

The net employment impacts of climate change policies

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Report by Access Economics Pty Limited for
Clean Energy Council

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Glossary

ANZSIC	Australian and New Zealand Standard Industrial Classification
CCGT	Combined cycle gas turbine
CCS	Carbon capture and storage
CPRS	Carbon Pollution Reduction Scheme
EI	Energy efficiency initiative
ETS	Emissions trading scheme
FTE	Full-time equivalent
GW	Gigawatt
GWh	Gigawatt hours
KW	Kilowatt
KWh	Kilowatt hours
MEPS	Minimum Energy Performance Standard
MW	Megawatt
MWh	Megawatt hours
OCGT	Open cycle gas turbine
REC	Renewable Energy Certificate
RET	Renewable Energy Target
TWh	Terrawatt hours

Executive Summary

Access Economics was engaged by the Clean Energy Council (CEC) to quantify the net impact on employment resulting from various current government climate change policies, at both the state and federal level.

Particular emphasis was placed on the Renewable Energy Target and state and federal energy efficiency policies. The potential impact of the proposed Carbon Pollution Reduction Scheme (CPRS) has not been included in this study, although the scheme is assumed to influence the base case generation scenarios against which other policy options are modelled.

It is important to recognise that this study takes a narrow focus with respect to the employment effects of the policies being considered. The analysis does not take into account potential second round effects on employment, which may be negative, due to changes in electricity prices driven by the policies considered. Nor do we consider the merits, or otherwise, of any of the particular schemes assessed herein *per se*.

Renewable Energy Target

The impact of the Renewable Energy Target (RET) on future Australian generating capacity has been modelled using Access Economics' AE-RECM – a model specifically designed to capture the market for Renewable Energy Certificates (RECs) and the factors that influence electricity prices and production.

The net employment impact from the construction of new generating capacity is projected to be positive throughout the period 2010 to 2018, but net negative in 2019 and 2020 when a larger amount of project deferrals are expected to occur. The employment gains will be concentrated in the period 2013-2018, during which the majority of the wind power driven by the scheme is installed. The annual net positive employment impacts peak in 2018, at just over 4,000 full-time equivalent (FTE) positions.

Energy efficiency schemes

There are many state and federal energy efficiency schemes which have been introduced in recent years including via building codes, rebate schemes or solar feed-in tariffs. The employment created by these schemes is additional, that is there will be no direct employment losses resulting from their implementation.

Access Economics estimates that over 4,200 new FTE positions will be created as a direct result of these schemes over the period 2009 to 2020, for example in the installation of solar hot water and PV systems or roofing insulation. This employment will be predominantly in the residential sector, towards which many of the policies are specifically aimed. Commercial sector FTEs created are also significant, while the industrial sector plays a much smaller role in employment creation.

In aggregate, Access Economics estimates that the climate change policies assessed for this report will create a net 28,230 FTE positions over the period 2010 to 2020. The largest net gains will be in Victoria and South Australia, with net losses likely in New South Wales due to deferred investment in coal-fired generation in the later years.

1 Background

Access Economics was engaged by the Clean Energy Council (CEC) to quantify the net impact on employment resulting from various current government climate change policies, at both the state and federal level.

Access Economics has drawn on the extensive modelling work which has been undertaken in-house, as well as publicly available research from government sources and other independent consultants.

Programs which have been assessed in this report are outlined below.

- The Renewable Energy Target (RET).
 - This is the most significant policy to be assessed for the purposes of this study. The Federal Government and the Council of Australian Governments (COAG) agreed the key features of an extended Renewable Energy Target at a meeting on 30 April.
 - Victoria has also implemented the Victorian RET (VRET).
- Energy efficiency targets.
 - Each state employs a variety of energy efficiency standards, principally embedded in building codes.
 - The Federal Government has also adopted a variety of energy efficiency policies e.g. energy rating standards for whitegoods.
 - A variety of rebate programs for solar, heat pump and gas hot water systems are available from the Federal Government and some state governments.
 - The Federal Government's new Homeowner Insulation Program becomes effective on 1 July 2009, although rebates are already available for early uptake.
 - Solar PV incentives (including feed-in-tariffs) are available from both state and federal governments.
 - The Federal Government's rebate scheme for solar PV will change from 1 July 2009, with a wider range of households becoming eligible.
 - All states, other than New South Wales, have – or plan to have shortly – feed-in tariff schemes.

This study does not include the recently announced \$1.5 billion 'Solar Flagships' program that will demonstrate large-scale solar thermal and solar photovoltaic technologies, as there are as yet no details for the scheme.

The report assesses employment gains and losses resulting directly from the clean energy policies identified here. Given the current uncertainty surrounding the likely nature of the proposed Carbon Pollution Reduction Scheme (CPRS), the direct employment impacts of this scheme will not be included in this review.

Potential second round and indirect effects on employment are outside the scope of this review.

2 The Renewable Energy Target

2.1 Policy background

The Mandatory Renewable Energy Target (MRET) is enacted through the *Renewable Energy (Electricity) Act 2000* which came into force in 2001 and has since gone through two revisions. The first of these revisions was introduced to Parliament in 2006 with the second being introduced more recently in 2008 but not yet in force.

2.1.1 The Renewable Energy (Electricity) Act 2000

In 1997 the Prime Minister announced a new scheme designed to increase the amount of electricity generated using renewable sources of energy. The Act commenced on 1 January 2001 and expires on 1 January 2021. It sets out yearly targets that wholesale purchasers of electricity need to meet, the sources of generation that are eligible under the scheme and a framework for accounting for purchases of renewable energy.

The target for renewable energy generation is outlined in the Act. Table 2.1 shows the targets over time begin at 300 gigawatt hours (GWh) of additional renewable energy generation in 2001 and increase each year thereafter. For 2010 and subsequent years the target is 9,500 GWh per annum.

Table 2.1 Required GWh of renewable source electricity

Year	GWh
2001	300
2002	1,100
2003	1,800
2004	2,600
2005	3,400
2006	4,500
2007	5,600
2008	6,800
2009	8,100
2010 and later years	9,500

Source: Renewable Energy (Electricity) Act 2000

The energy used to meet these targets must come from a power station accredited under the scheme. Each power station is given a baseline (calculated in accordance with the Renewable Energy (Electricity) Regulation 2001) and power generated over and above this baseline is eligible. In general, renewable generating capacity that commenced operation after 1997 is eligible under the scheme.

Renewable Energy Certificates (RECs) are created based on eligible capacity. Several criteria must be met before RECs can be issued – the power station must be accredited, the electricity used to create the certificate must be in excess of the 1997 baseline and the electricity must be generated from a renewable source.

The amount of electricity that can be used to create RECs is calculated according to the following formula found in the Regulations:

$$TLEJ - [FSL + AUX + (DLEG * (1 - MLF))]$$

Where:

- TLEJ is the total amount of electricity, in megawatt hours (MWh), generated by the power station in the year, as measured at all generator terminals of the power station in the year.
- FSL is the amount (if any) of electricity, in MWh, generated by the power station in the year using energy sources that are not eligible renewable energy sources, worked out under regulation 15.
- AUX is the auxiliary loss, in MWh, for the power station for the year.
 - Note: See regulation 16 in relation to working out the auxiliary loss if some of the electricity generated by the power station in the year was generated using energy sources that are not eligible renewable energy sources.
- DLEG is the amount of electricity, in MWh, transmitted or distributed by the power station in the year, measured:
 - if the power station is part of the national electricity market — at the point determined under the National Electricity Rules; or
 - in any other case — at the point determined by an authority of the State or Territory where the power station is located.
- MLF is the marginal loss factor, to allow for the amount of electricity losses in transmission networks, as determined by:
 - if the power station is part of the national electricity market — NEMMCO; or
 - in any other case — an authority of the State or Territory where the power station is located.

2.1.2 Renewable Energy (Electricity) Amendment Act 2006

In June 2006 the Renewable Energy (Electricity) Amendment Act 2006 became effective. The amendments largely sought to clarify certain aspects of the original Act but also introduced some new important elements into the legislation.

Most notably the Act:

- specifies with greater clarity the list of eligible renewable energy sources; and
- requires that RECs only be created in the time between the eligible electricity being generated and the end of the year after such generation takes place.

Wording has also been inserted that allows '*any other energy source prescribed by the regulations*' to be eligible for the creation of RECs.

2.1.3 Renewable Energy (Electricity) Amendment Bill 2008

Further amendments have been put forward but are not yet in force. These amendments are included in the Renewable Energy (Electricity) Amendment Bill 2008 which has yet to go before parliament.

The amendments extend the expiry of the Act from the end of 2020 to the end of 2030:

This Act applies to the year commencing on 1 January 2001 and to all subsequent years. However, no certificates can be created, and no liability arises, in respect of electricity generated on or after 1 January 2031.

The treatment of small generating units is also altered and will allow for multiplication of the number of RECs issued in certain circumstances. The conditions under which the multiplier can be applied relate to the capacity of the generating unit and the time at which it is installed.

The multiplier may only be applied to the first 1.5 kilowatts (kW) of the rated output of the small generation unit. Capacity over and above this limit is given the normal one-for-one treatment afforded to larger generators.

The rate at which the multiplier can be applied is dependent on the time that the generation unit is installed. For small generation units installed between 1 July 2009 and 30 June 2012 the multiplier means that five times as many RECs can be issued as would normally be the case. The multiplier decreases by one for each year after 2012 until it reduces to one at 1 July 2015 (see Table 2.2).

Table 2.2 Multiplier for certificates for small generation units

Period	Multiplier
1 July 2009 to 30 June 2012	5
1 July 2012 to 30 June 2013	4
1 July 2013 to 30 June 2014	3
1 July 2014 to 30 June 2015	2

Source: Renewable Energy (Electricity) Amendment Bill 2008

The relevant targets for renewable source electricity are also revised in the latest amendments. The increase is significant and brings the target to 45,000 GWh by 2020, and then declining after 2025. In April this year, COAG made further suggested amendments (not yet included in the Bill) to the targets so that 45,000 GWh must be supplied under the scheme from 2020 out to 2030. The scheme will then begin to be phased out in 2030, as per the existing arrangements.

The schedule of targets is shown in Table 2.3 below.

Importantly the amendments require that the operation of the Act, the regulations and the *Renewable Energy (Electricity) (Charge) Act 2000* all be independently reviewed as soon as practicable after 31 December 2014. A report must be given to the Minister before 1 September 2015 who must table it in each house of parliament within 15 sitting days after receiving it. This review will offer an opportunity to assess if the Act and its subsequent instruments are having the desired effect on renewable electricity sources.

Table 2.3 Revised required GWh of renewable source electricity

Year	GWh
2010	12,500
2011	14,400
2012	16,300
2013	18,200
2014	20,100
2015	22,000
2016	26,600
2017	31,200
2018	35,800
2019	40,400
2020	45,000
2021	45,000
2022	45,000
2023	45,000
2024	45,000
2025	45,000
2026	45,000
2027	45,000
2028	45,000
2029	45,000
2030	45,000

Source: COAG (2009), Renewable Energy Target Scheme Design

2.1.4 Shortfalls

Where a purchaser does not obtain the required amount of RECs a penalty may be imposed. If the shortfall exceeds 10 per cent then a penalty of \$65/MWh will be imposed¹. This penalty is defined in nominal terms in the *Renewable Energy (Electricity) (Charge) Act 2000* and does not change over time.

In those cases where a penalty is imposed the liable party may purchase the required number of certificates within three years of the shortfall. In this instance the penalty will be reimbursed to the liable party minus a small administration fee as detailed in Table 2.4.

¹ COAG agreed to raise the legislated penalty (from \$40/MWh) at its April 2009 meeting.

Table 2.4 Administration fee for REC shortfalls

Total shortfall value	Administration fee
< \$1000	2.0 per cent
≥ \$1000 and < \$5000	1.5 per cent
≥ \$5000 and < \$15000	1.0 per cent
> \$15000	0.5 per cent

Where a liable party has a shortfall of less than 10 per cent no financial penalty is imposed. The shortfall does however carry over in to the following year where it may cause a penalty to be charged.

2.1.5 Upper price bound

The price of RECs is bound at both the upper and lower ends. The upper end bound is the effective price of the penalty while the lower bound reflects alternatives for electricity producers.

Shortfalls attract a penalty of \$65/MWh which is not tax deductible. Using a standard financial relationship, the tax deductible equivalent price of a REC is:

$$\text{Tax deductible price} = \frac{\text{Penalty price}}{[1 - \tau \cdot (1 - \gamma)]}$$

Setting τ at the standard company tax rate, 30 per cent, and the value of a franking credit, γ , at 0.5 to be consistent with the weighted average cost of capital (WACC) calculation used elsewhere in the model (see discussion in Appendix A) yields an equivalent price of \$76.47 per REC. If REC prices rise beyond this it will be cheaper for firms to incur the penalty and they will no longer purchase certificates thus placing an upper bound on the price.

2.2 The model description

Access Economics has developed AE-RECM, a model specifically designed to capture the unique characteristics of the market for RECs and the factors that influence prices and production. AE-RECM has its foundation in a simple merit order model and adds a series of complicating features to accurately reflect what happens in the market.

Details of the model are set out in 0.

3 Model outputs

3.1 Key outputs from the modelling

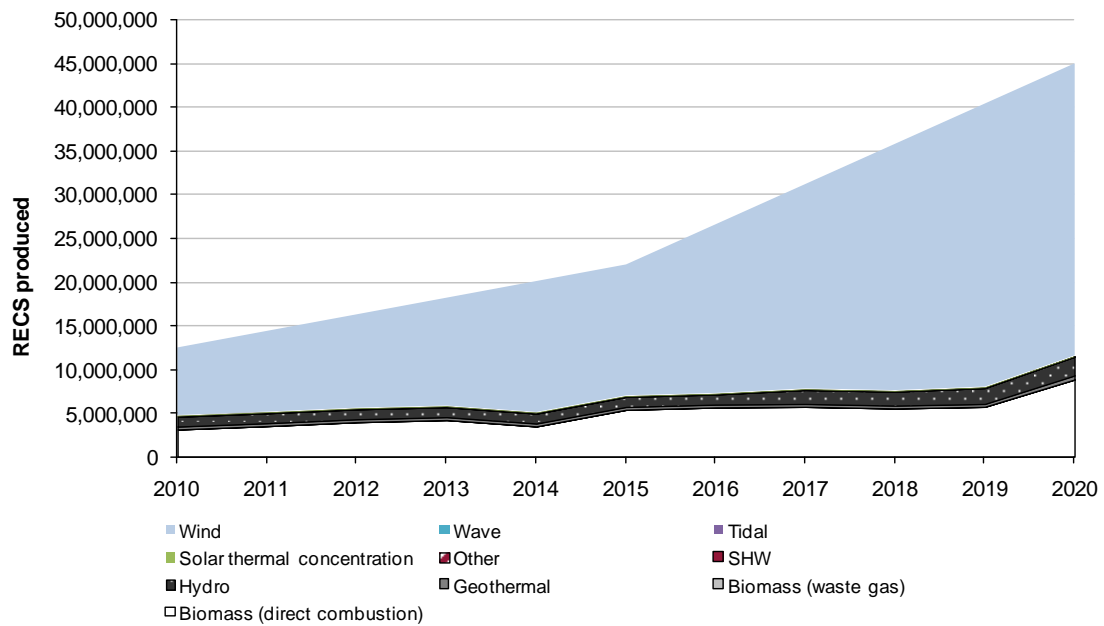
The key outputs of AE-RECM are:

- the quantity of RECs produced in any given year;
- the price of RECs; and
- renewable electricity generation capacity.

3.1.1 Modelling results

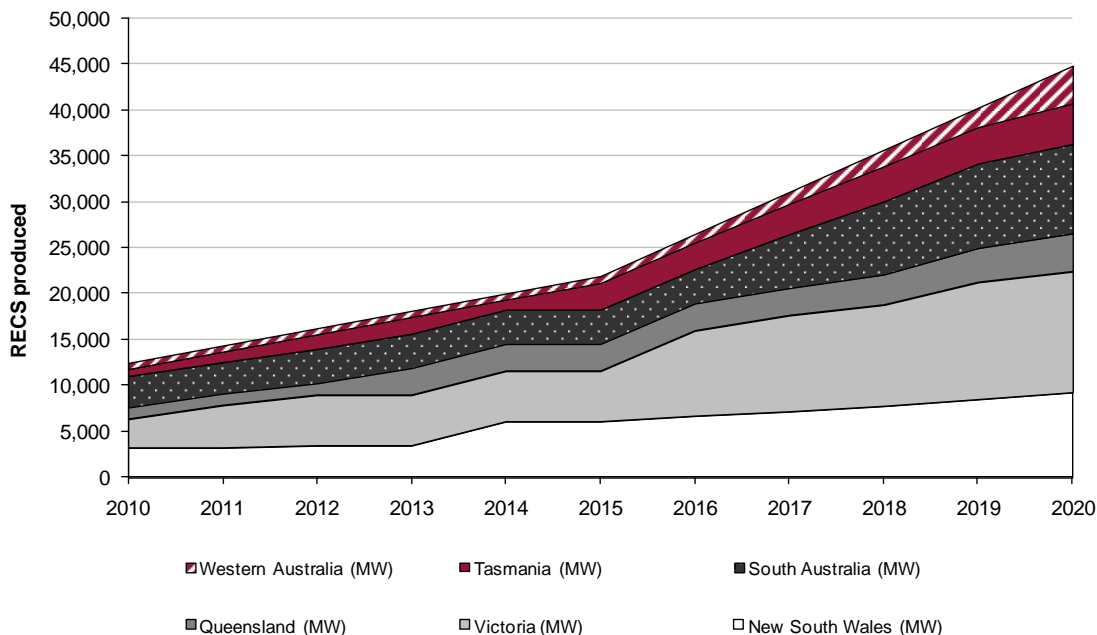
The quantity of RECs produced in any given year follows the schedule shown in Chart 3.1. From 2010 through to 2015 total eligible capacity exceeds the requirements of the scheme. From 2015 onwards capacity is added to meet increasing demand. The target levels out at just over 45,000 GWh.

