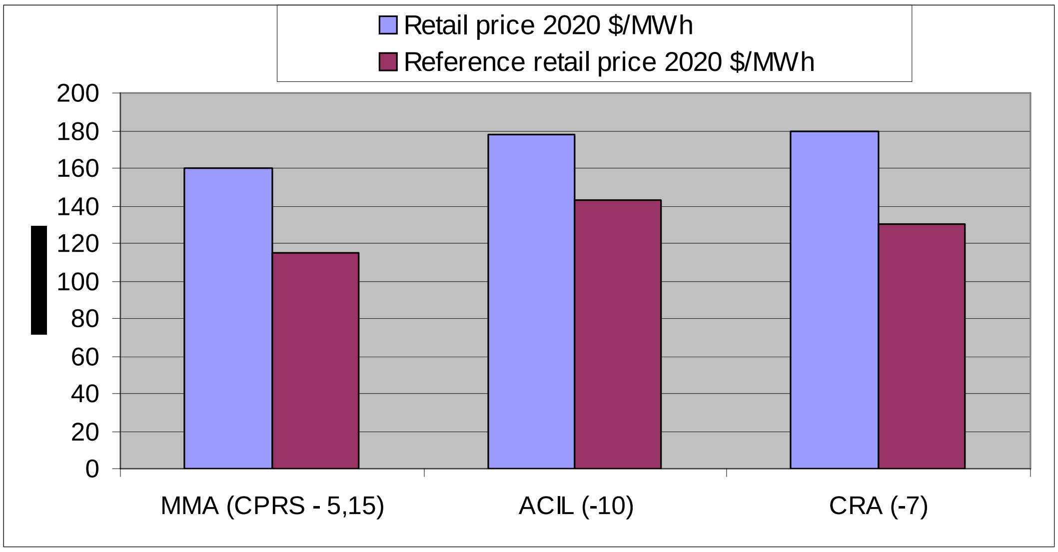
Data source: ACIL Tasman *GasMark* modelling

Source: ACIL Tasman (2008, p8)

Retail electricity prices

Retail prices will increase due to the impact of the CPRS on wholesale costs and the costs of the expanded RET borne directly by retailers. The impact will be lower than for wholesale prices due to the significant share of network costs in total costs of electricity supply. A summary of the projected average retail prices by the analysts is shown in Figure 6.5, fvr the reference case (BAU) and as consequence of the CPRS and MRET. From this it is clear that ACIL Tasman and CRA are projected approximately equivalent retail prices, while MMA's projection are a little lower. Consistent with increases in wholesale prices, MMA are projecting the greatest increase in retail prices relative to the reference.

Figure 6.5. Projected retail prices



Source: MMA (2008a, p 48), Port Jackson Partners (2008, p105)

Wholesale energy costs make up less than half of the average retail price. The other costs of providing electricity at retail are not expected to rise as significantly as the wholesale price. The CPRS will therefore increase average retail prices but by less than the impact on wholesale prices. The expanded RET will impose an additional cost on retailers. This will also increase retail prices.

ACIL Tasman's forecasts of the impact of the two policies on retail prices are shown in Table 6.3. The forecast is for retail prices to be 12 per cent higher under BAU by 2020. The impact of climate change policies would further increase retail prices by 25 per cent (for the 10 per cent scenario) to 28 per cent (for the 20 per cent scenario).

Table 6.3: ACIL Tasman forecast of impact on retail tariffs

Table 2 Indicative pass through to retail tariffs, cents/kWh ($2008)