Chart 3.1 RECs produced each year – all regions



Source: Access Economics

Chart 3.2 RECs produced each year – by region



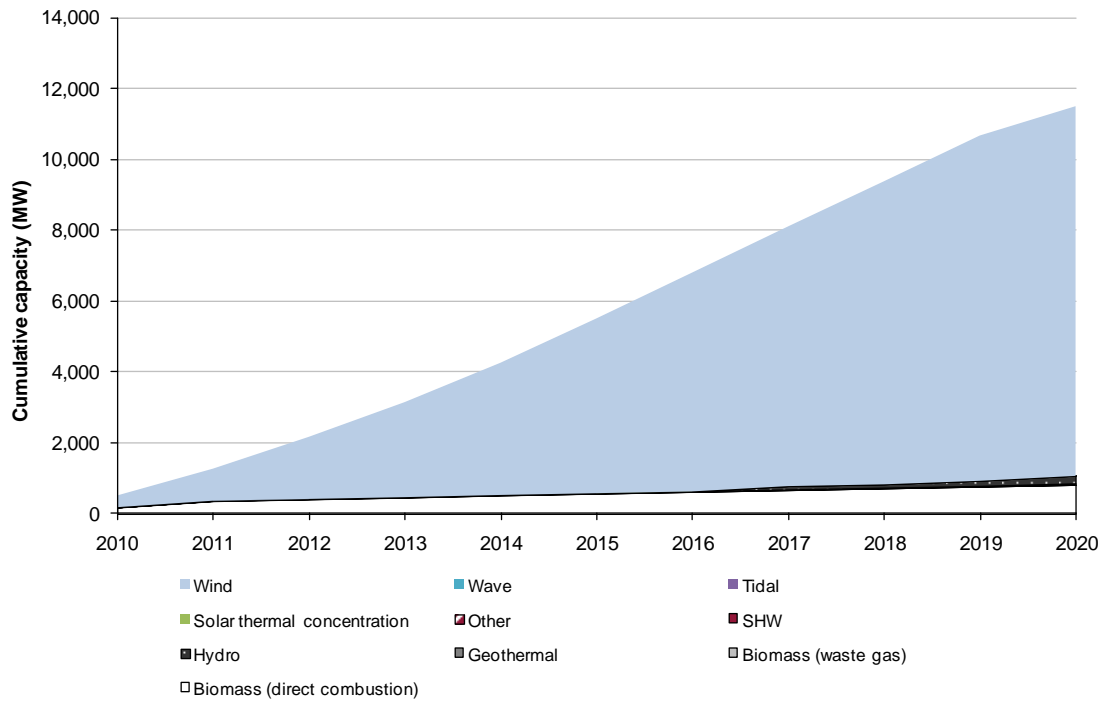
Source: Access Economics

The predominant generator type is wind. In 2001 wind accounts for 47 per cent of total renewable electricity generation and this grows to 94 per cent in 2020. Although biomass grows in capacity in the early years as a share of total generation it falls over time. All other technologies fall in a similar manner.

The increasing proportion of wind projects is in keeping with the general trend in current renewable electricity planning. In the model database there are 558 existing renewable generators. 85 of these are wind generators which account for 17 per cent of current capacity. Of the 53 currently planned projects within the database with a planned start date, some 26 are wind. These projects account for 69 per cent of the proposed capacity with a known start date which reinforces the view that wind will become more prevalent over time.

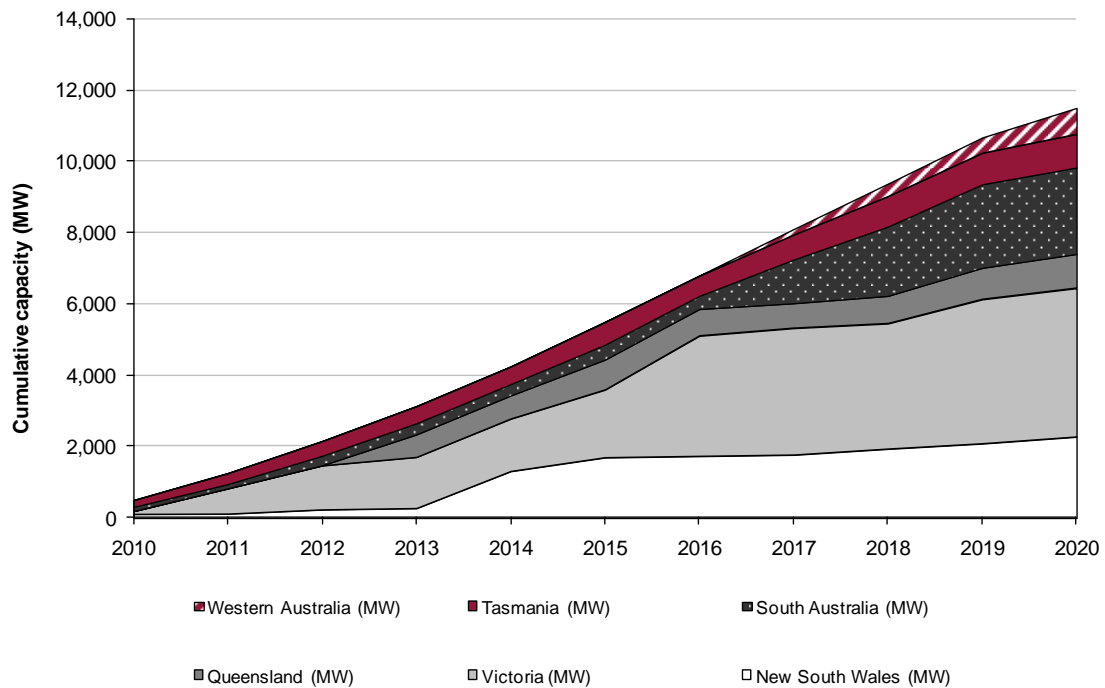
After wind, biomass fuelled plants are the next largest contributor to renewable electricity. Hydro is limited in terms of its ability to expand due to natural resource constraints.

Chart 3.3 Renewable electricity capacity installed from the expanded RET – all regions



Source: Access Economics modelling

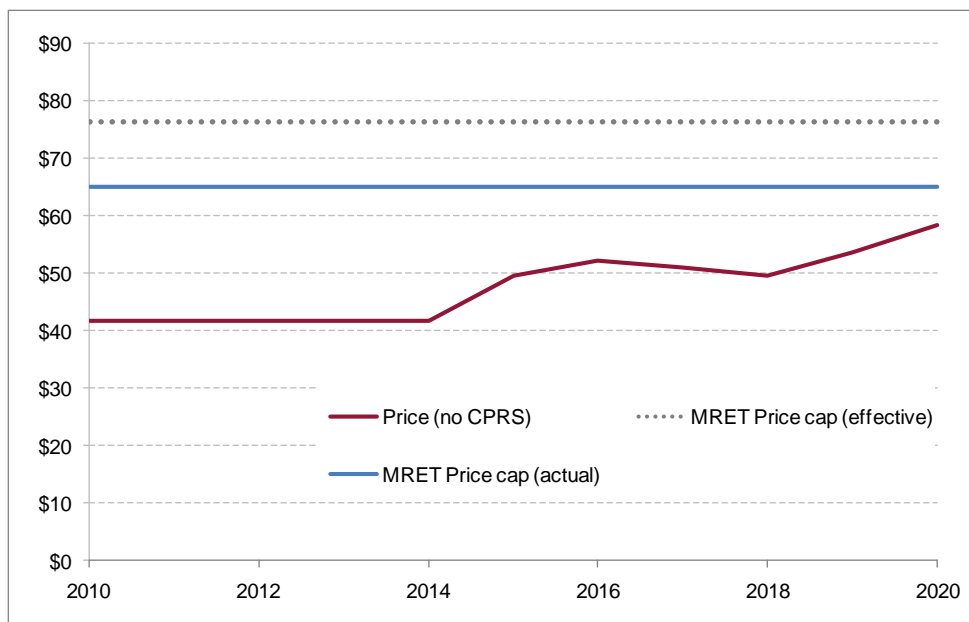
Chart 3.4 Renewable electricity capacity installed from the expanded RET – by region



Source: Access Economics modelling

The renewable energy target essentially forms the demand side of the market and thus, as it increases, the prices of RECs will also generally increase (notwithstanding the limitations imposed by the upper price bound). Chart 3.5 shows the REC prices over time together with the actual price cap and the effective price cap. The effective price is the equivalent price a liable party would be willing to pay for the REC after taking into account the tax advantages of buying a REC versus paying the shortfall penalty. (N.B. It should be noted that Chart 3.5 shows annual averages, and there may be potential for greater volatility in the spot price from time to time.)

Chart 3.5 REC prices over time (\$/MWh)



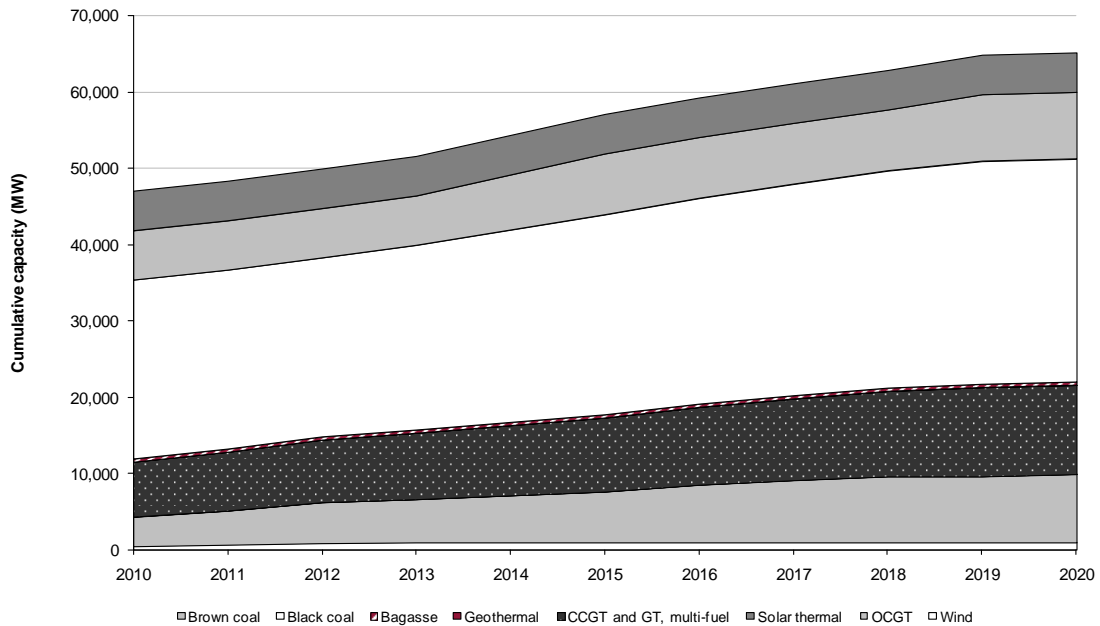
Source: Access Economics modelling

3.1.2 Impacts on electricity markets

The expanded RET will lead to the deployment of significant quantities of renewable generating capacity by 2020 (approximately 11,500 MW of capacity is installed by that year, as shown in Chart 3.3). In considering the employment impacts of the RET, the deferred or non-installed capacity resulting from renewable generation should also be considered. However, because a majority of the renewable capacity installed will be intermittent in nature (primarily wind), the capacity installed will only partially defer or replace conventional reliable generating technologies. In summary, a higher amount of lower reliability generating capacity will be added to the system.

The impacts of the RET on the electricity generator capacity mix was analysed through Access Economics modelling of the National Electricity Market (NEM) and the Western Australia and Northern Territory markets. The generating capacity mix in the RET case was compared to the no CPRS reference case. In the reference case scenario, the main capacity additions are black coal, gas CCGT (combined cycle gas turbine) and gas OCGT (open cycle gas turbine) plant (Chart 3.6).

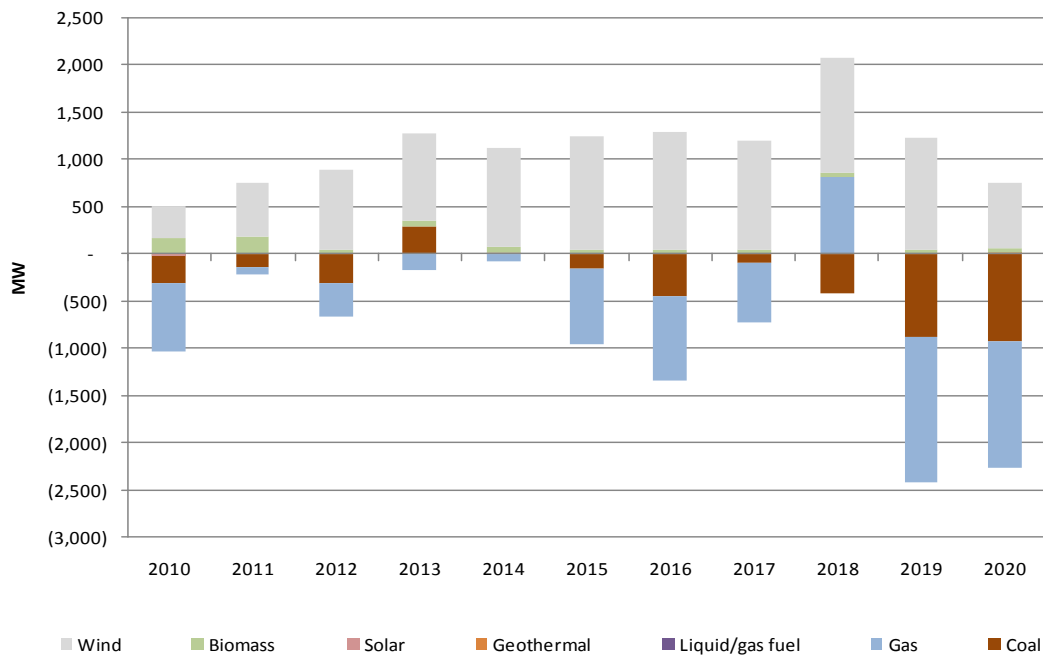
Chart 3.6 Electricity generating capacity – no CPRS reference case



Source: Access Economics modelling

Chart 3.7 shows the modelled effects of the RET on annual capacity additions. The renewable capacity additions driven by the RET generally occur at the expense of fossil fuel capacity additions (a mixture of coal and gas), with the exception of 2018, where a net addition of gas fired OCGT capacity is modelled to occur.

Chart 3.7 Annual capacity additions – relative to the reference case



Source: Access Economics modelling

3.2 Estimating employment impacts

Project construction and operating expenses, of which labour is a component, are associated with the deployment of renewable generating capacity described above. This analysis focuses on the employment impacts of the construction and operating phases. Negative employment impacts also result from the electricity generating capacity foregone as a result of the RET, leading to a net employment outcome.

There is a wide range of data on the capital costs associated with new power plant, fossil and renewable, from which to derive estimates of the expenditure associated with the RET.

In summary, the RET drives into the electricity supply mix more capital and labour intensive technologies which would otherwise not be installed. This leads to higher cost generating technologies being operated, but generally with the creation of more employment. This analysis takes account only of direct impacts, and does not consider flow on effects through changed electricity prices, or flow on effects to electricity support industries such as the coal industry.

3.2.1 Methodology

Access Economics has derived estimates for labour intensity of construction and operation for the renewable energy technologies that will be deployed as a result of the RET scheme. These labour intensities are then applied to the capacity and production results from the RET modelling as described in the previous section.

3.2.1.1 Capital costs of new plant

Access Economics has undertaken a review of Australian and international literature for the capital costs associated with building new entrant power plant. For existing or well established technologies, such as gas CCGT and coal supercritical, average capital costs of recent build or soon to be built projects were used, based on Access Economics research. The research incorporates a review of recently built and committed or planned projects. The costs data for already built or committed projects derives from:

- Access Economics own *Investment Monitor* Publication;
- ASX releases and company websites; and
- ABARE.