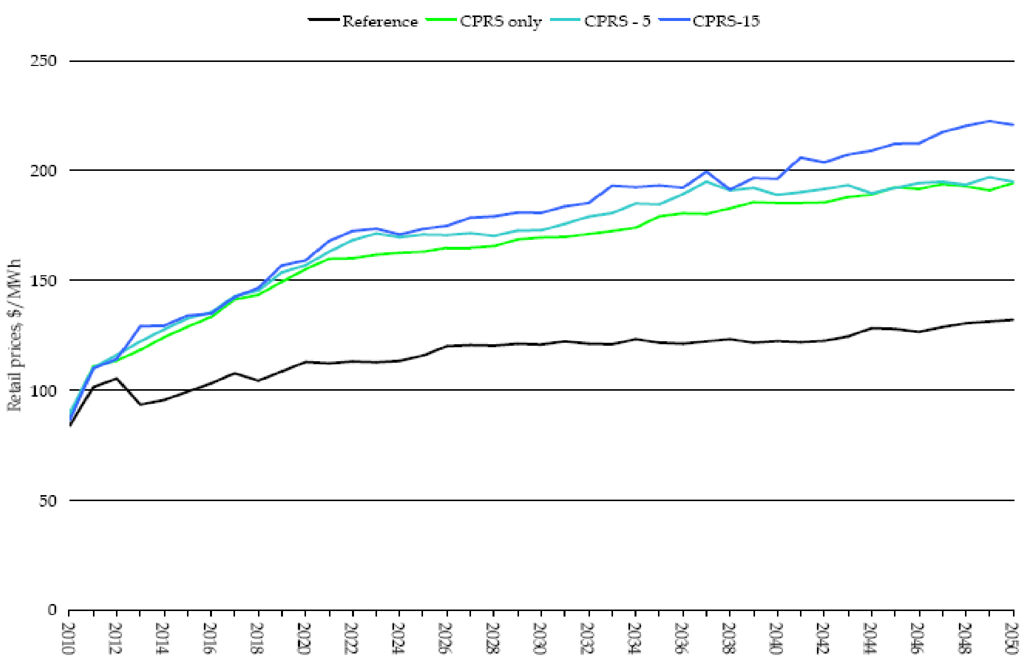
	2008	2020		
		BAU	10% case	20% case
Cost of energy	5.8	7.3	9.4	9.9
Network costs	5.5	5.5	6.0	6.0
Retail margin	1.5	1.5	1.5	1.5
RET cost (20% by 2020 target)			0.9	0.9
Total	12.8	14.3	17.8	18.3

Data source: ACIL Tasman

Source: ACIL Tasman (2008, p7)

The MMA Treasury modelling of retail tariff impacts for the CPRS scenarios is shown in Figure 6.6. This shows that retail prices are expected to be around $160 MWh in 2020, compared to the reference retail price of around $120/MWh, an increase of 33 per cent.

Figure 6.6: Treasury projections of retail tariff impacts



Source: MMA Report to Federal Treasury (2008a, p48)

Price volatility

The risk associated with price volatility, and the transaction costs of managing that risk, also create costs for market participants. The use of a capacity market in the West Australian market design reduces price volatility. The energy-only market design in the NEM results in a high level of price volatility.

Climate change policies may affect price volatility. The main ways that volatility may be affected are through the increase in intermittent generation due to the expanded RET, and changes in the merit order due to the impact of permit prices on operating costs for different plant.

Volatility in electricity prices

The AEMC has received different advice on the impact of climate change policies on price volatility. The increased variation in output from intermittent generation may increase volatility. Under some scenarios, the expanded RET could increase transmission congestion and so the incidence of price separation.

However the CPRS may reduce price differences between coal-fired and gas-fired plant. In so far as variable costs are reflected in bids, this would reduce volatility. There may also be an increased level of gas-fired plant located close to major loads leading to a reduction in intra-regional constraints.

An increase in price volatility increases the risk for both generators and retailers.

Market participants normally need to be rewarded for bearing risk. As a result, an increase in volatility may also increase prices over the long term, unless market participants can hedge the risk concerned at zero extra cost.

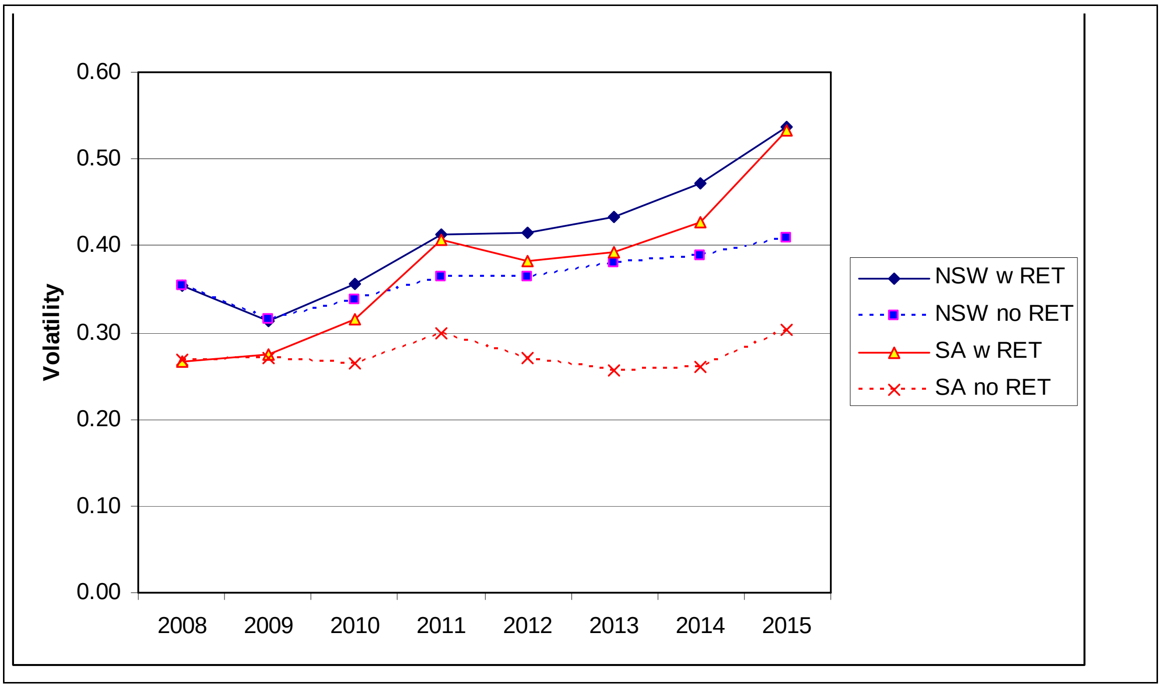
The NEM is an energy-only market. A consequence of this design is that prices are very volatile. The WAM includes a capacity payment. This reduces the level of volatility.

ROAM Consulting considered the possible impact of the expanded RET on daily volatility, or the standard deviation based on 48 half hourly periods. Calculating volatility on individual days rather than a longer time period minimises errors from expected periodic trends such as seasonal variations.

The simulations considered both the presence and absence of the expanded RET and included both SRMC based bidding and existing bidding. The scenarios included explicit modelling of wind farm output based on wind trace data obtained from the Bureau of Meteorology, as well as estimates for bagasse, solar thermal and geothermal plants.

Figure 6.7 shows pool prices for New South Wales and South Australia under historical bidding conditions. In both regions volatility rises as the RET creates additional renewable generation.

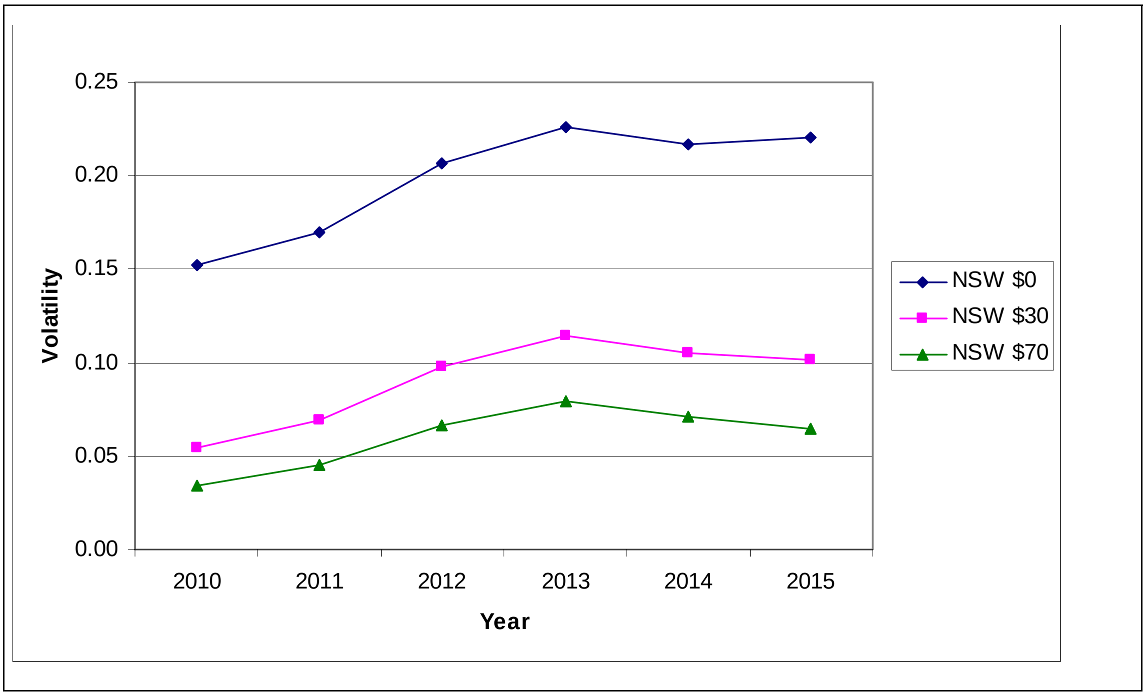
Figure 6.7: Impact of RET on volatility of wholesale prices