Where data gaps exist, particularly for developing or prospective technologies, this data has been supplemented through a review of Australian and international primary source estimates for power station capital costs. Access Economics has drawn on a number of primary sources including:

- Cottrell et al (CCSD 2003), *Systems Assessment of Future Electricity Generation Options for Australia*;
- Graham et al (CCSD 2008), *Options for Electricity Generation in Australia – 2007 update*;
- Royal Academy of Engineering (RAE 2004), *The costs of generating electricity*;
- International Energy Agency (IEA 2003), *Renewables for Power Generation*;
- Hydro Tasmania Consulting (Hydro Tas 2007), *A Practical Guide to Assessment and Implementation of Small Hydropower*;

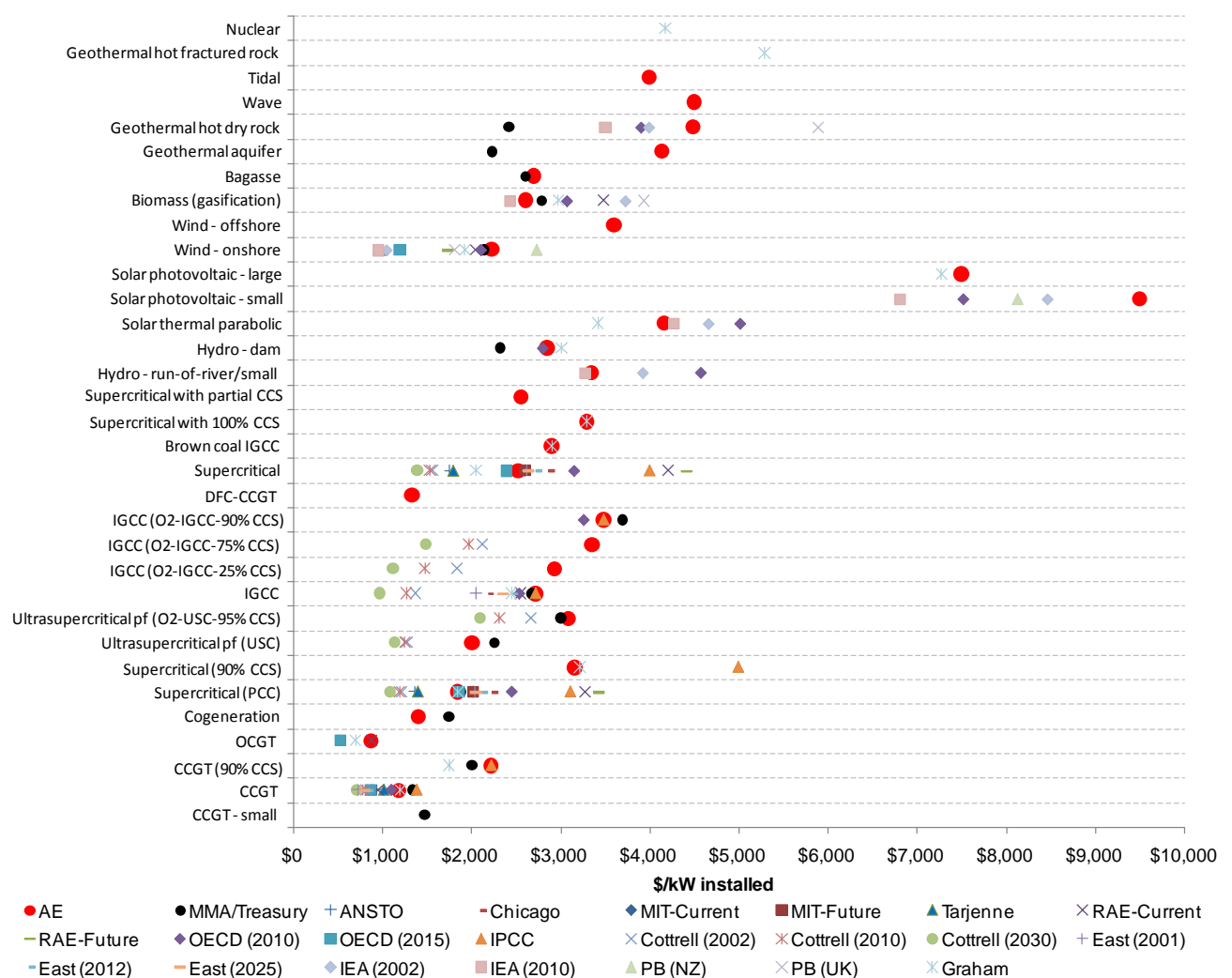
- International Energy Agency (IEA 2005), Projected Costs of Generating Electricity;
- PB Power (PBNZ 2006a), Emerging Supply-Side Energy Technologies;
- PB Power (PBNZ 2006b), Statement of Opportunities 2006;
- Massachusetts Institute of Technology (MIT 2007), *The Future of Coal*; and
- Electric Power Research Institute (2006), Review and Comparison of Recent Studies for Australian Electricity Generation Planning, A report to the Australian Government.

Access Economics also received some input from several CEC members regarding capital construction costs, which was consistent with Access Economics' own modelling outcomes.

International data was converted to Australian estimates using exchange rate and price inflation adjustment factors. Estimates were then scaled to a consistent capacity base for comparisons across each generation technology.

Chart 3.8 shows the estimates of capital expenditure by project from the literature and the Access Economics adopted value for the purposes of this analysis.

Chart 3.8 Capital cost estimates of new plant at 2009 (\$2009)



Source: Access Economics, sources as cited above

Chart 3.9 shows the specific capital cost estimates for each technology and the source used to derive each estimate.

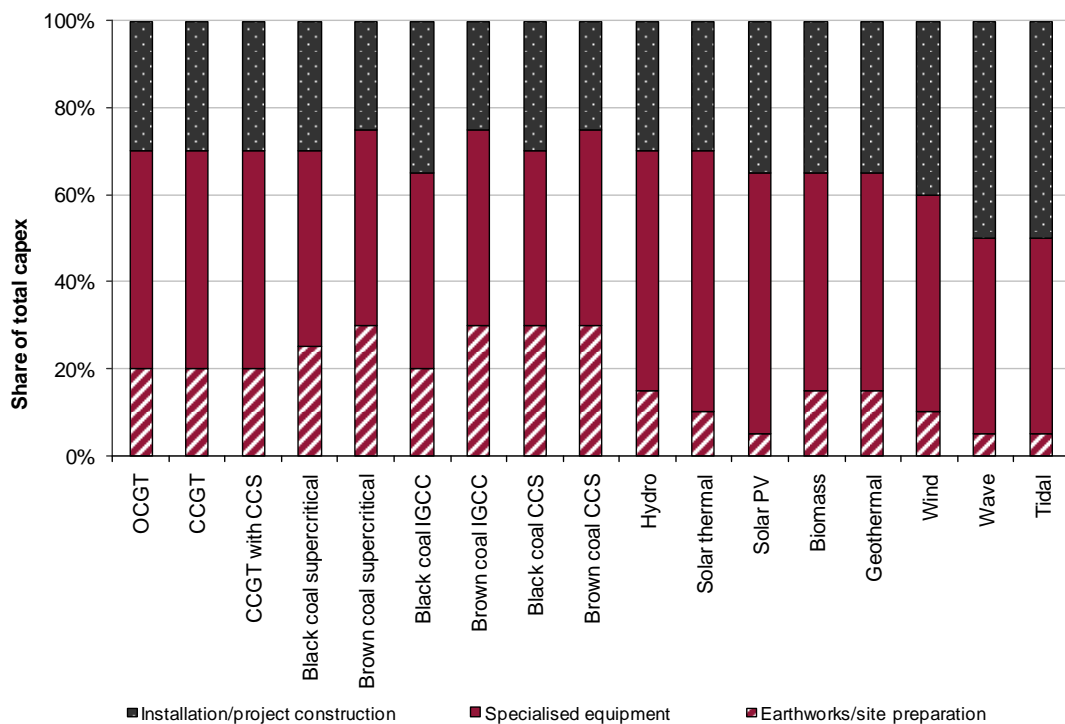
3.2.1.2 Labour component of capital costs

The construction of power projects typically involves three major stages:

- site preparation and earthworks;
- the manufacture of specialised generating equipment, such as turbines; and
- building construction and equipment installation.

Each of these involves a different combination of labour and materials, from domestic and imported sources. Typically, the larger base load power facilities, particularly brown coal generators, involve a large amount of site clearing and earthworks, reflecting their scale and the extent of the generating site. These projects also have a significant building construction and installation component which reflects the large generating equipment housing facilities and offices associated with such large scale projects. The smaller scale renewable projects tend to display a higher share of costs accounted for by specialised equipment and its installation.

Chart 3.9 Breakdown of capital costs, by generating technology



Source: Access Economics research, industry consultation

For the purposes of this analysis, each of the broad categories listed above has been further broken down into three broad categories:

- materials such as steel, aluminium and concrete, which are either imported or manufactured in Australia;

- manufacturing of specialised equipment (e.g. blades, turbines). Some of these specialised parts may need to be imported and future costs will be subject to sovereign risk and exchange rate fluctuations as well as technology improvements. Other equipment including control and monitoring systems, and electronics which are more accessible and technically advanced and thus less susceptible to large cost increases in the future; and
- engineering and construction services – primarily labour.

The earthworks and site preparation stage typically involves labour and also materials such as concrete, steel and other construction materials. The manufacture of specialised equipment is characterised by the input of steel and aluminium, coupled with labour in the processes of fabrication and manufacture. The final stage of building construction and installation typically involves inputs such as concrete, steel, aluminium and labour. Based on assumed splits of imported versus domestic source for each of these inputs to project construction, an estimated share of factor inputs has been derived for each broad grouping of power generating technology.

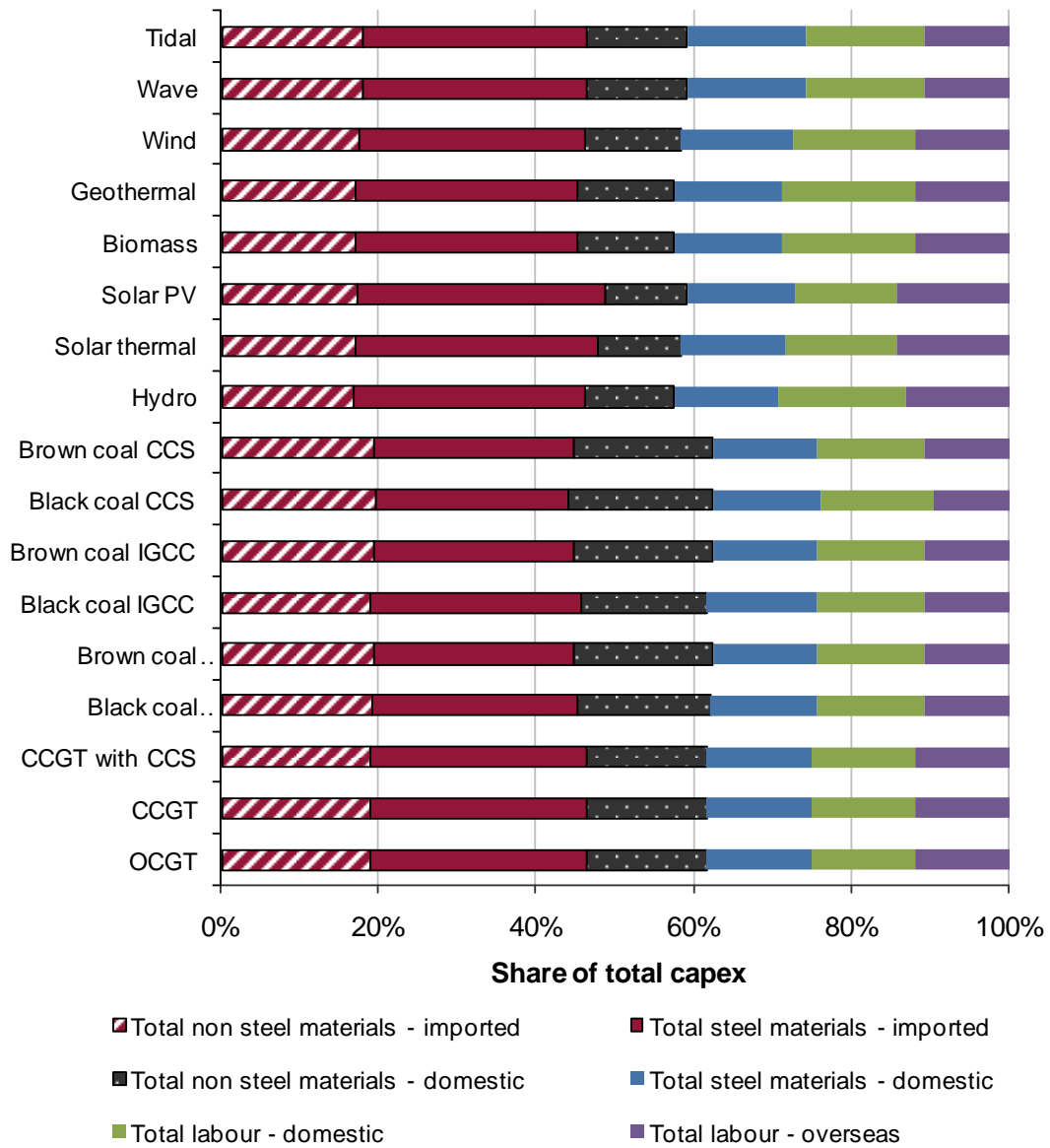
These shares are converted into labour expenditures using the estimates of capital expenditure by project described above, and further allocated to per unit employee numbers based on assumptions about average wage per employee. The results are shown in Table 3.5.

Table 3.5 Per unit employment estimates for a range of new entrant generators

Technology	Domestic labour expenditure (\$/kW)	Indicative installed capacity (MW)	Total labour cost (\$'000)	Total employees per project (FTE)	Employment FTE/kW installed capacity
OCGT	114.01	450	51,306	428	0.95
CCGT	153.59	500	76,797	640	1.28
Black coal supercritical	252.40	1,000	252,396	2,103	2.10
Brown coal supercritical	346.09	1,000	346,094	2,884	2.88
Black coal IGCC	372.68	1,000	372,679	3,106	3.11
Brown coal IGCC	397.30	1,000	397,300	3,311	3.31
Small hydro	430.48	5	2,152	18	3.59
Solar thermal	586.98	100	58,698	489	4.89
Solar PV	1,220.75	5	6,104	51	10.17
Biomass	436.99	100	43,699	364	3.64
Geothermal	502.50	50	25,125	209	4.19
Wind	345.31	25	8,633	72	2.88
Wave	672.75	40	26,910	224	5.61
Tidal	598.00	100	59,800	498	4.98

Source: Access Economics research

Chart 3.10 Breakdown of generators' capital costs by input



Source: Access Economics research, industry consultation

Table 3.6 Capital cost assumptions for new entrant plant at 2008 (\$2008)

Technology	Capacity (MW)	\$/Kw	Source
Gas			
CCGT -large	500	1,181	Average cost of projects build 2000-2011
OCGT	400	877	Average cost of projects build 2000-2012
Cogeneration		1,409	AGL Energy Coopers project
Black coal			
Supercritical (PCC)	1000	1,842	Average cost of projects build 2006-2009
IGCC	750	2,720	Intergovernmental Panel on Climate Change (IPCC)
Brown coal			
Supercritical	1000	2,526	MIT, as reported in EPRI
Brown coal IGCC	1000	2,900	Graham et al
Renewables			
Large hydro	120	3,010	Graham et al
Solar thermal parabolic	100	4,163	MIT, as reported in EPRI
Solar photovoltaic - small	0.01	9,500	BP Solar
Solar photovoltaic - large	0.5	7,500	IEA
Wind - onshore	25	2,228	Average cost of projects over the period 2009-2011
Wind - offshore	25	3,600	IEA
Biomass (gasification)	100	2,609	MIT, as reported in EPRI
Bagasse (direct combustion)	100	2,698	Average cost of projects over the period 2009-2011
Geothermal aquifer	50	2,769	MIT
Geothermal hot dry rock	50	3,050	MIT, as reported in EPRI
Wave	40	5,000	PB Power, as reported in EPRI
Tidal	100	3,500	PB Power

Source: Access Economics, sources as listed

3.2.1.3 Labour component of operating costs

Generator operating labour is typically a component of fixed operating and maintenance (O&M) costs. This is because labour would not be expected to vary with production of electricity by each generator, across the year. Fixed O&M costs by generator technology types are widely available from the literature and from consultant's reports. For this analysis, we have chosen estimates of fixed O&M costs used in the Commonwealth Treasury modelling of the CPRS and RET conducted in 2008. The breakdown of fixed O&M costs into labour and non-labour components were based on a desktop review of power sector data, mainly deriving from overseas. Combining these data yielded average operating employee estimates for indicative sized new entrant plants (Table 3.7 below).