Source: ROAM Consulting (2008, p 83)

Figure 6.8 shows the change in volatility when the expanded RET is combined with a carbon price and the assumption that bids reflect SRMC bidding. This shows a reduction in volatility. The analysis showed similar outcomes for other regions.

Figure 6.8: Volatility for New South Wales market price (SRMC bidding)



Source: ROAM Consulting (2008, p 84)

ROAM concluded:

> As would be intuitively expected, the RET increases price volatility. This is due to the entry of large quantities of intermittent wind generation. The impact of the CPRS upon pricing outcomes is more difficult to assess, due to uncertainty over the amount of market power that generators may hold under varying levels of carbon price. At the extreme where generators are forced to bid close to their short run marginal costs, price volatility is significantly reduced under the CPRS.[33]

Volatility in gas prices

There was greater consensus on the impact of volatility on gas demand. The CPRS is likely to lead to an increased share of gas-fired generation. The expanded RET is likely to require greater variation from thermal generation and an increased share of that generation may be provided by gas-fired plant. This would increase the volatility of gas demand. The extent to which this is reflected in prices will depend on the differing gas market arrangements.

Several reports suggested that there will be increased volatility in demand for gas-fired generation. This is because there will be a large increase in intermittent wind generation. At the moment much of the fast demand response is provided by hydro plant. However hydro plant will be unable to fully meet the changes required as a result of wind generation. Gas-fired generation will therefore play a greater role in providing generation that is able to rapidly respond to changes in demand.

33 ROAM 2008 Market Impacts paper, p.V.

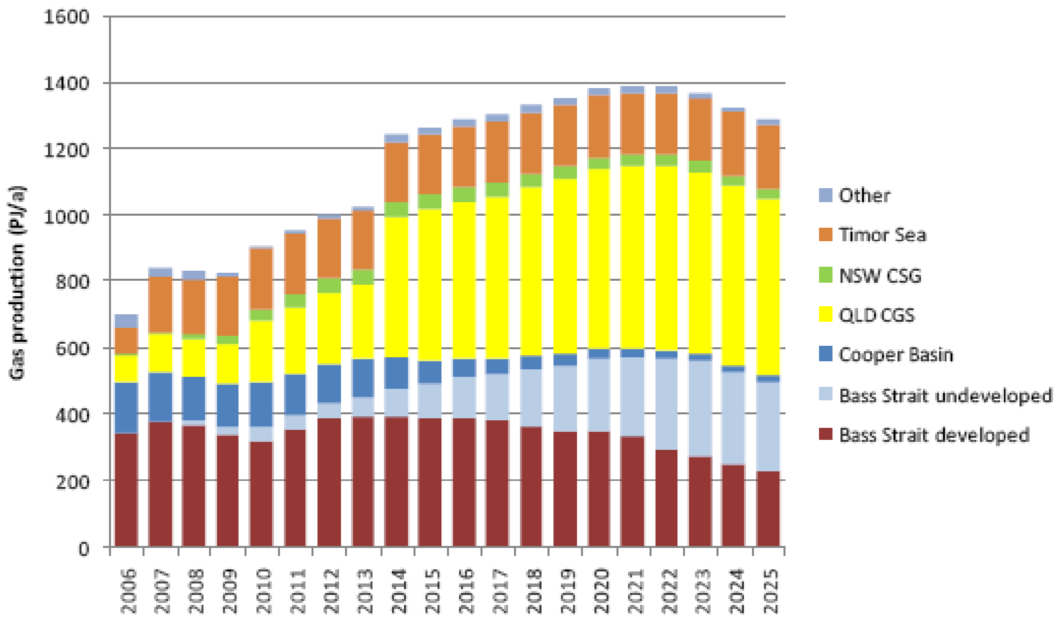
7. Gas infrastructure

All studies have concluded that there is likely to be an increased in the demand for gas-fired power generation in the period up to 2020, regardless of whether climate change policies are implemented. The likely sources of future supply could include the Bass Strait and new coal seam methane resources particularly in Queensland, and possibly also New South Wales.

ACIL Tasman assume that future gas supply will be drawn from existing gas fields, new conventional gas discoveries and existing and future coal seam methane developments in Queensland and New South Wales.

The main anticipated source of future conventional gas discoveries is from the Bass Strait region of southern Australia. There has been a significant increase in proven and probable reserves in the Bass Strait. ACIL Tasman's forecast of gas production by source is shown in Figure 7.1.

Figure 7.1: Modelled gas production by source

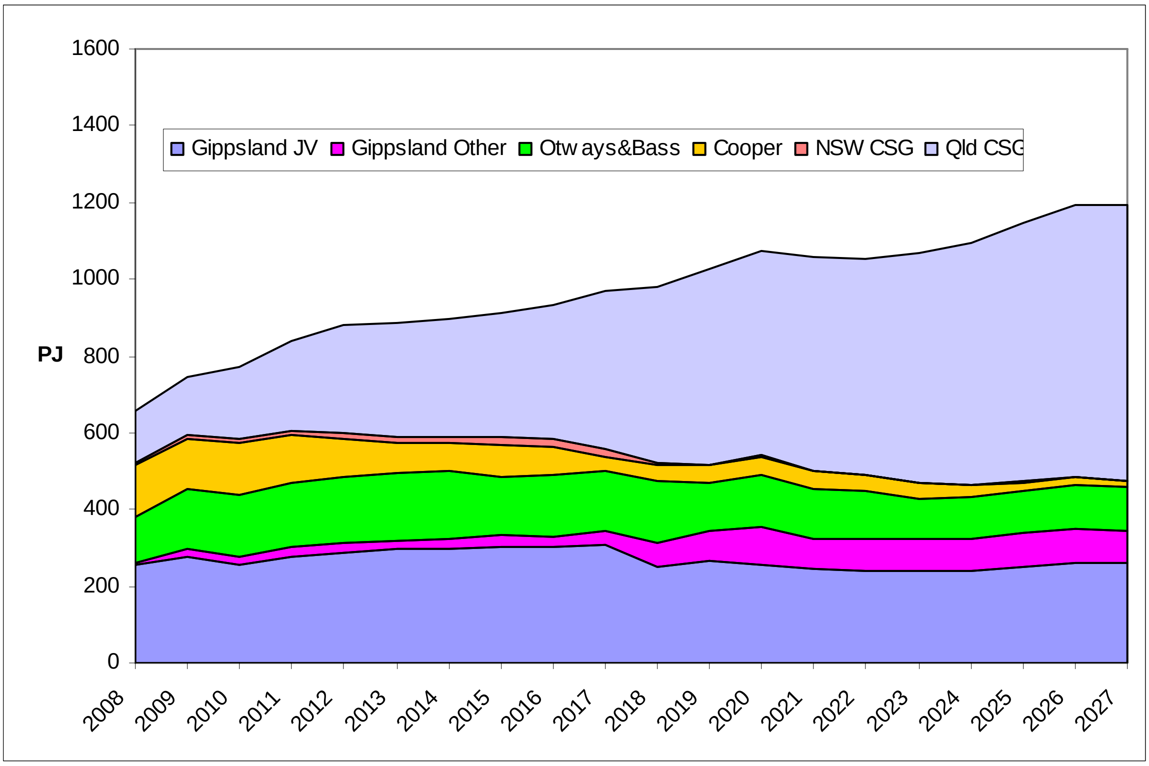


Data source: ACIL Tasman GasMark modelling

Source: ACIL Tasman (2008, p48)

ACIL Tasman's analysis suggests a continued major role for the Bass Strait. MMA Treasury analysis suggests a decline. Figure 7.2 shows one MMA/AEMC projection of utilisation of gas sources to 2030 excluding any major demand for LNG. The Cooper Basin is in decline. Bass Strait production levels out until about 2017 and then falls away. Coal seam gas from Queensland plays a very major role.

Figure 7.2: MMA gas production scenarios (excluding LNG)



Source: MMA 2008 Initial Market Issues paper to AEMC, p.37.