Table 3.7 Operating assumptions for new entrant plant in 2008

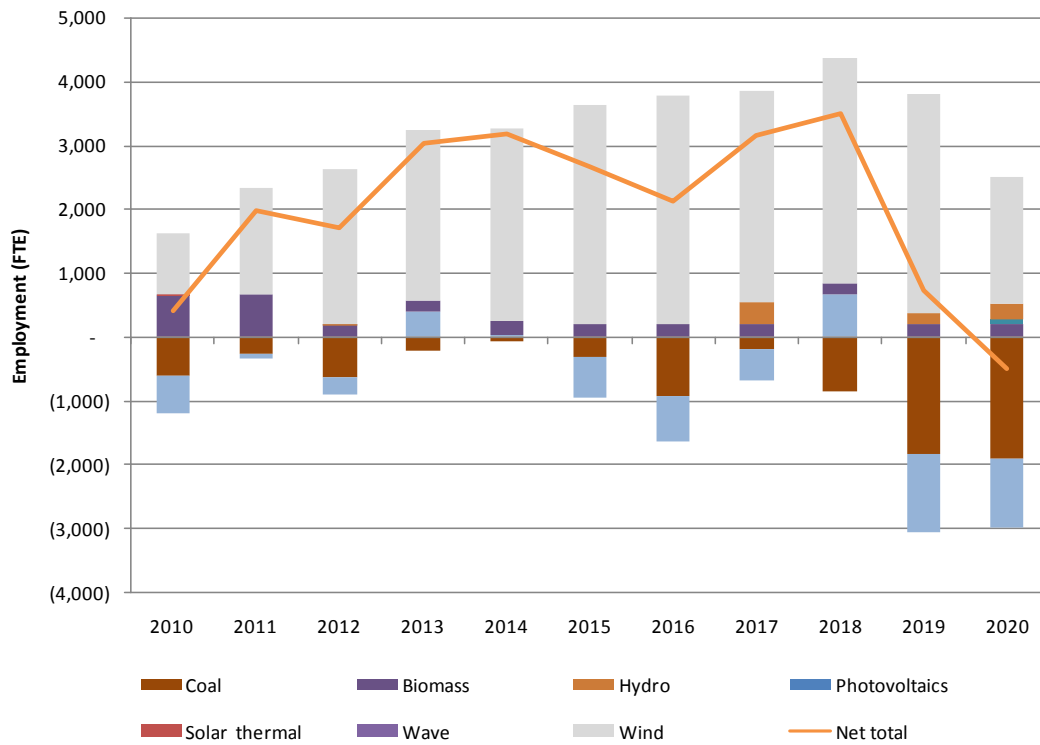
Technology	Indicative capacity (MW)	Labour cost (\$000/annum)	Number of employees (FTE/annum)
OCGT	450	5,400	54
CCGT	500	6,000	60
Black coal supercritical	1,000	18,000	180
Brown coal supercritical	1,000	25,800	258
Black coal IGCC	1,000	26,400	264
Brown coal IGCC	1,000	29,400	294
Small hydro	5	53	1
Solar thermal	100	1,500	15
Biomass	100	1,500	15
Geothermal	50	1,050	11
Wind	25	263	3

Source: Commonwealth Treasury, Access Economics analysis

3.2.2 Results of the analysis

Chart 3.11 shows the employment associated with the construction of new entrant generators over the period 2010-2020, net of the negative impacts associated with plant construction deferrals. The employment is concentrated in the period 2013-2018, during which the majority of the wind power driven by the scheme is installed. The net employment impacts are positive throughout the period to 2020 with the exception of the last two years, where a larger amount of coal and gas project deferrals occur. The annual net positive construction FTE impacts peak in 2018 at just below 3,500 FTE positions.

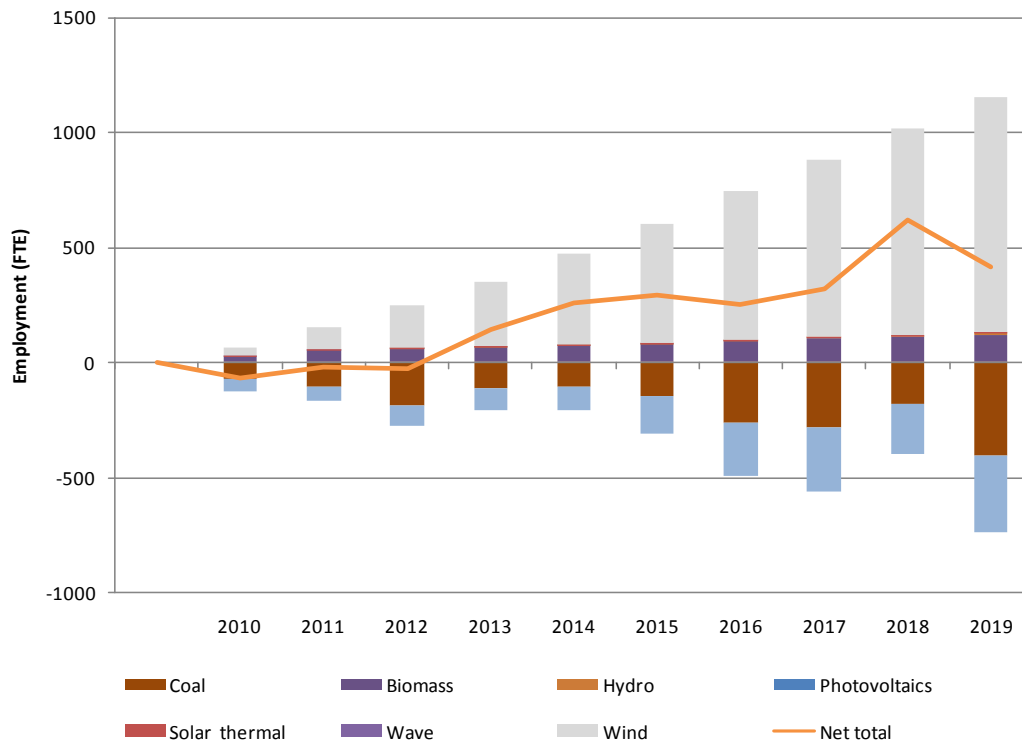
Chart 3.11 Direct construction employment associated with the RET, by technology



Source: Access Economics research

Chart 3.12 shows the operating employment impacts of the RET, which grow during the projection period as net capacity levels increase across the electricity markets.

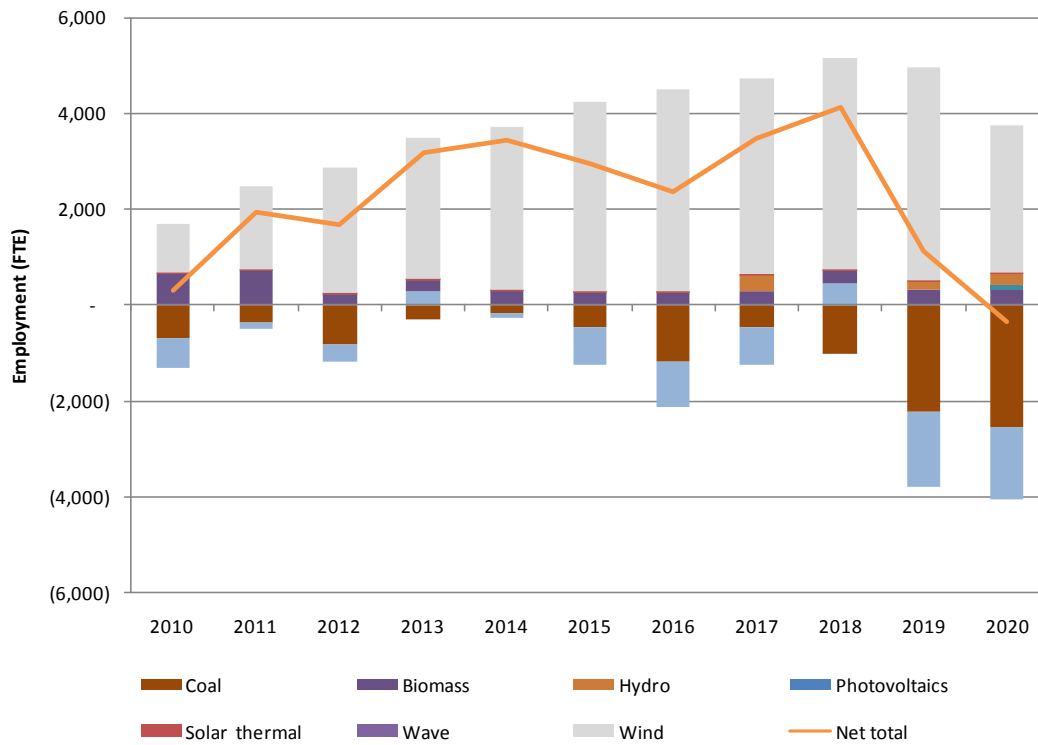
Chart 3.12 Direct operating employment associated with the RET, by technology



Source: Access Economics research

Chart 3.13 shows total construction and operating employment associated with the RET. Annual net FTEs peak at about 4,000 FTEs in 2018. In the last two years of the projection, there is a greater negative impact associated with the deferral of coal and gas fired capacity, with a net negative employment impact modelled for 2020.

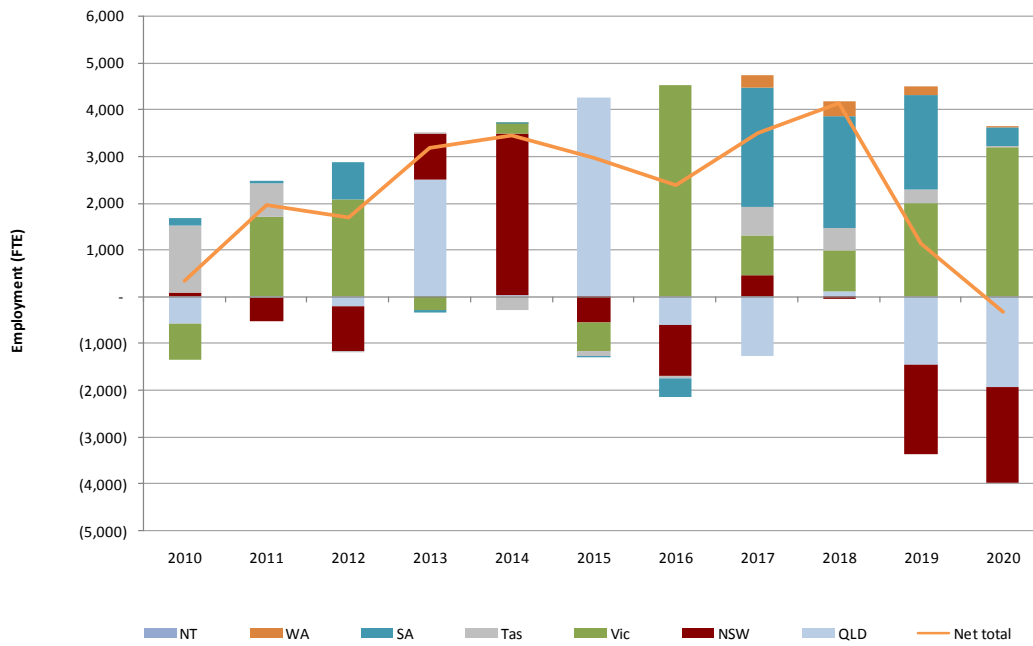
Chart 3.13 Direct (construction and operating) employment effects of RET



Source: Access Economics research

Chart 3.14 shows net employment impacts in each state and territory (columns) and the net employment impact Australia-wide (line). For most of the projection period, the majority of states and territories yield net employment benefits from the RET, because more labour and capital intensive (on a MW basis) generating capacity is installed relative to the reference case. The net employment benefits are concentrated where renewables uptake is greatest – according to the modelling this is concentrated in Victoria early in the scheme and in Queensland and South Australia later in the scheme. In the later years of the projection, New South Wales and Queensland experience net employment losses as a result of the deferral of coal and gas fired capacity in those states. Victoria is less affected, as most of the capacity assumed to enter in Victoria in the reference case is gas capacity, which serves as backstop capacity to the intermittent generating technologies driven by the RET.

Chart 3.14 Net employment impacts associated with the RET, by region



Source: Access Economics research

4 Energy efficiency policies

4.1 Description of energy efficiency initiatives

States and territories are undertaking a range of energy efficiency related policies and targets. The employment impacts estimated to result from these policies are net impacts as they are all additional to a business as usual case. A description of the various schemes is provided in Table 4.8.

Table 4.8 State energy efficiency schemes

Jurisdiction	Energy efficiency programs	Policy objectives
New South Wales	Greenhouse Gas Abatement and NSW Energy Efficiency Trading Schemes (GGAS-NEET)	Will commence 1 July 2009. Objectives include reducing greenhouse gas emissions by encouraging energy efficiency, reducing the cost impact of a CPRS on customers (primarily for households) and delaying the need for additional energy supply infrastructure. The GGAS-NEET scheme is expected to deliver about 4,000 GWh of savings annually by 2020.
Victoria	Victorian Energy Efficiency Target	Sets a target for energy savings, initially in the residential sector, and requires energy retailers to meet their own targets through energy efficiency activities, such as providing households with energy saving products and services. The first phase of the energy saver incentive will save 8.1 million tonnes of greenhouse gas.
Queensland	The Sustainable Housing Code	Requires new houses in Queensland to be more sustainable by ensuring efficient water and energy use.
	Smart Energy Savings Program	Legislative initiative effective from 1 July 2009. The program aims to drive energy saving improvements in Queensland businesses.
South Australia	Sustainable Housing scheme	Aims to increase energy efficiency in dwellings by 10 per cent within 10 years.
Western Australia	Regional Energy Efficiency Program	Designed to help people save energy in areas outside of Western Australia's main electricity grid.
ACT	ACT Energy Wise program	Provides subsidised home energy audits to identify priority areas for energy efficiency improvement.

The Federal Government has also embarked on its own energy efficiency initiatives (see Table 4.9). Major federal initiatives include energy efficiency programs announced as part of the Nation Building Stimulus Plan that are aimed at upgrading water heaters and insulation which have similar objectives to programs already running or proposed by State governments.

State and Federal governments also cooperate on energy efficiency initiatives such as the National Appliance and Energy Efficiency Program, which is administered through COAG.

Table 4.9 National energy efficiency schemes

Jurisdiction	Energy efficiency programs	Policy Objectives
Federal Government	Homeowner Insulation Program and Low Emission Assistance Plan for Renters	The program provides rebates to encourage homeowners and renters to install ceiling insulation. The two insulation programs will start on 1 July 2009 and run until December 2011.
Federal Government	Solar Hot Water Rebate	This rebate scheme provides a rebate to offset the cost of replacing existing electric hot water systems with solar or heat pump hot water systems.
Federal and State Governments	National Appliance and Equipment Efficiency Program	The aim of these programs is to improve the energy efficiency of household appliances and industrial equipment by mandating Minimum Energy Performance Standards (MEPS). It is a program shared by State and Federal governments. Governments have agreed that there is a need for nationally consistent standards, which requires Federal involvement and constitutionally energy efficiency regulation is the responsibility of State governments.

4.2 Activities driven by the schemes

4.2.1 Residential

State and federal energy efficiency initiatives affect residential activity in three key ways:

1. changes to building codes that affect new home buyers;
2. rebate schemes to encourage the replacement by existing home-owners of inefficient appliances; and
3. mandatory energy efficiency standards for new appliances purchased by all households.

New homes initiatives have been implemented as changes to building codes. Key building code changes aimed at improving energy efficiency include:

- Improvement of building code for new homes: these programs are aimed at improving energy efficiency by increasing the star rating applying to the building shell of new construction. The introduction of higher star ratings, such as in the case of NSW, are to be phased in by 2020, so the policy is not expected to have an immediate impact on economic activity.
- Energy efficiency initiatives also include specific changes to the building code, such as the lighting code requirement that all lights installed in new homes are as efficient as possible. This goes above the Federal Government ban imposed on incandescent lights, by requiring that developers install the most efficient light fixtures for the intended purpose. There are no exemptions. It is assumed that developers in the absence of this code would install less expensive inefficient fixtures, so the policy is expected to

generate new capital expenditure. This expenditure will reflect the additional cost of upgraded lighting fixture and additional cost of installation.

- States have adopted a similar requirement to the proposed Federal Government policy to ban installation of electric water heaters, by requiring that all new homes be fitted with low emission water heaters (solar, heat pump, or high efficiency gas) and that the water heater system is well insulated. There are no exemptions. To be consistent with the general building code view, it is assumed that prospective buyers would in the absence of this policy demand the same energy efficient appliances, so there is no additional capital expenditure from this initiative.

Existing home initiatives involve the mandatory phasing out of products or rebate schemes to encourage retrofitting existing homes. Major initiatives include the following Federal and State programs.

- In a similar move to the Federal Government's ban on incandescent lights, states have adopted specific requirements to ensure the gradual phasing out of halogen lamps. There is an assumed rate of retrofit of halogen lights for an assumed maximum proportion of homes per annum. This capital expenditure will involve the cost of the upgraded appliance and the cost of installation.
- State and Federal governments have adopted rebated schemes that encourage the early replacement of electric water heaters in existing homes (before the time the units would normally be replaced). These retrofits typically fall under the building code requirement outlined above so that installers must also ensure the associated insulation to water pipes and tanks in existing systems is consistent with the current code. There is an assumed rate of retrofit of water heaters for an assumed maximum proportion of homes per annum. This capital expenditure will involve the cost of the upgraded water heater and the cost of its installation.
- State and Federal governments have also introduced rebate schemes to encourage the installation or upgrading of roof insulation. There is an assumed rate of retrofit of insulation to roof spaces and cavities for an assumed maximum proportion of homes per annum. This capital expenditure will involve the cost of the insulation and the cost of its installation.

Federal and State government-required minimum energy performance standards (MEPS) mandate a minimum level of energy efficiency requirements for appliances. The impact is measured across three types of household appliances that are subject to MEPS: refrigerators, consumer electronics, and air conditioners. In general savings from replacing appliances are too small to cause individuals to bring forward expenditure on these items. Similarly, affected appliances or components are typically imported, so labour inputs used in raising the efficiency of appliances are not Australian workers. Overall, these policies are not expected to have an impact on Australian workers beyond the business as usual case.