8. Electricity transmission networks

The impact on electricity transmission networks will be through increased connections applications, especially for renewables, and required investment on the shared network. The extent of these impacts will depend upon the changes in the generation mix, and its location on the grid.

At this stage, it is not clear whether material and persistent congestion will arise as a result of these policies. This will depend upon the response of network service providers and renewable generators are unlikely to locate in areas where there is weak available transmission capability.

Connection Applications

In the absence of the expanded RET, the demand for connection to the transmission grid is likely to mainly come from relatively few large thermal generators. The expanded RET will result in a larger number of smaller generation investments. In some cases low cost renewable generation may be viable despite being located far from the grid and incurring high connection costs. Both factors will mean that climate change policies may increase the scale and cost of the connection task.

Thermal Plant Connections

The ACIL Tasman Study for ESAA showed a requirement for 5000 to 7000 MW of additional gas turbine capacity by 2020 (450 to 650 MW per year). This required rate of development with respect to thermal plant is comparable with the rate over the last 10 years (although connection of a gas plant rises different issues compared to connecting coal plant). A higher level of connection would be required under the low probability scenario of high carbon prices forcing significant fuel switching between gas and coal (with new gas plant needed to replace the closure of brown coal).

Renewable Connections

8000 MW of new renewable plant by 2020 has been forecasted by the different models. This is expected to come mostly from wind due to its relative cost competitiveness, with the remainder coming from a combination of geothermal, solar and biomass. The ACIL Tasman model assumes that by 2020 1500 MW of geothermal will be commissioned (mostly located in South Australia).[34]

Renewable generation is often some distance from established electricity networks, and hence has implications for network connection and augmentation arrangements. The impact on connection costs will depend on the scale, timing and location of new renewable generation.

Figure 8.1 illustrates the existing and potential installed wind capacity by NEM region, assuming all proposed wind plant reported by Geoscience Australia is built. While the extent to which these proposed projects reach fruition is uncertain, the data regarding proposed wind plant reported by Geoscience Australia provides a rough indication of the relative intensity of wind farm development across the NEM. We note that the

34 ACIL Tasman, The impact of an ETS on the energy supply industry, 22 July 2008, p.37.

indications of proposed installed wind capacity as reported by Geoscience Australia are broadly consistent with those reported by NEMMCO[35] and VENCorp (2007b).

Figure 8.1: Existing and Proposed wind capacity by region

Source:Geoscience Australia (2008), Frontier Economics Report to AEMC, p.51

While South Australia currently has the largest quantity of installed wind capacity in the NEM, Victoria, New South Wales and Queensland are all likely to experience greater growth in wind generation going forward. We note that the majority of proposed new plant in Victoria and New South Wales is likely in response to (or anticipation of) the VRET and NRET schemes in those states. Assuming all proposed plant are built, Victoria would have the greatest quantity of installed wind capacity (3,932 MW) followed by South Australia (2,910 MW), New South Wales (2,280 MW), Queensland (907 MW) and Tasmania (565 MW).

35 http:ww/nemmco.com.au/about/057-0401.pdf

Consistent with the number of proposed wind plant in each region cited by Geoscience Australia, Queensland, New South Wales and Victoria (respectively) are expected to have the largest *percentage* increase in wind generation over the short to medium term. This growth in proposed plant in Victoria and NSW may be partly driven by the introduction of the VRET and the NRET, though this does not fully explain why the new plant is mostly located in these states. Firstly, the proposed NRET recognises generation from renewables across the NEM. Secondly, although the VRET only recognises generation in Victoria, this will also have implications for the national REC price (since Victorian generation can produce either RECs or VRECs). Other reasons must contribute to the decision to locate in these regions, such as demand growth and quality of sites.

The extent of connection applications is likely to depend upon the extent of available transmission capacity and the likelihood of reinforcement to the shared network in the area.

In its report, ROAM Consulting argued that wind generation, despite the strength of resource in an area, will avoid clustering in remote areas of the grid given the risk associated with poor transmission access and security. ROAM modelling shows that the introduction of wind farms in north and south East South Australia will cause significant curtailment and volume shortfall (between actual wind output and target output) due to transmission congestion. It concluded that such wind farms will not be constructed in these areas unless transmission upgrades alleviate the problem.[36]

Investment in the shared network

Investment in the shared network will be needed to maintain reliability in response to demand growth and to address any material congestion. ACIL Tasman estimates that $4 billion of investment in electricity transmission will be required under the CPRS.[37]

The impact of climate change policies on the likelihood of material and persistent congestion is unclear at this stage. Climate change policies may alter the location of generation in the NEM. Possible impacts could include large volumes of wind generation located in regions with good wind resource, early closure of brown coal generation and investment in new gas-fired generation. Whether this leads to persistent congestion will depend on the mitigation actions taken by the TNSPs.