4.2.2 Commercial sector

The specifics of State and Federal government energy efficiency initiatives aimed at reducing the demand for energy by the commercial sector are not as well-defined as for the residential sector. Four main areas of activity have been identified in the energy efficiency literature (see for example, EMET Consultants (2004b) and McLennan Magasanik Associates (2008)), which largely mirror residential programs:

- changes to building codes that affect new commercial spaces;
- changes to building codes that affect refitting of commercial spaces; and
- mandatory energy efficiency standards for new appliances purchased by new and existing commercial spaces.

The average office building has a 2 star rating for energy performance. Some states have proposed or altered their building code requiring that the star rating on new buildings rise to 4 stars by 2020 and 5 by 2030. The business as usual case assumes that commercial spaces would remain at a 2 star rating in the absence of the building code change. The impact of the policy therefore reflects the capital expenditure necessary to achieve a 4 star rating. This additional capital expenditure will involve additional expenditure on materials and additional installation cost.

Building code upgrades are also expected to have an impact on refitted commercial space by requiring that refits incorporate the most efficient lighting available and upgrade wall and ceiling insulation. This capital expenditure will involve the cost of the upgraded lighting and upgraded insulation and the cost of their installation.

Building codes governing commercial spaces are also expected to have an impact on appliances. In particular, code changes are expected to increase the rate of adoption or replacement of refrigeration and heating/cooling systems to world's best practice models. This capital expenditure will involve the cost of the replacement appliance and the cost of its installation.

4.2.3 Industrial sector

Following the energy efficiency literature (see, for example, Sustainable Energy Authority of Victoria (2003) and McLennan Magasanik Associates (2008)), State and Federal policies are expected to have a broad impact on capital expenditure in the industrial sector, which includes agriculture, mining and manufacturing. In other words, the literature does not identify specific capital expenditure impact such as upgrading of appliances, but instead has identified a level of capital expenditure for a given level of energy saving. Estimates of the likely impact of energy efficiency initiatives are based on estimates of the cost effective level of capital expenditure.

4.3 Methodology

A key feature of energy efficiency modelling is the relationship between the additional cost of an energy efficient appliance (i.e. a solar hot water heater) and the energy saving that appliance generates. In general, estimates of this relationship are based on detailed analysis of the relative energy efficiency and associated capital costs of rival appliances. Given the timeframe and scope of this consultancy, it was necessary to rely on available published research to provide estimates of these energy saving/capital cost relationships. A survey of the literature found that the most widely cited source of estimates was research undertaken for the National Framework for Energy Efficiency, which was documented in Sustainable Energy Authority of Victoria (2003). The popularity of this research as a reference source is due to the fact that it is comprehensive in its coverage of energy efficiency options across appliances and sectors. That said, the research and assumptions underlying its findings are subject to review, so the estimates provided in this report will have a confidence interval that is wider than if the energy saving/capital cost research had been conducted using more recent data.

4.3.1 Residential

The impact on the residential sector from various energy efficiency initiatives (EEl) identified above are divided into the impact on existing and new dwellings. In particular, attention must be paid to:

- the business as usual case for new and existing homeowners;
- the extent of additional capital expenditure resulting from the EEl; and
- the rate at which homeowners undertake EEl related capital expenditure.

Assumptions underlying capital cost and take-up rates of residential initiatives are summarised in Table 4.10.

Table 4.10 Residential energy efficiency initiatives, key assumptions

Energy efficiency initiative	Cost per household (\$2005)	Annual share of new households (%)	Annual share of existing households (%)
Lighting code	200	100	0
Water heater replacement	1500	0	2
Roof space insulation	4000	0	1
Phase out of halogen lights	200	0	10
Refrigeration efficiency (MEPS)	400	100	5
Air conditioning efficiency (MEPS)	300	100	5
Consumer electronics efficiency (MEPS)	500	100	10

Source: Access Economics and Sustainable Energy Authority of Victoria (2003) Table 5.1

Changes to building codes mean that new standards must be applied to all newly built dwellings. Therefore a key assumption in modelling the impact on new dwellings is the level of energy efficiency that would have existed without the EEl (i.e. the business as usual case). It is assumed that energy conscious consumers would demand no less than a 5 star rated dwelling, so the EEl relating to the shell of the house and water heaters are not expected to have an impact on capital expenditure. In contrast, it is assumed that developers in the absence of the upgraded lighting code would install less expensive inefficient fixtures, so the policy is expected to generate new capital expenditure. Similarly, mandated energy standards are expected to raise the capital expenditure of new homes above the business as usual case, as these standards are assumed to be binding in the sense that developers and homeowners would have otherwise opted for less expensive inefficient appliances.

The key assumption in estimating the impact of EEl on existing dwellings is the proportion of dwellings to which the EEl measure will be applied. Our modelling has relied on estimates of the likely take up rate identified in the literature, such as Sustainable Energy Authority of Victoria (2003). In general this take-up rate is tied to the life of the policy and/or the extent of the value of rebate schemes. For example, the phase-out of halogen lights is expected to take roughly 10 years with 10 per cent of existing households replacing their lights per year of the policy's life.

Estimates of the additional capital cost associated with the EEI are based on estimates reported in Sustainable Energy Authority of Victoria (2003). These initial estimates have been adjusted to reflect costs in 2004-05 dollars terms. This step greatly simplifies the analysis because the employment contribution is derived using the latest Australian Bureau of Statistics (ABS) input-output tables for the Australian economy (ABS Cat 5209.0), which are based on the disaggregated sectoral input and output data for the 2004-05 financial year. When matched with contemporaneous estimates of value of capital expenditure and sectoral employment, the input-output tables provide a consistent estimate of both direct and indirect labour inputs required to make each output.

Estimates of the size of the housing stock are based on initial estimates of the housing stock reported by the ABS and forecasts of the rate of household formation, with the latter implying additions to the stock. Access Economics has relied on its in-house demographic model AE-DEM to generate individual state and territory level forecasts of household formation. This in turn allows us to derive estimates of the likely employment impacts of EEI's at the state and territory level.

Using forecasts of the stock of houses, along with the take-up rate and cost assumptions in Table 4.10, an estimate of the total capital cost for every year of the initiative is calculated (current policies are expected to end in 2020). These annual capital costs are averaged over the period from 2009 to 2020 to calculate a typical level of annual economic activity associated with the EEI.

Estimates of the employment contribution of retrofitting and adhering to building code requirements is calculated by identifying the share of the capital cost that is associated with the installation of the appliance and the cost of the appliance. Direct employment effects are then calculated using historic direct employment to residential construction cost ratios derived from ABS input-output tables. Total employment effects associated with the installation and appliance spending are also calculated using total employment to capital spending ratios derived from ABS input-output tables. The total installation employment contribution is based on total employment to residential construction costs ratio derived from ABS input-output tables, while the total appliance employment contribution is based on the total employment to appliance cost ratio (i.e. the total employment required to make a specific appliance) derived from ABS input-output tables.

In general, savings from replacing appliances are too small to cause individuals to bring forward expenditure on these items. Similarly, affected appliances or components are typically imported, so labour inputs used in raising the efficiency of appliances are not Australian workers. Overall, these policies are not expected to have an impact on Australian workers beyond the business as usual case.

4.3.2 Non-residential

Estimates of the employment impact of non-residential energy efficiency are divided into the commercial and industrial sector impacts.

- Commercial is divided into the following Australian and New Zealand Standard Industrial Classification (ANZSIC) sector groupings: offices (codes J,K,L,M), retail (codes F,C,Q), health (code O) and other commercial (codes N,P).
- Industry covers the following ANZSIC sectors: mining, agriculture, wood, petroleum, non-metallic mineral products, metals and other manufacturing (remaining manufacturing sectors).

Using assumptions/modelling from Sustainable Energy Authority of Victoria (2003), capital cost curves per unit of energy efficiency were calculated. These costs curves report the cumulative capital cost as a ratio of the cumulative energy saving. The total capital cost of an initiative is then calculated using an assumed level of energy saving. In all cases, the assumed level of energy saved by the sectoral EEI is based on the potential national saving estimated by McLennan Magasanik Associates (2008) for 2020.

Commercial and industrial capital costs are also measured in 2004-5 dollars. Consistent with the methodology used for the residential sector, the average annual capital expenditure estimated over the EEI policy life is assumed to be 2009 to 2020.

Estimates of the employment contribution of each commercial EEI initiative are calculated by identifying the share of the capital cost that is associated with the installation of the appliance and the cost of the appliance. Direct employment effects are then calculated using historic direct employment to non-residential construction cost ratios derived from ABS input-output tables. Total employment effects associated with the installation and appliance spending are also calculated using total employment to capital spending ratios derived from ABS input-output tables. The total installation employment contribution is based on total employment to non-residential construction costs ratio derived from ABS input-output tables, while the total appliance employment contribution is based on the total employment to appliance cost ratio (i.e. the total employment required to make a specific appliance, such as an air conditioner) derived from ABS input-output tables.

Estimates of the employment contribution from energy efficiency initiatives undertaken by industrial sectors are based on the allocation of the capital spending to equipment and non-residential construction. This aspect of the modelling is calibrated using the historic ratios of sectoral investment devoted to equipment and construction estimated from ABS Cat 5204.0 *Capital Stock by Industry*. Following the approach in other sectors labour directly employed by the EEI are assumed to be those workers directly employed in the construction capital expenditure. Direct employment effects are calculated using historic direct employment to non-residential construction cost ratios derived from ABS input-output tables.

Total employment effects associated with the construction and equipment spending are also calculated using total employment to capital spending ratios derived from ABS input-output tables. The total construction employment contribution is based on total employment to non-residential construction costs ratio derived from ABS input-output tables, while the total equipment employment contribution is based on the total employment to equipment investment cost ratio derived from ABS input-output tables.

4.4 Employment outcomes

4.4.1 Residential

Table 4.11 reports estimates of the annual employment contribution of state and federal residential energy efficiency schemes. These estimates should be interpreted as the additional workers that would be employed each year over the business as usual case. For example, upgrading the lighting code is expected to generate additional annual capital of \$22.9 million (in 2004-05 terms) from 2009 to 2020. This initiative is expected to save 27 GWh annually by 2020. It is also expected to employ an additional 96 full-time equivalent (FTE) workers on average from 2009 to 2020 in the direct installation of the upgraded fixtures and another 93 FTE workers in the manufacture of the upgraded appliance. This implies a total annual employment contribution of 189 FTE workers for this initiative.

The biggest energy savings are expected to come from Minimum Energy Performance Standards (MEPS), especially refrigeration. However, as we noted above this capital expenditure is unlikely to be the result of consumers actively switching to new energy efficient appliances, so the additional capital spending reflects the costs of enhancing the energy efficiency of the appliance which we have argued is unlikely to generate additional Australian employment.

In contrast, the replacement of water heaters, installation of roof space insulation and the phasing out of halogen lights are expected to have a positive albeit modest impact on annual employment over the business as usual case. For example, roof space insulation initiatives are expected to generate additional annual capital spending of around \$133.5 million (2004-05 dollars). This in turn is expected to employ an additional 475 FTE workers in the direct installation and another 461 FTE workers in the manufacture of the insulation material. In combination, this implies an additional 936 FTE workers employed, on average, from 2009 to 2020.

Table 4.11 Residential energy efficiency initiatives: estimated employment contribution

Energy efficiency initiative	Annual energy saved (2020 GWh)	Average annual capital cost (\$M 2004-5)	Average annual direct installation employment (2009-20)
Lighting code	27	22.9	96
Water heater replacement	1,852	226.3	948
Roof space insulation	2,365	113.5	475
Phase out of halogen lights	1,473	175.1	734
Refrigeration efficiency MEPS	4,071	181.0	0
Consumer electronics MEPS	2,962	461.3	0
Air conditioning MEPS	1,171	230.7	0
Total	13,922	1411	2,253

Source: Access Economics, Sustainable Energy Authority of Victoria (2003) and McLennan Magasanik Associates (2008)

Overall, state and federal energy efficiency initiatives are expected to generate additional annual capital expenditure of \$1.4 billion (2004-05 dollars) over the period from 2009 to 2020. This additional spending is expected to lead to the employment of an additional 2,252 FTE workers annually to install energy efficient appliances and another 2,185 FTE workers in the manufacturing of the appliances, which implies a total annual employment contribution of 4,438 FTE workers from residential EEI.

The direct impacts of the household energy efficiency policies, by state, are shown in below.

Table 4.12 Employment generated through household initiatives, 2009 - 2020

State	Direct employment
New South Wales	739
Victoria	558
Queensland	471
South Australia	173

State	Direct employment
Western Australia	231
Tasmania	34
ACT/NT	48
Total	2,207

Source: Access Economics, Sustainable Energy Authority of Victoria (2003) and McLennan Magasanik Associates (2008)

4.4.2 Commercial

Estimates of the employment contribution of commercial energy efficiency initiatives are reported in Table 4.13. These estimates are based on an assumed level of energy saving which was derived from current energy efficiency literature (see for example McLennan Magasanik Associates (2008)). These assumed levels of energy saving are reported in the first data column of the table. Capital cost estimates associated with these expected energy savings are reported in the second data column. Employment flowing from the installation/construction of capital items is reported in the third data column.

Table 4.13 Commercial energy efficiency initiatives: estimated employment contribution

Sector/Energy efficiency initiative	Annual energy saved (2020 GWh)	Avg annual capital cost (\$M 2004-5)	Avg annual direct installation employment (2009-20)
Offices			
Building code	2,829.4	271.8	1,117.6
Retail			
Refrigeration	97.6	10.7	44.2
Lighting	683.0	5.5	22.7
Air Conditioning	97.6	11.6	47.8
Health			
Lighting	97.6	8.9	36.6
Air Conditioning	292.7	36.0	148.1
Insulation	292.7	28.9	118.7
Other commercial			
Lighting	97.6	9.5	39.0
Air Conditioning	292.7	32.4	133.3
Total	4,780.7	415.4	1,708.0

Source: Access Economics, Sustainable Energy Authority of Victoria (2003) and McLennan Magasanik Associates (2008)

Based on the methodology outlined above the biggest employment impact is expected to come from building code upgrades. Undertaking the expected average annual capital expenditure of \$271.8 million (2004-5 dollars) from 2009 to 2020 implies annual energy savings by 2020 of 2,829 GWh. This capital expenditure is also expected to add on average 1,117 FTE workers in the direct installation of energy efficient building standards and another 1,168 FTE workers in the manufacture of upgraded/additional appliances to meet the code requirements from 2009 to 2020. The total additional annual employment generated by this initiative is expected to be on average 2,286 FTE workers from 2009-2020.

The total average annual capital expenditure flowing from commercial energy efficiency initiatives is expected to be \$415.4 million (2004-05 dollars) from 2009-2020. This is expected to deliver annual energy savings by 2020 of 4,780 GWh. Installation of this capital spending is expected to generate additional annual employment of 3,675 FTE workers, with 1,708 FTEs employed in the installation of building code requirements and the remaining 1,966 FTEs employed in the manufacture of upgraded appliances.

4.4.3 Industrial sector

Estimates of the employment contribution of industrial energy efficiency initiatives are reported in Table 4.14. These estimates are also based on an assumed level of energy saving which was derived from current energy efficiency literature (see for example McLennan Magasanik Associates (2008)). These assumed levels of energy saving are reported in the first data column of the table. Capital cost estimates associated with these expected energy savings are reported in the second data column. Employment flowing from the installation/construction of capital items is reported in the third data column.

Table 4.14 Industrial energy efficiency initiatives: estimated employment contribution

Sector	Annual energy saved (2020 GWh)	Average annual capital cost (\$M 2004-5)	Average annual direct installation employment (2009-20)
Agriculture	97.6	10.6	23.8
Mining	780.5	24.1	70.3
Wood, Paper and Printing	195.1	8.8	15.9
Petroleum, Coal, Chemicals	292.7	21.9	39.8
Non-Metallic Mineral Products	292.7	9.6	17.4
Metals	1,951.3	29.8	54.1
Other Manufacturing	97.6	35.8	48.6
Total	3,708	141	270

Source: Access Economics, Sustainable Energy Authority of Victoria (2003) and McLennan Magasanik Associates (2008)

Energy efficiency initiatives are expected to have a modest impact on the average capital expenditure of industrial sectors over the period from 2009-20. The largest efficiency gains are expected in the metals sector. According to available research, average annual capital expenditure of \$29.8 million (2004-05 dollars) from 2009-20 is expected to generate annual energy savings 1,951 GWh by 2020. Based on historic ratios this additional capital expenditure will require on average an additional 54 FTE workers from 2009-2020 to install the energy efficiency capital and 195 FTE workers to manufacture the capital items.

Total energy efficiency related capital is expected to be on average \$140.6 million (2004-05 dollars) from 2009 to 2020, which implies an additional 269 FTE workers to install the capital and 909 FTE workers to manufacture the capital components or a total average annual contribution of 1,179 FTE workers.

4.4.4 Total impact of energy efficiency schemes

Table 4.15 summarises the results from previous tables. The largest energy savings and are expected to come from the residential sector, with the commercial and industrial sectors expected to deliver one third of the gain from the residential sector by 2020.

The additional capital expenditure required to achieve these energy savings is expected to add on average around 4,230 FTE equivalent workers annually to the installation/construction sector and another 5,061 FTE workers annually to appliance/capital input producing sectors, with a total average annual employment impact of 9,292 FTE workers from 2009 to 2020.