Inter-connector capability

The MMA Treasury modelling assumed that the existing interconnectors are augmented as required.[38] They considered that the utilisation of the NEM interconnectors in response to CPRS and expanded RET may change as follows:

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36 In its report ROAM consulting reported that there is evidence that transmission congestion is limiting the construction of wind farms in some parts of Australia. For example, Shea Oak Flat has been approved but is suspended until transmission constraints on the Yorke Penninsula are addressed. Similarly, Wattle Point 11 is reportedly suspended due to constraints.

37 ACIL Tasman, The impact of an ETS on the energy supply industry, 22 July 2008, p.10.

The **QNI and Directlink interconnectors** will continue to direct energy south for some time due to lower energy costs in Queensland and the expansion of coal seam gas fired generation. The MMA modelling for Treasury assumed that:

- 100 MW increase in line rating on QNI in both directions through thermal rating upgrade of the Armidale – Tamworth 330 kV line will proceed when required;
- Relaxation of some constraints affecting southerly flow on QNI by installing a phase angle regulator to prevent overloading on the Armidale – Kempsey 132 kV line;
- Network augmentation through series compensation in South East Queensland.; and
- Upgrades to relax the Tarong limit are assumed as required to ensure that the capacity in the Torang region can reach the South East Queensland load.

The **Heywood and Murraylink interconnectors** are in the process of changing from serving South Australia with base load power since 1990 towards enabling the export of peaking power and renewable energy from South Australia to Victoria. The congestion on these interconnectors will depend upon the extent of which wind power is developed in South Australia and Tasmania and the retirement of brown coal in Victoria. The interconnection could become a major impediment to the connection of geothermal power in South Australia unless its performance is upgraded for export of power from South Australia. The Heywood interconnection may also provide a constraint on the amount of wind power than can be connected in South Australia. The MMA modelling for Treasury assumed that:

- An upgrade of the existing Victoria to South Australia export limit from 460 MW to 630 MW by additional transformation at Heywood Terminal Station and possibly series compensation on the Tailem Bend - South East 275 kV lines; and

The **Victoria-Snowy-NSW interconnectors**[39] will become the major highway for supporting the replacement of brown coal generated power in Victoria and trading the surplus renewable energy from the southern regions. The role of Snowy in providing backup for variable renewable energy is expected to increase and the volatility of interconnection flows on a day to day and hourly basis would be expected.

Options to enhance the Victorian export capacity would be expected to increase in value as more renewable energy is developed in the southern NEM regions. The MMA modelling for Treasury assumed that:

- A 180 MW upgrade of the Snowy to Victoria transmission link over time, which would enable additional imports from Snowy/NSW into Victoria. This option has