Table 4.15 All energy efficiency initiatives: estimated employment contribution

Sector	Annual energy saved (2020 GWh)	Average annual capital cost (\$M 2004-5)	Average annual direct installation employment (2009-20)
Residential	13,922.0	1,410.8	2,252.6
Commercial	4,780.7	415.4	1,708.0
Industrial	3,707.5	140.6	269.9
Total	22,410.1	1,966.8	4,230.5

Source: Access Economics

Appendix A: AE-RECM

The following section sets out details of the AE-RECM model, which has been specifically designed to capture the unique characteristics of the market for Renewable Energy Certificates (RECs) and factors influencing electricity prices and production.

Demand

The demand for RECs is relatively straightforward in that for any given year, wholesalers must purchase a predetermined amount of RECs as outlined in the Act. In this sense the demand for RECs is perfectly inelastic in the short run.

However if a purchaser of RECs believes the price will fall in subsequent years they can hold off on purchasing in the year in which the liability occurs, incur a penalty and then purchase the required number of RECs up to three years later. At this point the penalty is reimbursed and the only cost imposed on the liable party is the interest costs associated with carrying the penalty payment and the associated administration fee. In all other cases we assume REC targets are met where there is sufficient capacity.

Similarly if prices are assumed to increase in later years purchasers are assumed to buy and bank RECs ahead of time.

Supply

Electricity is different to other homogenous goods in that it can be generated using a variety of technologies with vastly different cost structures. The nature of electricity (non-storability, homogeneity, etc.) means that these technologies and dissimilar marginal cost curves can co-exist. The industry wide marginal cost curve is thus a stepwise function consisting of the individual technology curves. AE-RECM takes this process one step further and examines costs at the project level rather than the technology level.

Each project has a set of defining characteristics that determine the cost of production:

- fixed and variable costs;
- capacity;
- capacity factor;
- thermal efficiency;
- auxiliaries;
- generator on date; and
- life expectancy.

Generating plants tend to exhibit economies of scale so larger plants have smaller marginal costs. This is especially so for those plants where variable costs such as fuel are quite low. In these instances increasing the output of the plant by increasing the low cost inputs can be cost effective by spreading the capital costs over a larger amount of output.

To calculate a levelised cost at the project level the model begins with a standard levelised cost for each technology using the default output capacity shown in Table A.1. Capital costs, fixed

operating and maintenance costs and variable operating and maintenance costs are used to estimate the per MWh levelised cost for each technology.

Table A.1 Default capacities for capital cost calculations

Technology	Default capacity (MW)
Biomass	100
Geothermal aquifer	50
Geothermal hot dry rock	50
Photovoltaics	5
Solar thermal concentration	100
Tidal	100
Wave	40
Wind - onshore	25
Wind - offshore	25
Hydroelectric	5
Dam	120

The capital costs for establishing a plant are assumed to be incurred over a period of time. Each technology has a different time profile associated with its capital expenditure as shown in Table A.2.

Table A.2 Capital expenditure profile over time (%)

Technology	Year 1	Year 2	Year 3	Year 4
Biomass	0	0	30	70
Geothermal aquifer	0	0	30	70
Geothermal hot dry rock	0	0	30	70
Photovoltaics	0	0	30	70
Solar thermal concentration	0	0	30	70
Tidal	0	30	30	40
Wave	0	30	30	40
Wind - onshore	0	0	30	70
Wind - offshore	0	0	30	70
Hydroelectric	0	0	30	70
Dam	0	0	30	70

The capital costs, fixed operating and maintenance costs and variable operating and maintenance costs for each technology are given in Table A.3.

Table A.3 Capital, fixed O&M and variable O&M costs (\$/MW)

Technology	Capital		Fixed O&M		Variable O&M	
	2008	2030	2008	2030	2008	2030
Biomass	3,000,000	2,785,627	84,096	84,096	6.03	4.15
Geothermal aquifer	3,900,000	3,067,524	105,120	105,120	6.65	4.58
Geothermal hot dry rock	5,000,000	3,932,723	105,120	105,120	6.65	4.58
Photovoltaics	7,500,000	5,027,052	136,000	100,103	1.09	0.75
Solar thermal concentration	5,000,000	3,887,614	70,000	15,000	1.09	0.75
Tidal	4,000,000	2,355,676	150,000	100,000	1.09	0.75
Wave	4,500,000	2,650,135	150,000	100,000	1.09	0.75
Wind - onshore	2,400,000	1,606,124	20,000	15,000	1.09	0.75
Wind - offshore	3,600,000	2,409,186	20,000	15,000	1.09	0.75
Hydroelectric	3,350,000	3,110,616	65,447	61,816	1.09	0.75
Dam	2,850,000	2,646,345	56,040	52,930	1.09	0.75

Source: NEMMCO

A scaling factor unique to each technology is then applied to calculate specific levelised costs for each project taking into account the capacity of the plant in question. This cost is then adjusted according to the other characteristics listed above.

Thermal efficiency is also a factor in determining costs. Plants powered by sources such as biomass rely on the conventional idea of generating heat from a fuel source and converting this into electrical energy by turning a generator. The process of converting fuel to heat to steam to mechanical energy to electricity involves losses along the way so thermal efficiency is less than 100 per cent. Other technologies such as solar, tidal and so forth do not rely on the conversion of heat for electricity generation. In these cases the thermal efficiency is assumed to be 100 per cent (see Table A.4). In later years technology is assumed to improve and the thermal efficiency will rise.

Table A.4 Thermal efficiency of generators (%)

Technology	Thermal efficiency (2008)	Thermal efficiency (2030)
Biomass	24	37
Geothermal aquifer	10	19
Geothermal hot dry rock	10	19
Photovoltaics	10	19
Solar thermal concentration	21	34

There are also losses associated with running the generating plant itself. Ancillary systems such as water pumping, control and monitoring systems, etc. all require some level of energy to run which reduces the effective output of the power station. Although this is generally quite small it is still accounted for in the model.

Technology is assumed to improve over time so adjustments are made according to the generator on date for each project. Projects with a later starting date have a lower per MWh

cost than those starting earlier. The rate at which the costs change over time is set by technology with some experiencing more rapid declines in costs than others.

The life expectancy of the generator plays a role in the marginal cost of generation. Clearly, a longer life will allow for fixed costs to be amortised over a longer period of time thus reducing per unit costs of generation. The assumptions on project life are set by technology allowing each method of generation to have its own unique life span.

The capacity factor indicates how much of the plant’s full capacity is available for use at any given time. Wind generators for example are only available when there is sufficient movement of air to turn the generators. If this wind is not available the generator cannot produce electricity and so the capacity factor will be less than 100 per cent. Even for technologies such as hot dry rock the capacity factor will not be 100 per cent as there is still downtime required for maintenance, breakdowns and so forth. As with thermal efficiency the assumption that technology will improve over time applies to the capacity factor as well. This allows a given technology to exhibit higher capacity depending on when it is commissioned. Table A.5 shows the capacity factors used in AE-RECM.

Table A.5 Capacity factors (%)

Technology	Capacity factor (2008)	Capacity factor (2030)
Biomass	80	80
Geothermal aquifer	80	80
Geothermal hot dry rock	80	80
Tidal	40	47
Wave	25	35
Hydroelectric	50	50
Dam	30	45

Solar and wind generation are unique in the sense that they both rely on some natural phenomena in order to generate electricity. With this in mind the capacity factors used to estimate actual levels of production are calculated outside of AE-RECM in separate modules. A description of each follows.

Solar capacity factor

For solar technologies we calculate the hours of daylight as a function of latitude and the day of the year. This is done using the following formulae:

$$\theta = 0.2163108 + 2 \times \tan^{-1}[0.9671396 \times \tan(0.00860 \times \{J - 186\})]$$

$$\varphi = \sin^{-1} [0.39795 * \cos \theta]$$

$$D = 24 - \frac{24}{\pi} \cos^{-1} \left[\frac{\sin \frac{p \cdot \pi}{180} + \sin \frac{Lat \cdot \pi}{180} \cdot \sin \varphi}{\cos \frac{Lat \cdot \pi}{180} \cdot \cos \varphi} \right]$$

Where:

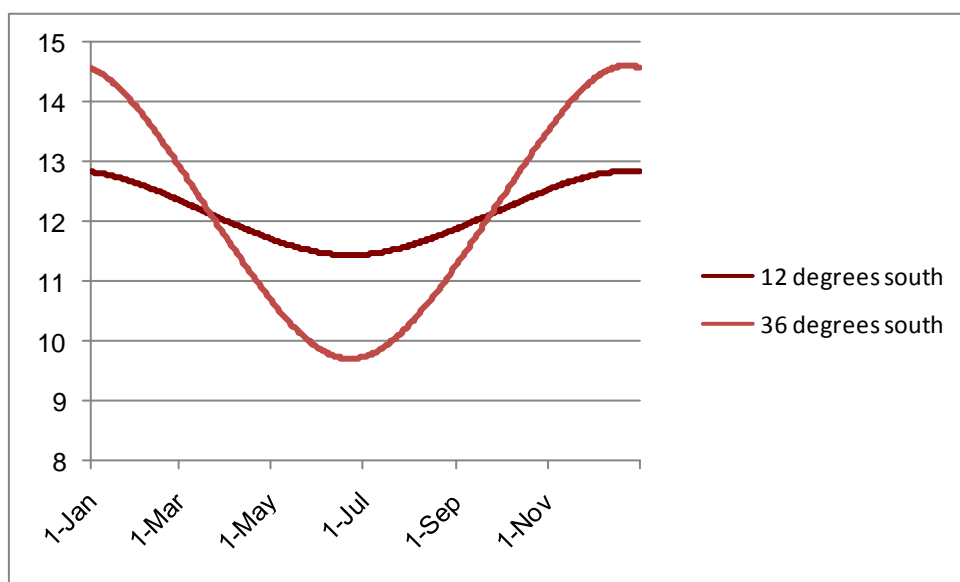
- J is the day of the year (i.e. 1 Jan = 1, 31 Dec = 365);
- p is the daylight parameter in degrees;
- Lat is the latitude of the location in degrees;
- D is hours of daylight; and
- θ and φ are in radians.

The value used for p in AE-RECM calculations is 0.8333 which corresponds to the US Government definition of sunrise/sunset as being when the top of the sun is apparently even with the horizon. For a more in depth treatment of the daylight model see Forsythe *et al.* (1995).

Forsythe *et al.* test the accuracy of the model against published meteorological tables and find the errors are within 1 minute for latitudes between 40 degrees north and south and a maximum of 7 minutes at 60 degrees. We consider the errors as being acceptable for use in AE-RECM.

Most of Australia falls between 12 and 36 degrees south of the equator. Chart A.1 shows there is less variation in the number of daylight hours for those locations closer to the equator. At 12 degrees south daylight hours vary by only 1.4 hours per year while at 36 degrees they vary by almost 5 hours.

Chart A.1 Australian daily hours of sunlight



The nature of most solar projects means that the whole array of cells, mirrors, etc. is rarely taken out of service at once. Smaller components of the generator are usually taken out which reduces output by a relatively small amount. Moreover much maintenance can be done in low light conditions which impacts the overall capacity even less. For this reason the capacity factor ignores this aspect and is calculated using the light conditions only as follows.

Having established the number of hours of daylight, for any given day the distribution of daylight is assumed to be normal and symmetric with a midpoint at noon. Maximum output of the power station occurs at (some) per cent of maximum daylight, as the days get shorter this threshold percentage of daylight is sustained for shorter periods thus reducing the output of the power station.

Wind capacity factor

The capacity factor for wind generation is calculated in a similar manner. The locations of wind generators are contained within the database and the closest weather stations to these farms is identified using the spherical law of cosines²:

$$Distance = \cos^{-1}[\sin(lat_1) \cdot \sin(lat_2) + \cos(lat_1) \cdot \cos(lat_2) \cdot \cos(lon_2 - lon_1)] \cdot R$$

Where:

- lat_n, lon_n refer to the latitude and longitude of location n (the generator and the weather station); and
- R refers to the radius of the earth in kilometres.

Note: Latitude and longitude information is normally expressed in degrees but must be converted to radians for this formula to give correct distances.

Wind conditions at the generator locations are assumed to be the same as those conditions present at the nearest weather station. In a similar manner to the solar capacity calculations maximum output is assumed to occur at a given wind speed. Two important distinctions are made however – both minimum and maximum thresholds are applied.

The minimum threshold is quite simple in nature. A certain amount of friction and inertia must be overcome to turn the wind turbine thus a minimum wind speed greater than zero is required before any generation can take place. The minimum wind speed applied in the model is 3m/s.

Conversely there are physical limits on how fast turbine blades can rotate, how fast the turbine itself can spin and structural limits on other components. Thus, if the wind speed exceeds a certain limit the generator must be slowed or even shut down.

The wind data (supplied by the Bureau of Meteorology) is valid at 10m above ground level. This is adjusted to account for variations in wind speed due to the height of the generator above ground. This variation in speed, U , for a generator with height z is given by:

$$V_h = V_{10} \cdot \frac{\ln\left(\frac{h}{z}\right)}{\ln\left(\frac{10}{z}\right)}$$

² Strictly speaking the Haversine formula should be employed here. Despite this the accuracy of modern computers means the errors associated with the spherical law of cosines are as small as 1 metre in most cases. Moreover we are more interested in determining which weather station is closest rather than the actual distance so such errors become insignificant making the much simpler spherical law of cosines more attractive.

Where:

- V_h is the wind velocity at height h ;
- V_{10} is the wind velocity at 10 metres above ground; and
- z is the roughness length.

The roughness length parameter for various surface types is given in Table A.6.

Table A.6 Roughness parameters for various surface types

Surface type	Roughness parameter
Ice, water	0.001
Grass, airports	0.03
Trees, scattered buildings	0.2
Rough terrain	0.25
Towns, very rough terrain	0.5
Cities, forests	1.0
City centre, high rise buildings	2.0

The model assumes all wind farms are built in areas with grass surfaces and the hub height of the generator is 65 metres above ground level.

Discounted cash flow

Having estimated each of the above factors (fixed and variable costs, capacity factors, efficiencies, etc.) the costs are discounted over time.

The discount rate used in the model is set by estimating a weighted average cost of capital (WACC) for each technology. The WACC is a standard financial method of weighting each component of capital proportionately according to its share in total capital. AE-RECM uses two forms of capital – equity and debt. Equity consists of that portion of capital held by owners of the firms while debt is simply the borrowings of the company.

The WACC is calculated as follows:

$$WACC_{post-tax-nominal} = RE \cdot \left[\frac{1 - \tau}{(1 - \tau \cdot (1 - \gamma))} \right] \cdot \frac{E}{V} + RD \cdot (1 - \tau) \cdot \frac{D}{V}$$

Where:

- RE is the return on equity;
- RD is the return on debt;
- τ is the effective tax rate;
- γ represents the gamma of the equity;
- E is the share of equity in total capital;

- D is the share of debt in total capital; and
- V is the total liability.

As the tax rate increases the WACC will decrease which represents a lower discount rate and thus a higher NPV. Similarly, as the responsiveness of the returns on equity to underlying changes in price increases, the WACC will decrease. Higher returns to either debt or equity will both increase the WACC allowing us to discount at a higher rate. With this in mind the WACC can be interpreted as a measure of an assets valuation and risk – higher WACC means higher risk and therefore lower valuation.

The WACC is deflated by the inflation rate to give a real post tax WACC. Although it varies by technology typical values for the parameters detailed above are given in Table A.7.

Table A.7 Typical WACC parameter values

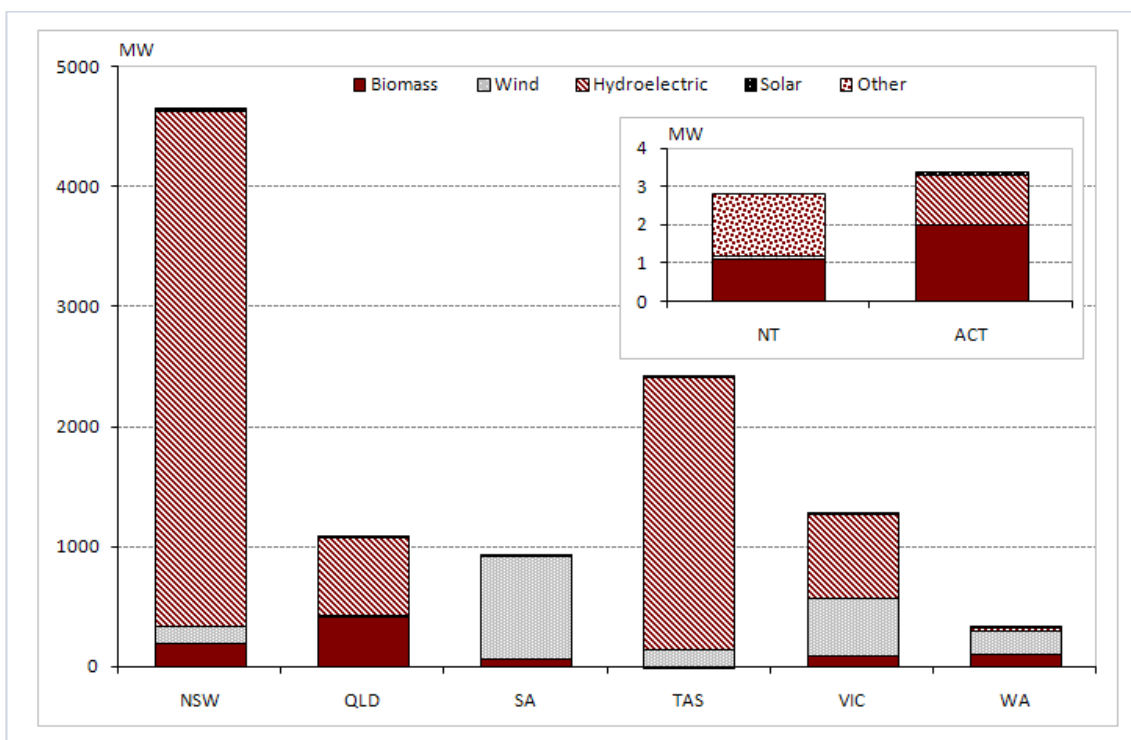
Parameter	Value	Parameter	Value
RE	16.21 %	RD	7.70 %
τ	22.5 %	γ	0.5
E	40 %	D	60 %

The database

Current capacity

Current renewable generating capacity is in the order of 10.8 GW across the country. Most of this capacity, some 6.5 GW, comes from hydroelectric sources located in the Snowy Mountains Scheme and Tasmania. New South Wales has the highest renewable electricity capacity of all the states with around 4.6 GW of generating capacity located within the state. Conversely the Northern Territory has the least with only 2.8 MW which consists of roughly equal amounts of wind and solar. Chart A.2 shows the breakdown of capacity across all states, which is then discussed in more detail.