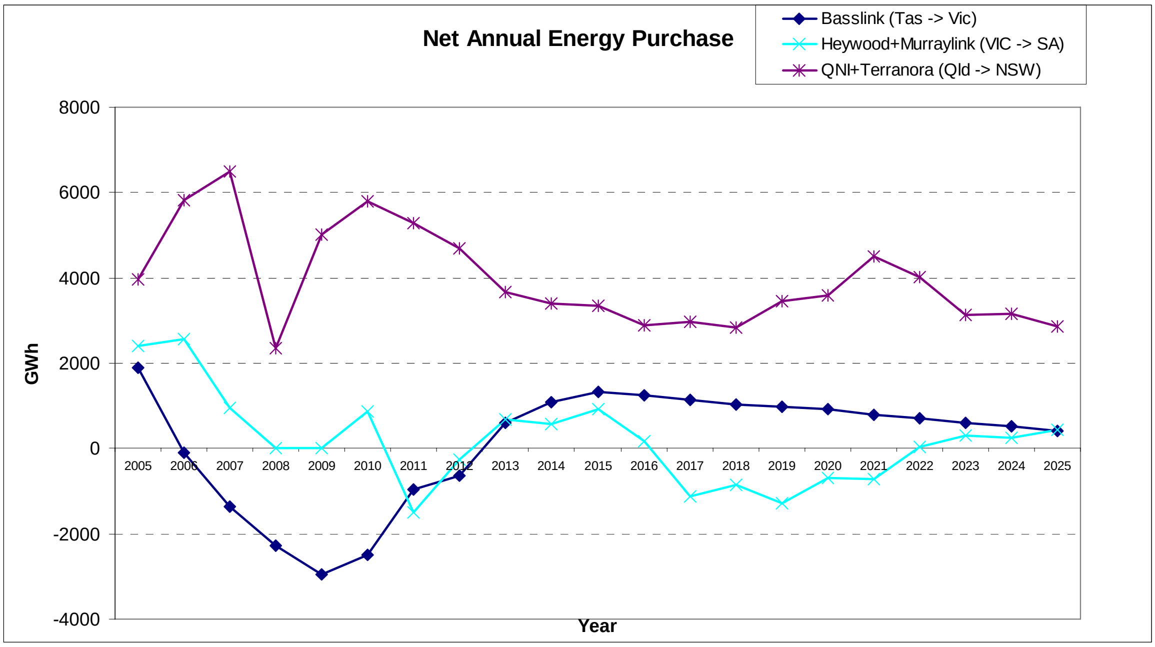
38 MMA 2008 Treasury Paper, p.63.

39 Even though the Snowy region has been abolished, it remains useful to think of Snowy to Victoria and Snowy-NSW as interconnectors on a physical basis. MMA does not consider that the abolition of the Snowy region is economically sustainable as the original analysis was apparently flawed.

been further developed to include an augmentation of 180 MW and then up to 2500 MW total transfer from Snowy to Victoria.

Figure 8.2 shows an example of forecast interconnector energy flows among the NEM regions for a medium carbon price and medium demand growth. It may be seen that the energy flow from Queensland to NSW is relatively stable with some reduction after 2010 as additional renewable energy from the southern regions displaces thermal generation. The flow reverses on Basslink with net exports assuming that hydro yield recovers in Tasmania, Tamar Valley operates at intermediate duty and wind farms are added in Tasmania. These levels of power flow are within the capabilities of these interconnectors without uneconomic constraints. However, the flow between Victoria and South Australia reflects significant constraints for flow to Victoria from about 2017 and in 2010/11. This flow is driven by assumptions in the modelled scenario about the development of geothermal power connected into South Australia from 2015.

Figure 8.2: MMA AEMC modelling of interconnector energy flows



Source: MMA 2008 Initial Market Issues Paper to AEMC, Figure 2.6, p. 30

Intra-Regional Capability

The picture on intra-regional congestion is unclear, as it depends upon:

- the growth in demand;
- the amount new plant connecting;
- the amount of old plant retiring; and
- the relative location of new plant to retired plant.

Modelling by ROAM Consulting found that the incidence of binding congestions on most flow-paths will increase significantly. This is under the assumptions of high carbon price and significant fuel switching. It considered that this should be expected with a large amount of new plant locating in a constant transmission grid. Congestion is heavy at areas where there is substantial wind generation (South East SA). Increase in congestion between Northern NSW and South QLD occurs after 2018/19 once there is a 1000MW wind capability is the area.

There is likely to be changes in the pattern of congestion across the NEM to reflect the changes in the power flows under CCPS. However whether this congestion becomes persistent will depend upon the response of the TNSPs and their use of non-network solutions.

The changing generation mix and the increase penetration of renewables will mean that transmission planning will need to be expanded to contemplate new regions and new long-distance connections:

- Connection of Mt Isa to Central Queensland may become prospective to lower the costs of energy supply to Mt Isa and to open up renewable energy sources in Western Queensland. It may not be justifiable solely on the benefits from Mt Isa.
- Connection of Moomba to Port Augusta and Adelaide with additional export capacity from South Australia to open up the geothermal resources in Central Australia. It would not be justified solely for the first block of geothermal power which is expected to be about 100 MW.
- Opening up stronger connections to the Eyre Peninsula in South Australia associated with increased export capacity from South Australia. This would enable the wind potential of the Peninsula to be developed. It will be necessary to ensure that the total amount of wind that is connected can be absorbed without deterioration of supply quality or threat to system security. The existing arrangements for this type of analysis are suitable except that major transmission developments would have to consider ultimate wind potential that is economically and technically feasible.

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