Chart A.2 Current operating renewable capacity (KW)



Source: DEWHA

New South Wales

NSW, with over 4,500 MW of capacity, has the largest installed base of renewable generators.

NSW capacity is dominated by hydro capacity and more specifically the Snowy Mountains Hydro Scheme which accounts for more than 3,700 MW in its own right. Table A.8 shows the seven power stations built as part of the scheme. The biggest of these is the Tumut 3 station, which has an installed capacity of 1,500 MW. The smallest station is Guthega with 60 MW of capacity.

Table A.8 Snowy Hydro Scheme installed capacity

Station name	Installed capacity (MW)	No of generating units
Blowering	80	1
Guthega	60	2
Murray 1	950	10
Murray 2	550	4
Tumut 1	330	4
Tumut 2	286	4
Tumut 3	1500	6
Total	3756	31

Source: Snowy Hydro Ltd
(<http://www.snowyhydro.com.au/LevelThree.asp?pageID=244&parentID=66&grandParentID=4>, accessed 3 April 2009)

Biomass is the next largest source of renewable energy for the state. Breaking this down into the source of fuel reveals that bagasse, primarily sourced from sugar cane, is the dominant source (80 MW) followed by land fill methane (58 MW) and woodwaste (42 MW). Solar provides almost 30 MW of generating capacity for the state which comprises mainly of solar concentrator technology (26 MW) and photovoltaic technology (3.4 MW).

Tasmania

The pattern in Tasmania is similar to that of NSW in that the bulk of renewable electricity comes from hydro capacity followed by landfill methane fuelled biomass generators. The total capacity is 2,432 MW from all sources of generation.

Most of the hydro capacity in the state comes from Hydro Tasmania (2,270 MW) who also contribute to the amount of wind power via their part owned subsidiary Roaring 40s. Hydro Tasmania also have some wholly owned wind assets on King Island and Flinders Island that provide around 10,000 MWh of power.

Victoria

Victoria's 1,300 MW comes from a wider range of sources than we have seen in NSW and Tasmania although the single largest source is still hydro which provides around 710 MW.

Unlike the other states however wind is more prominent producing around 490 MW. Biomass accounts for most of the remaining capacity with a small contribution coming from tidal, wave and solar based generators.

Queensland

Queensland is very much dominated by two main fuel source as far as renewable electricity is concerned – bagasse and hydro. Given the high levels of sugar cane production and high average rainfall per annum this is not surprising and the two fuels provide some 1,000MW of the total 1,090 MW capacity. The remaining capacity comes from other biomass sources, wind and solar.

South Australia

South Australia has ideal wind sites located around the Eyre, Fleurieu and Yorke Peninsulas so it is not surprising that the largest source of renewable energy comes from this source. There are 18 projects in total which generate around 870 MW of electricity. Like other states biomass is also dominant with woodwaste providing approximately 40 MW of power for the state. Geothermal and solar powered stations are also present although these account for only 1 MW and 2.4 MW respectively.

Western Australia

Like South Australia, Western Australia has many sites suitable for wind generation. Currently there are 19 generators operating but the average size is smaller than in South Australia and they contribute only 200 MW to the state's electricity supplies (Table A.8). Biomass fuelled from landfill methane is the next largest source of electricity with a little under 24 MW coming from this type of generation. Despite having some of the best resources in terms of solar radiation this type of technology has not been widely adopted and there is only 718 kW of generation capacity currently installed.

Australian Capital Territory

The Australian Capital Territory is quite small both geographically and population wise so there is little generation that occurs within its borders. There are two generators fuelled from landfill methane, each with a capacity of 1,000 kW. There are also two hydro sites generating around 1,300 kW in total and two solar installations generating 100 kW of power (although one of these is experimental only).

Northern Territory

The Northern Territory has 67 operating solar generator sites producing 1.6 MW of power, three wind sites generating about 90 kW and a single biomass generator producing 1.1 MW. The solar sites are quite diverse in size ranging from 4 kW to 288 kW and are mainly used in remote communities to supplement other forms of generation (generally diesel generators). Interestingly all of the wind sites are located inland with the site closest to the coast being located some 150km away from Tennant Creek, itself some considerable distance inland. The only biomass generator is located in Darwin at Shoal Bay.

Future capacity

It is difficult to predict future levels of capacity and supply deliverable from renewable energy sources, as the rate of growth depends on:

- the success of research, development and demonstration;
- successful operational deployment;
- funding for R&D;
- government policies regarding research funding, preferential tariffs or other incentives for renewable energy;
- policies relating to the level of greenhouse gas emissions such as emissions trading;
- encouraging fuel switching and shortening the operational lives of conventional power stations; and

- any future policies to encourage decommissioning of coal-fired power stations in favour of less polluting alternatives.

Needham (2008) identifies four models of clean energy supply:

1. **An Australian model ‘clean energy supply mix’ delivered by 2040** entailing:
 - coal-powered generation of 9 per cent (plants decommissioned as circa 35-year operational life is reached);
 - natural gas 30 per cent (using both cogeneration and combined cycle power stations);
 - bioelectricity from crop residues 28 per cent;
 - wind 20 per cent;
 - hydro 7 per cent;
 - solar 5 per cent (produced during peak periods when its economic value is highest); and
 - oil 1 per cent (which could progressively be replaced by biofuels).
2. **A German model which claims that by 2050 half of global energy demand can be met by renewable energy technology.** This model foresees a much greater role for solar generation than the Australian model.
3. **Australian State and Territory programs** which will demonstrate the capability of renewables to contribute to the energy mix and reduce the need for new conventional baseload power stations. For example, the ACT Government is undertaking a feasibility study into the construction of a 33 MW solar plant in 2009 ‘capable of supplying electricity to 10,000 homes’, and a new 71 MW wind farm near Adelaide will see South Australia achieve its target of 20 per cent power from renewables by 2009, 5 years ahead of schedule.
4. **CSIRO and ABARE (2006) scenarios for the contribution for renewables by 2050.** Their most ‘renewable-friendly’ assessment, assuming high levels of policy intervention on emission levels and maximum use of technology, concludes that coal will still contribute about 30 per cent of total electricity, gas around 20 per cent, renewables about 47 per cent, and possibly nuclear 3 per cent. Potential for significant contributions from solar energy and geothermal energy (hot fractured rocks) is discounted on the basis of technological infancy, lack of demonstration, and unknown costs of electricity produced.

Given these view points, Needham reasonably concludes that at least 50 per cent of electricity will be generated from renewables by 2050:

“provided that suitable policy instruments are in place to encourage transition from a high-carbon (coal/gas/petroleum) to a low-carbon (biomass/solar/wind) infrastructure. With increased penetration of the more reliable renewable sources (i.e. biomass and potentially hot dry rock), and successful development of storage systems, there appears to be little impediment in the longer term to the total displacement of coal as the mainstay of baseload generation.” (Needham 2008, p.31)

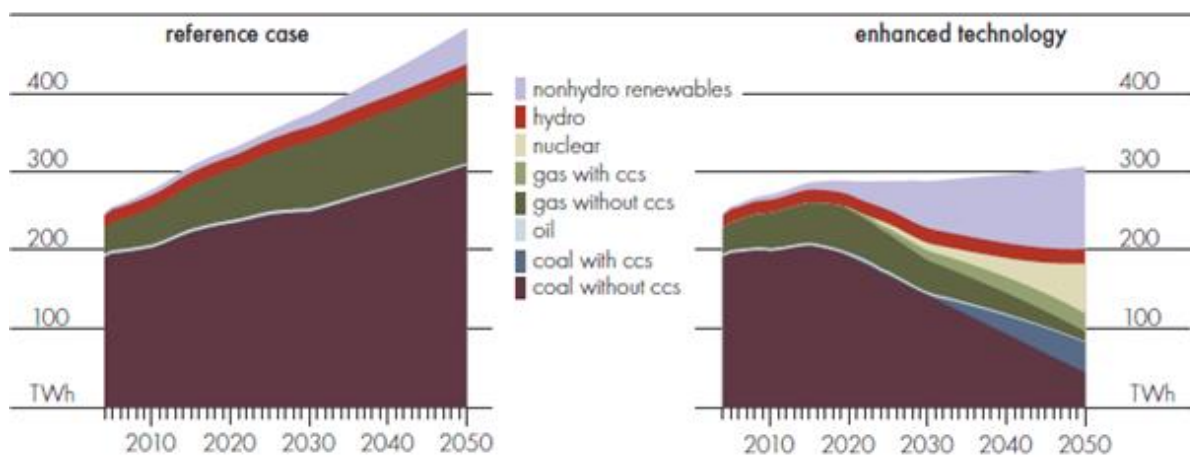
ABARE, Technology: toward a low emissions future

ABARE conducted a study in which their model of the world economy is used to assess these impacts by developing an enhanced technology scenario and comparing the projected energy consumption and emissions impacts in this scenario with those in the reference case.

In the enhanced technology scenario analysed in this report, a variety of energy efficient and low emission technologies and energy services are assumed to be widely adopted across the global economy. These include end-use energy efficient appliances, carbon capture and storage (CCS) in electricity generation, non fossil fuel electricity generation, energy efficient vehicles such as hybrid vehicles, solar heating systems, biofuels, fluidised bed combustion technologies and a range of fugitive emission abatement measures and technologies.

A range of complementary policies and measures will be required to achieve the development and widespread uptake of the advanced technologies.

Chart A.3 Australian electricity and heat generation



Source: ABARE 2007

The reference case aims to reflect a world in which technological development and government policies progress along their expected pathways in the absence of any major regional or global climate change initiatives and without any significant technological breakthroughs. The key drivers of energy consumption and greenhouse gas emissions in the reference case are economic growth, population growth and the uptake of energy efficient and lower emission technologies and energy sources.

In Australia, in the enhanced technology scenario a nuclear electricity generation industry is assumed to develop. The first nuclear power plant is assumed to begin full scale operation in 2025 with subsequent plants following, such that by 2050 around 63 terrawatt hours (TWh) of power generation is produced by nuclear reactors, equivalent to around eleven medium size (750 MW) nuclear plants.

Renewable electricity generation (non-hydro and hydro combined) is projected to contribute 124 TWh of electricity in the enhanced technology scenario at 2050 in Australia, compared with only 65 TWh in the reference case. Wind power and solar power are projected to contribute 30 TWh and 44 TWh respectively in 2050 in the enhanced technology scenario.

Table A.9 Electricity generation by fuel technology (Enhanced Scenario) in TWh

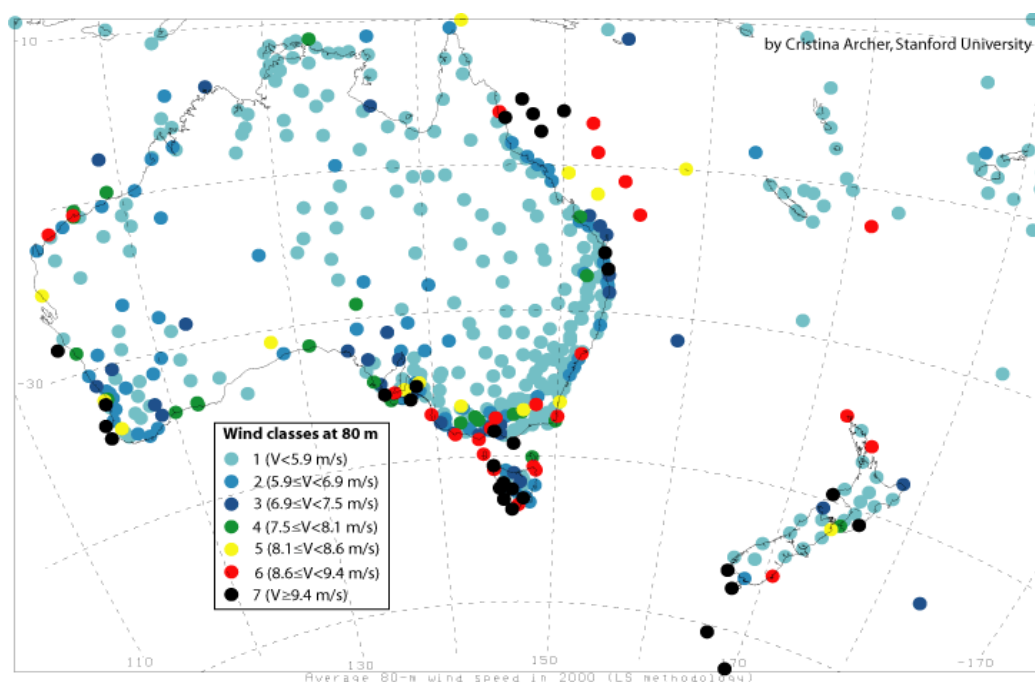
Technology	2004	2010	2030	2050
Nuclear	0	0	9	63
Hydro	16	17	19	19
Wind	1	3	13	30
Solar	0	0	22	44
Biomass	1	2	21	21
Other renewables	1	2	3	10

Source: Global Energy Network Institute (GENI), Renewable energy resources in Oceania
<http://www.geni.org/globalenergy/library/renewable-energy-resources/world/oceania/index.shtml>

Australia is one of the few developed countries that can boast an abundance of wind, sun, water and land. The southern-most region of Australia is buffeted by the 40-50°S wind zone, known as the 'Roaring Forties'. The westerly winds are strong and steady. Australia also rests in the most favourable solar radiation belt - between latitudes 15° and 35°S. Within this belt, an average of 3000 hours of sunshine per year can be relied on as an endless source of energy.

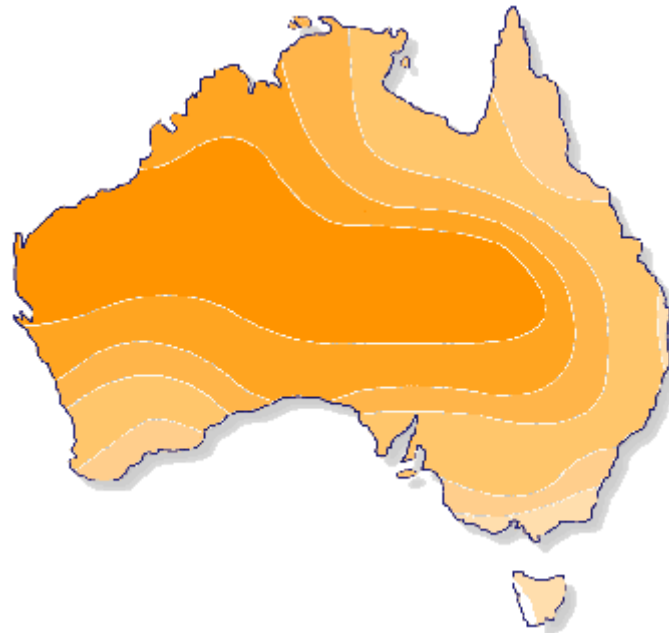
Wind speeds are calculated at 80 m, the hub height of modern, 77-m diameter, 1,500 kW turbines. Annual mean wind speeds $\geq 6.9\text{m/s}$ at 80m (i.e. wind power class 3 or greater in Figure A.1) can be considered suitable for low cost wind power generation.

Figure A.1 Wind speeds in Australia and New Zealand










The annual average daily solar energy available (in megajoules per square metre per day, MJ/m²/day) for a fixed solar collector facing north and tilted to the latitude angle for near optimum year round performance is shown in Figure A.2.

Figure A.2 Solar radiation in Australia



Legend

 greater than 24MJ/m ² day	 less than 22 but greater than 20MJ/m ² day
 less than 24 but greater than 23MJ/m ² day	 less than 20 but greater than 18MJ/m ² day
 less than 23 but greater than 22MJ/m ² day	 less than 18 but greater than 16MJ/m ² day
	 less than 16MJ/m ² day

By way of example, the solar energy available in western Victoria on an average day (18.1 MJ/m²day) would provide about 1 kWh of electricity through a commercially available system comprising a small battery bank and two square metres of solar panel with an overall efficiency of just 10 per cent. This is ample to light 4 rooms for 10 hours each using fluorescent lighting of either the compact or conventional tube designs.

AE-RECM database

The database used in AE-RECM contains details on 275 proposed projects. The majority of these are based on wind technology (see Chart A.4). Victoria has the largest proposed capacity of wind projects (37 per cent of the total) followed by New South Wales and South Australia with 24 per cent and 21 per cent respectively. The Australian Capital Territory and Northern Territory each have no proposed capacity most likely due to a lack of suitable sites.

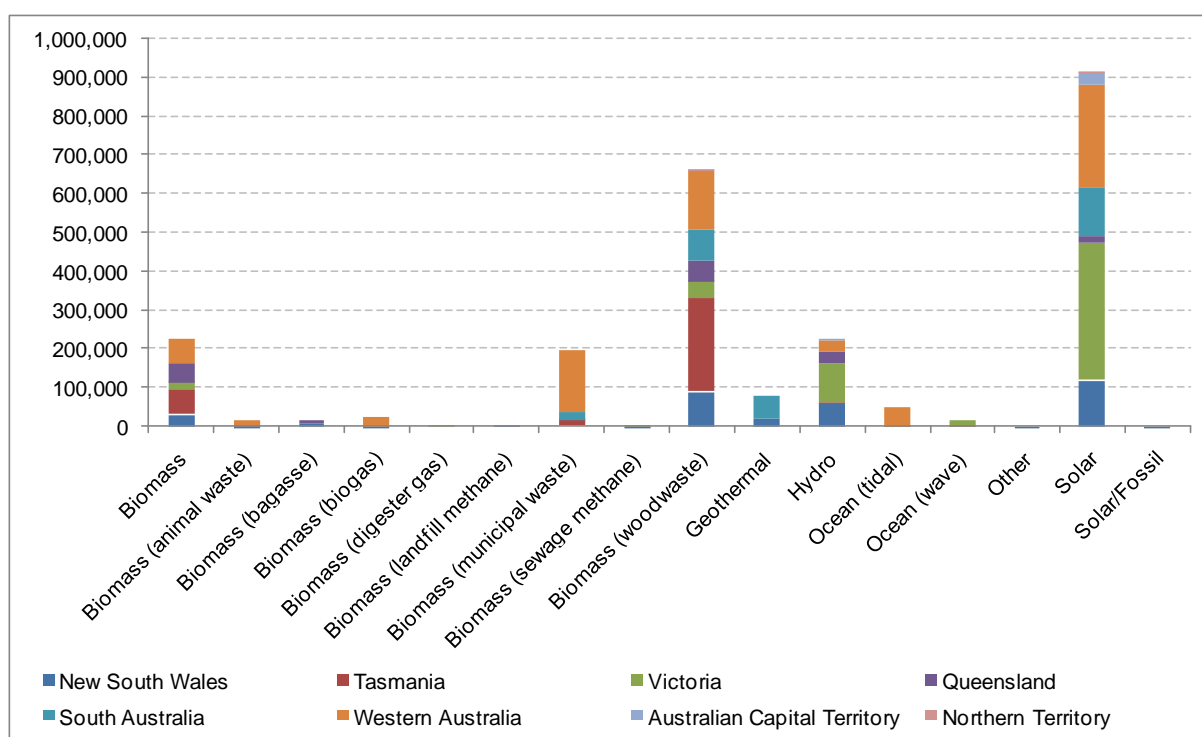
Table A.10 Proposed wind generation capacity

State	Capacity (kW)
New South Wales	2,330,026
Tasmania	420,900
Victoria	3,548,500
Queensland	894,100
South Australia	2,042,518
Western Australia	451,000
Australian Capital Territory	500
Northern Territory	0
Total	9,687,544

Of the remaining projects solar is the most predominant (see Chart A.4). Almost 920 MW is planned in various locations but interestingly the Northern Territory, despite being ideally located in terms of solar resources, has very little capacity planned. Biomass features heavily as a source of renewable electricity with woodwaste being the most common fuel source. Hydro and geothermal are also notable. Almost half of the 230 MW of proposed hydro comes from Victoria with the rest being spread across all other states aside from South Australia and the Northern Territory. The geothermal sites are mainly located in South Australia.

We note that geothermal and solar technologies are still in their infancy. Access Economics has therefore taken a conservative approach to these technologies and included only known projects within the model's parameters. Similarly, upgrades to current hydro capacity are not expected to have any significant impact on total sector capacity.

Chart A.4 Proposed renewable generation (excluding wind) KW



Source: DEWHA

Solar hot water heaters

The Australian Bureau of Statistics estimates there to be 8,060 households in Australia and expects this number to grow to 10,440 by 2026 at a linear rate. AE-RECM extrapolates this growth at a constant rate through to 2030 (Table A.11) and forecasts solar hot water heater numbers on this basis.

Table A.11 Number of households ('000s)

Year	Households	Year	Households
2001	7367.5	2016	9333.4
2002	7505.7	2017	9452.3
2003	7645.4	2018	9569.2
2004	7783.7	2019	9685.5
2005	7920.8	2020	9801.3
2006	8058.2	2021	9914.7
2007	8186.8	2022	10025.0
2008	8315.6	2023	10132.4
2009	8444.8	2024	10237.7
2010	8575.0	2025	10340.9
2011	8706.4	2026	10440.9
2012	8832.4	2027	10649.8
2013	8957.4	2028	10773.4
2014	9082.5	2029	10897.0
2015	9208.3	2030	11020.5

Source: ABS Household and Family Projections, Australia, 2001 to 2026 (Cat no. 3236.0), data beyond 2026 is extrapolated.

DEWHA expect the proportion of solar hot water heaters to grow from 7.1 per cent in 2006 to 11.8 per cent in 2020. This growth rate is calibrated with data from the REC Registry to estimate the uptake of solar hot water heaters in any given year that corresponds with empirical data and forecast growth expectations.

The number of RECs generated is estimated based on the average number of certificates created per solar hot water heater and the multipliers given in Table A.11 above.

State and territory feed in tariff programs

For households and businesses that have PV systems connected to the grid, credits can be given for any electricity generated by their solar PV units. The credit, specified on a per KWh basis, is referred to as the feed-in tariff (FIT). FIT programs have been announced in a number of states, with varying rates and conditions. For example, returns will be affected by whether the tariff applies to gross or net output, any size restrictions on systems and even relative hours of sunlight per day. A gross FIT applies to all electricity generated by the PV system, whereas a net FIT applies to the electricity supplied from the household to the grid (total electricity generated less that consumed by the household). Details of the state and territory FIT schemes in place or planned are set out in Table A.12 below.

Table A.12 State FIT schemes

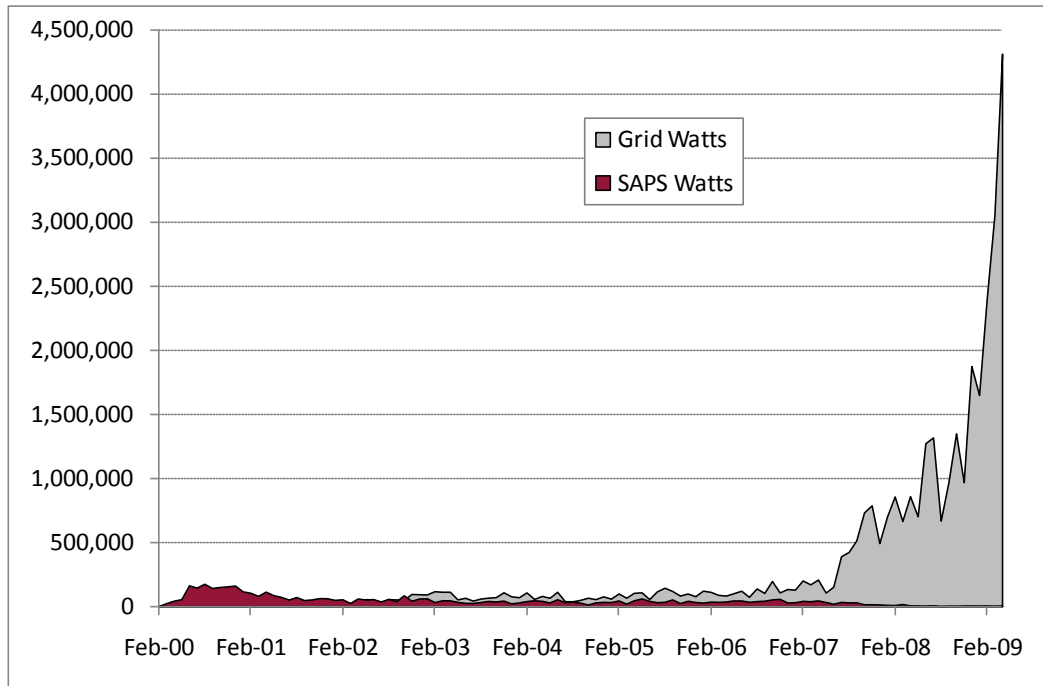
State/ Territory	Implementation Date	Tariff Rate	Gross/Net Tariff	Duration	Sectors included in FIT
NSW	Mid-2009, announced Nov 2008	Estimated to be approx 60c/kWh	TBC	TBC	TBC
Victoria	Premium FIT to commence 2009. Existing Fair & Reasonable (F&R) Tariff (1:1) to remain	Premium FIT for solar PV - 60c/kWh F&R Tariff - at least 1:1	Net	Premium FIT – 15 years	Premium FIT – Domestic F&R Tariff – domestic and small business
Queensland	1 July 2008	44c/kWh	Net	20 years	Domestic and Small Business
West Australia	1 July 2010	TBC	Net	TBC	TBC
South Australia	1 July 2008	44c/kWh	Net	20 years	Domestic and small business
Tasmania	To be announced. Currently only retail offering.	Current retail offer – at 20 cents / kWh FIT - TBC	Current retail offer – Net FiT - TBC	TBC	FIT - TBC
ACT	1 March 2009	50.05c/kWh up to 10kW, 40.04c/kWh 10-30 kW	Gross	20 years	Domestic and small business
NT	May 2008, Alice Springs Solar City only	45c/kWh	Gross		

Chart A.5 below shows the number of systems installed over the period 2000 to September 2008. It highlights the substantial increase in installations under the program following from the announcement to increase the rebate from \$4 per watt to \$8 per watt capped at 1kW per system in May 2007 and the continued growth in demand despite the means test in May 2008. Due to the rebate being capped for systems up to 1kW and the recent introduction of means testing, the average size of systems being installed has fallen to around 1.2kW, down from 1.6kW³ over the life of the program.

Based on the experience in foreign markets to the introduction of FITs and the responsiveness in Australia to the initial rebate program, we would anticipate a similar trend for the Australian market in terms of take up, however, to a lower extent given the overall size of the Australian market.

³ Standing Committee on Environment, Communications and the Arts *Save Our Solar (Solar Rebate Protection) Bill 2008 [No. 2] (August 2008)*

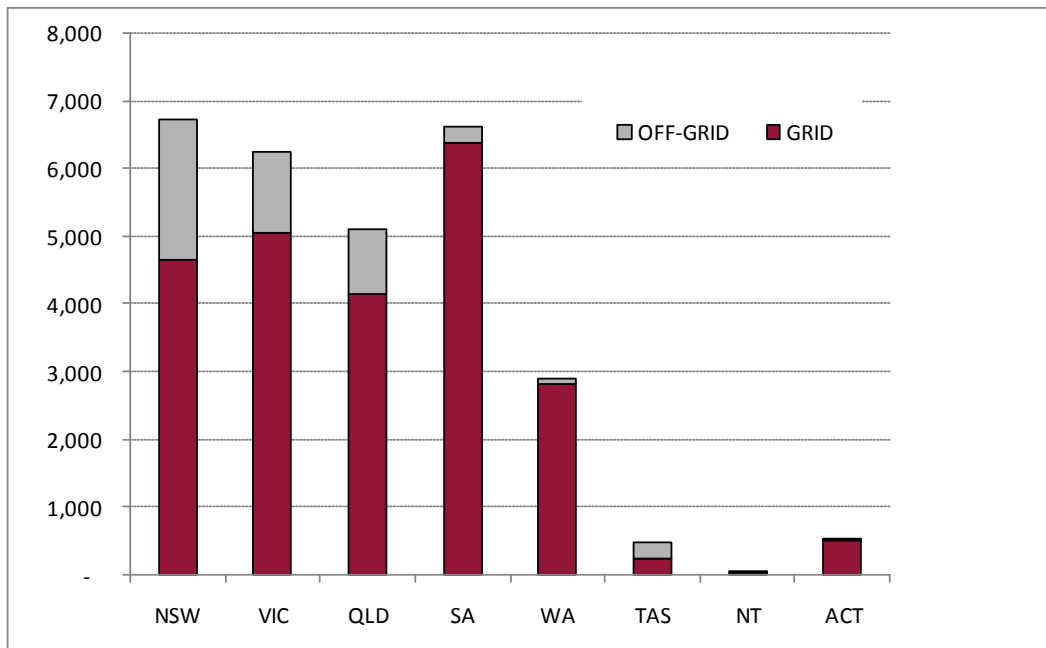
Chart A.5 Watts installed by month under SHCP



Source: DEWHA

Chart A.6 below, however, shows the disparity in uptake between the states and territories towards on- and off-grid connections.

Chart A.6 Number of PV systems installed, January 2000 to April 2009

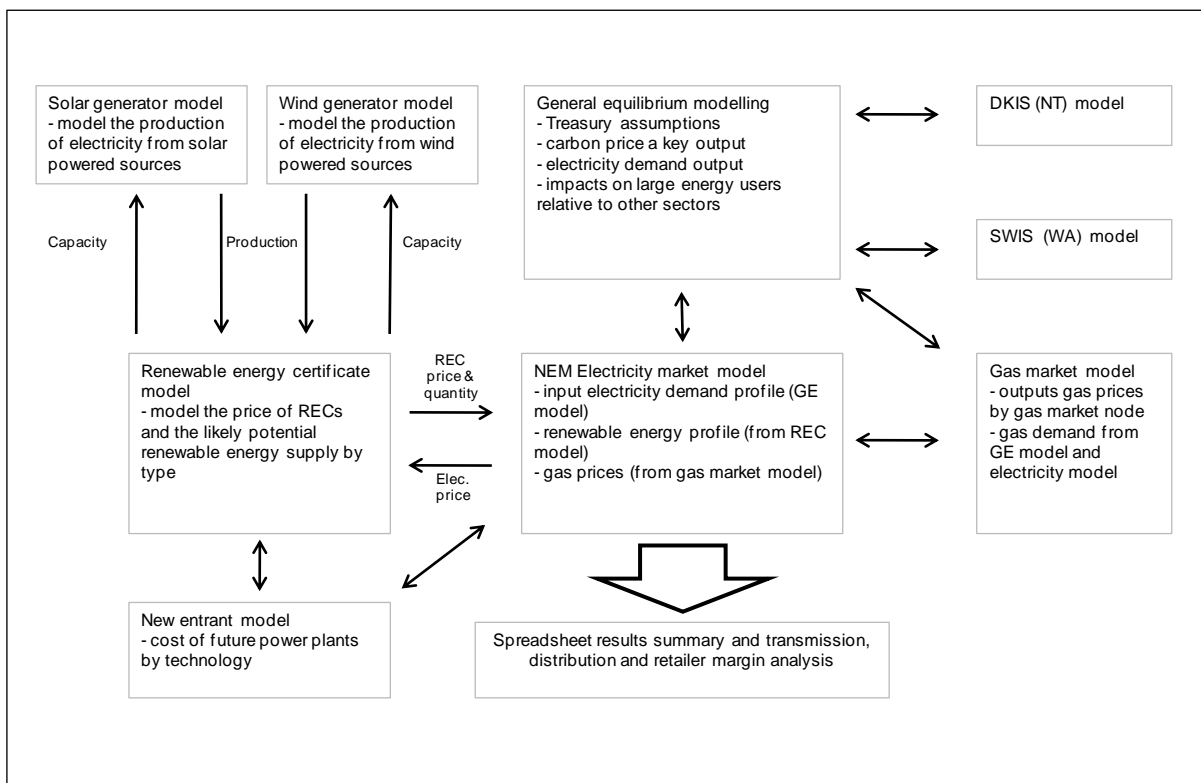


Source: DEWHA

Linkages with the electricity market model

AE-RECM and AE-NEMM are related through electricity market prices and quantities. Figure A.3 below shows the interaction between AE-RECM and other models used in the electricity market.

Figure A.3 Relationship between AE-RECM and other components



In simplified terms the process is as follows:

- inputs are taken from other components:
 - Prices for electricity are drawn from AE-NEMM; and
 - Costs of future plants are drawn from the new entrant model;
- information is exchanged between AE-RECM, the Solar Generator Model and the Wind Generator Model:
 - capacity details are passed from the AE-RECM database to the Solar and Wind models;
 - estimates of actual production using solar radiation, wind and spatial data are calculated; and
 - production figures are fed back into AE-RECM;
- AE-RECM models the market for renewable electricity and RECs and calculates an equilibrium price and quantity for each; and
- Renewable electricity and REC prices and quantities are fed into AE-NEMM where the impacts of RECs on the electricity market can be estimated.

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